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Keeping the lights on: Nuclear, Renewables and Climate Change

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The Environmental Audit Committee

The Environmental Audit Committee is appointed by the House of Commons to consider to what extent the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development; to audit their performance against such targets as may be set for them by Her Majesty's Ministers; and to report thereon to the House.

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Written evidence

Memorandum submitted by Air Products PLC

1. Introduction

Future energy policy in the UK must take account of the following important factors:

- The security of supply of primary fuels and energy sources.
- The relative cost of fuels and derived energy.
- The mix of fuels required to satisfy the demands of industry, commerce and the private sector.
- The ability of users and fuel suppliers, such as electricity utilities to use alternative primary fuels such as coal, natural gas, petcoke, bitumen, renewable sources, etc based on the flexibility of their systems.
- The constraints imposed by the requirement to meet our Kyoto objectives for greenhouse gas emissions, particularly CO_2.
- Our requirement to limit emissions of other atmospheric pollutants, particularly SO_2, NOx and particulates, which is focussed on the large plant directive which will compel all existing power stations still in operation by 2012 to meet stringent emission targets.
- The effect of the European carbon trading system on the value of traded CO_2 allowances, which will govern the incentive for organisations to undertake CO_2-free power and fuel production.
- The need to include carbon capture and storage in the CO_2 trading regime.
- The cost of renewable energy, particularly wind power, compared to the cost of CO_2 capture and storage from a modern fossil fuel power station, either by retrofit of an existing station or in a newly built station.
- The necessity to introduce a tax regime for tertiary oil recovery from CO_2 injection which will be sufficiently generous to the oil companies to ensure that they have a powerful incentive to store CO_2 in North Sea oil fields by practising enhanced oil recovery (EOR).
- The need to finance a network of large diameter high pressure CO_2 pipes so that captured CO_2 can be transported offshore for disposal.
- The need to continue to focus on energy efficiency. Appropriate consideration should given to the effectiveness of price mechanisms rather than subsidising fuel costs for sectional interests.
- The complex question of the future for nuclear power in the UK, which involves cost comparisons, the availability of uranium, the problem of plutonium production, particularly from breeder reactors as a means of extending the availability of nuclear energy for thousands of years, the current problems of nuclear proliferation, the question of nuclear waste disposal and spent fuel reprocessing and all the concomitant social and political pressures.

2. Status of Carbon Abatement Technology

The most profound changes to our current fuel usage scenario will be caused by the necessity to limit greenhouse gas emissions, particularly CO_2, and the cost and availability of secure sources of fossil fuels in the future. The current philosophy set out in the Energy White Paper calls for 20% reduction in CO_2 emissions compared to 1992 by 2020 and 60% by 2050. The energy White Paper, based on Markal modelling with assumptions for efficiency improvements, primary fuel costs and growth rates in the future, predicted these reductions were possible with a large growth in renewable energy, particularly wind power, a large and continuing achievement of efficiency gains across industry, commerce and the private sector and a very large increase in the use of natural gas with coal consumption being progressively reduced. The predictions even allowed for the phase out of nuclear powered electricity generation with no planned replacement programme.

The assumptions on which the White Paper was based have proved to be either based on optimistic judgements or on gross changes in the projected costs of primary fossil fuels.

2.1 *Wind Power*

The optimism on the projected capital cost of wind power and its on-stream factor, its effect on the electricity transmission system, its unpredictability and the effect on the environment appear to have been recognised. It is a very low-intensity electrical generation technology requiring substantial areas of land or sea to be covered by wind farms. The cost burden of the existing and projected installations will have to be borne by the consumer, with whatever consequential impact on the competitiveness of UK industry and commerce. The programme of investment in wind energy should be reviewed and its costs, characteristics and performance put on a competitive basis with carbon capture and storage ("CCS") using fossil fuel electrical generation systems. The share of future R & D for wind should be appropriate to wind's objectively determined potential to contribute to the UK's future energy sourcing. The subsidies currently available for wind should be made available for CCS projects, and the lowest-cost solutions will then be naturally identified and pursued. Wind power and other projected renewable energy solutions certainly have their proper place in the UK energy scenario serving markets remote from large base load power generation, but their suitability for provision of large proportions of our current and future power demand must be validated

2.2 *Nuclear Power*

It is conceivable that nuclear power will largely replace fossil fuel sources of energy for the generation of electricity in the far future: it is capable of providing, through electrolysis, or thermal generation chemical cycles, the hydrogen transportation fuel of the future; it is CO_2-free in operation; we can store enough fuel for a year's operation in an area the size of a football pitch. The real question concerns the need to use this technology now. There is wisdom in keeping a proportion of our electrical generation capacity as nuclear and this will require that we plan appropriately now, allowing us to retain expertise in an energy system of the future. This will probably require an examination of our philosophy of nuclear waste disposal—including examination of global options. The complex social and political issues outlined in the introduction are, of course, relevant to the immediate future and will be of prime importance in any decision to implement a new nuclear programme in the UK. On the technology side, we need to choose reactor systems of the most advanced kind which will offer very long life, good economics and low decommissioning costs. Safety and public acceptability for the whole system are of paramount importance.

2.3 *Fossil Fuel Power*

We are currently producing about 75% of our total electrical demand and all of the fuel for our transportation systems and space heating from fossil fuels: coal, oil and natural gas. All of this fossil fuel consumption generates CO_2 which is discharged into the atmosphere. Anthropogenic CO_2 emissions worldwide are now recognised as being the prime cause of global warming. The huge volume of research into the aspects of climate change reinforces this view.

Inevitably, fossil fuels will continue to provide a primary source of energy for mankind for the foreseeable future. If we are to have a sustainable future we must implement profound structural and technological changes in the way we use fossil fuels to largely eliminate the emission of greenhouse gases, particularly CO_2, to the atmosphere. This can be done in a positive manner by capturing CO_2 at the point at which the primary fossil fuel is burned and conveying the CO_2 to a storage site where it can be permanently stored with complete integrity for the future. This process of carbon capture and storage (CCS), with all of its complexities, is applicable to both electrical generation and to the production of hydrogen as the transport fuel of the future.

Power stations burning fossil fuels are massive point emissions sources of CO_2. In 2003 Drax power station emitted about 21 million tonnes, roughly 3% of the total UK CO_2 emission. The major UK power stations are obvious first choices for CO_2 capture. We must consider the problem of retrofitting existing power stations such as Drax with CO_2 capture systems as well as the problem of building new fossil fuelled power stations with CO_2 capture. The major effect of CO_2 capture is to reduce the efficiency of electrical power generation and impose a large increment of capital cost. This results in a large increase in the cost of electricity. We must also take into account the price of different fossil fuels. We could reduce our CO_2 emissions drastically by generating all our fossil fuel electrical energy from natural gas, which has about one third of the CO_2 emission per kWh of electricity compared to coal. Unfortunately, natural gas prices have been rising sharply and they are likely to be very much higher than coal in the future.

The question of fuel diversity and security of fuel supplies is also relevant. It is hard to conceive of a viable future in which the UK does other than generate a substantial proportion of its electrical power from coal. We should retain our existing coal fired power stations, modifying them for clean operation with CO_2 capture and upgrading their systems to improve basic efficiency and minimise the cost of implementing CCS. "New builds" for electrical generation must look carefully at the alternative systems available and compare total lifetime system costs for available fuels and technologies. This analysis will be possible only if there are stable values for CO_2 credits and if the cost of CO_2 storage is fixed for the life of the investment. Predicting future fuel costs when making decisions on new capacity is very difficult given the volatility of the future primary energy markets, particularly if demand continues to grow at the current pace and new fossil fuel sources become scarcer and more expensive to exploit. The question of fuel diversity may become paramount in choosing the fuel for new capacity.

The use of hydrogen as a future transportation fuel will enable fossil fuels to be efficiently converted to hydrogen in large centrally located plants with capture of carbon dioxide. The generation of hydrogen from fossil fuels is a well established technology which is capable, now, of meeting all possible future requirements. Research will concentrate on improvements in equipment and efficiency to reduce hydrogen generation costs. The main research efforts will concentrate on the hydrogen engine technology, using fuel cells and electrical drive systems, and advanced internal combustion engines. Very high efficiencies are possible. Currently, the UK is not contributing significantly to this new research area, which requires very good collaboration between industry and academia. We propose that Government strives to set this objective as one of the primary goals for our future UK research efforts. There are also challenges in the requirements for an efficient hydrogen supply system, using pipelines, delivery as liquid hydrogen or as high pressure compressed gas. There is also the need for further development of storage systems in the vehicle. Again, collaborative programmes are required.

2.4 *CO_2 Storage*

The UK is very fortunate in having the North Sea oil and gas fields as ideal storage sites for CO_2. The first choice for disposal of CO_2 offshore would be to use the CO_2 for tertiary oil recovery. A recently announced plan for CO_2 enhanced oil recovery in the Miller field envisages a recovery of an extra 40 million barrels of oil over a 20 year period by injecting about 1.25 million tonnes/year of CO_2 into the field. This equates to about 1.6 barrels of oil per tonne of CO_2 injected. Recent statements from oil industry sources suggest that current investment plans are based on an oil price of about $40/barrel in evaluations—a price which should ensure a positive value for high pressure pure CO_2 delivered to an offshore oil field. To ensure that this technique is widely used, the Government should consider review of the tax treatment for oil produced by tertiary means using CO_2 enhanced oil recovery techniques. There are four major benefits to the UK from CO_2 EOR: firstly, the life of North Sea oil fields is extended; secondly, it ensures we have a very positive and continuing saving in our import bill; thirdly, even with concessions, the Treasury will secure a large amount of future tax; and fourthly, the very large cost of decommissioning old oil platforms in the North Sea, part of which must be paid for by the Government, will be deferred for a considerable period.

The Government should consider supporting the construction of a CO_2 pipeline grid connecting large power stations in the UK to the North Sea oil fields.

The technology required for pipeline transportation of CO_2 and its injection into oil fields for EOR is well understood and has been practised in the US for decades. Currently, about 50 million tonnes/year of CO_2 is injected for EOR. It would appear that many of the North Sea oil fields could produce additional oil using CO_2 EOR. The capacity of the North Sea reservoirs is sufficient to store all fossil fuel derived CO_2 for over 100 years and there are also saline aquifiers which could be used for storage. Of great significance to the use of CO_2 EOR in the North Sea are the recent developments in directional drilling techniques, which will greatly facilitate the injection of CO_2 into the ideal location in a field and the rapid build-up in production of additional oil which will result.

3. The IPCC Report on CCS

The Directorate of the International Programme on Climate Control, together with a group of authors who are world experts in their various fields, has produced a major report on Carbon Dioxide Capture and Storage, which will be launched at the forthcoming Montreal Conference on Climate Control. This report gives a complete and up-to-date summary of the current status of the technology, the legal position and projected economics of carbon dioxide capture and storage based on an analysis of all available published data in the world. It is the document which the Committee should use when they consider current technology and economics. It also contains valuable projections of the likely direction for future technology developments.

This report can be used to assess the technical viability of CCS as a carbon abatement technology for the UK. The summaries which have been produced as part of the report should be particularly useful to the Committee members.

4. The Viability of CCS as a Carbon Abatement Technology for the UK

4.1 *The Current State of R & D and the Deployment of CCS Technologies*

CO_2 capture from fossil fuels uses one of the following technologies.

Post combustion CO_2 capture

The waste gases from fossil fuel combustion are treated to remove CO_2 before being discharged to atmosphere. The best means for CO_2 separation is the use of an amine scrubbing fluid, which reacts with the CO_2. The CO_2 is separated from the amine using a steam heated regeneration step and the amine is recirculated back to the scrubbing tower. Equipment sizes are very large and the steam consumption for regeneration is also large, affecting power station efficiency. In addition, the amines are prone to attack by other impurities in the flue gas, such as SO_2 and NOx, producing solid salts which must be removed and treated. This technique is well established for CO_2 removal in hydrogen production systems and has been used on power station flue gases on a small scale.

Scale-up studies and costing have been carried out. The technique could be deployed now on a large power station using existing technology. Research has been on-going for decades to obtain better amine formulations and improve equipment design and performance. Breakthroughs in technology are unlikely, but some future cost reductions are possible.

Precombustion CO_2 Capture

The fossil fuel is converted to hydrogen and carbon dioxide in a high pressure reaction with oxygen or with steam and oxygen or with steam plus external heating. Catalysts are used to enhance reaction rates. The CO_2 is separated from the gas mixture using liquid phase scrubbing with a chemical absorbent such as an amine or a physical absorbent such as cold methanol. Other methods of CO_2 separation used include a solid adsorbent in a multi-bed cyclic process or, less commonly, by using membranes.

The process of large scale hydrogen manufacture from fossil fuels is the most highly developed method available for CO_2 capture. It has been practised on a very large scale for decades, producing hydrogen for ammonia and methanol and for hydrotreating in the petroleum refining industry. Future research will involve new catalysts, new reactor designs, improved CO_2 separation systems and better process integration. The system can be used for any primary fossil fuel or for waste fuels such as petroleum coke or bitumen, or for biomass.

The largest natural gas based systems are currently being commissioned for conversion of natural gas to synthesis gas (hydrogen plus carbon monoxide) which is then converted to liquid transportation fuel using the Fischer-Tropsch process. Plants are being constructed in Qatar and Nigeria using remote gas deposits. This size of plant could produce hydrogen for large (300MW plus) power stations. The hydrogen would be available as a carbon free fuel for use in a such gas turbine combined cycle electricity generation systems or it could be used as a transportation fuel.

Coal gasification with CO_2 removal producing pure hydrogen has been demonstrated on a large scale and can be implemented now for new power stations. H_2 from coal as a transport fuel would also break the monopoly position of oil.

Oxyfuel Combustion

As its name implies, this technique involves the combustion of a fossil fuel with pure oxygen. The combustion temperature is moderated by either recycling flue gas or by adding a diluent such as steam or water to the gases in the burner. Current studies on oxyfuel systems mostly relate to coal fired pulverised fuel power stations. The technology is ideal for conversion of existing coal fired power stations to CO_2 capture. It competes with the amine based post combustion capture option. At Air Products we have devoted significant efforts to study this technology. We believe it will have very significant cost and operating advantages compared to amine based flue gas scrubbing. This should become apparent with current studies commissioned by the DTI on retrofitting UK power stations such as Ratcliffe and Drax and by the DTI and the Canadian Clean Power Consortium on a new build 400MW coal fired station in Canada. Both these studies will include both oxyfuel and amine based systems for comparison. The oxyfuel system has not been demonstrated at any real scale except in lab scale tests. These have concentrated mainly on burner performance. The oxygen production, although very large, uses proven technology at the scale required for a 500MW boiler. The burner design would require testing on existing test rigs at large scale (such as the Mitsui-Babcock testing facility at Renfrew).

We believe it is entirely feasible, using current technology to retrofit a 500MW boiler such as one of the Ratcliffe boilers. The grouping of Mitsui-Babcock, Alstom, E.On and Air Products would be capable of executing a retrofit contract which would include: a Mitsui-Babcock advanced supercritical steam boiler rebuild; a modified steam turbine system designed for the new supercritical steam conditions and supplied by Alstom; a new cryogenic oxygen plant and a combined CO_2 compressor and CO_2 purification system supplied by Air Products. The combination of a boiler/steam turbine upgrade plus the oxyfuel conversion would ensure CO_2 capture and delivery to a pipeline system at high pressure with only a very small reduction in overall station efficiency.

There is a need for further R & D on oxy-fuel systems, particularly covering the effects of CO_2 rich gas streams containing increased levels of SO_2 on corrosion, the problems of sulphur dioxide and nitrogen oxide removal and burner design. Future developments in oxygen production using high temperature ceramic membranes will significantly reduce CO_2 capture costs and make oxyfuel a clear winner for low cost CO_2 capture from coal fired power stations. This technique of oxygen production is in the pilot plant stage in the US in a programme led by Air Products. There may be opportunities for demonstration in Europe in the future. A 30MW oxyfuel boiler demonstration is currently being constructed by Vattenfall in Germany and another 30MW test is planned in Australia. A 500 MW boiler conversion in the UK would produce about 3.5 million tonnes/year of CO_2 and would need to be linked to a CO_2 EOR project in the North Sea.

There is significant scope for further efficiency improvements and capital cost reduction using oxyfuel systems in coal-fired pulverised fuel ("PF") power stations. Air Products has been developing technology which aims to raises the overall efficiency of the system with CO_2 capture to above 40% compared to the Ratcliffe current efficiency of about 38% without CO_2 capture. These developments mean that the oxyfuel system is capable of giving about the same overall cost of electricity generation as the IGCC system now and that further developments will continue to ensure its competitive position in the future. It could be a system with huge export potential, particularly to China, which is installing a very large amount of coal fired electrical generation capacity, based on conventional PF coal fired power stations.

There is one other area of oxyfuel technology which must be mentioned as a route to low cost, high efficiency power production with CO_2 capture. It is the direct combustion of a gaseous fuel with pure oxygen and preheated water at very high pressures to supply ultra high temperature, high pressure steam plus CO_2 directly from a compact burner with no requirement for a boiler. The steam/CO_2 mixture would be expanded in turbines producing electrical power with pure CO_2 produced from the steam condenser. Efficiencies of over 50% are possible, with low capital cost. This is another area which could be developed in the UK.

4.2 *Deployment of CO_2 Capture Technologies*

The three major CO_2 capture technologies could all be deployed now in a large scale demonstration using current technology. R & D should be planned for cost reduction and other improvements in the construction of follow-on facilities. CO_2 capture does not require any R & D period before its first large scale implementation. The first plants require good project planning based on careful preliminary design and evaluation in order to control overall project costs and performance.

4.3 *Costs*

The likely costs of CO_2 capture and storage have been carefully analysed based on published information and they are presented in the IPCC report on CO_2 capture and storage, which is currently in the hands of the Government and will be published in December 2005 following the Montreal conference.

4.4. *Geophysical Feasibility*

We are not qualified to comment on this area which is dealt with at length in the IPCC report.

4.5 *Other Obstacles or Constraints*

There must be sufficient incentives for the investments which must be made to introduce CCS for fossil fuelled energy systems. The incentives will be required to be assured for the life of the investments.

We would urge that CCS and nuclear be competitively evaluated on exactly the same basis as renewable energy in terms of life-cycle carbon abatement potential and overall cost of electricity produced. It would be a distortion if there were to be economically and environmentally unjustifiable subsidies for renewables which have no inherent moral superiority over, for example, fossil-fuel-based systems.

There is clearly a necessity to inform the general public of the issues involved. Pressure groups clearly have their place but their views should be balanced by dissemination of information, and informed opinion, based on objective evaluation of the economic, scientific and engineering realities pertinent to the debate.

5. The Government's Role in Funding CCS R & D with Incentives for Technology Transfer and Industrial R & D

The role of the UK Government in funding issues should be seen in the context of funding provided by the European Union. We must be aware of the fact that CCS technology and implementation is a global issue and that although the UK has some special characteristics, these are minor in the context of overall development of the technology. The major source of potential funding for the UK programme could be made available under the EU FP-7 programme. To attract this funding, it is necessary for all interested UK bodies, industrial technology and equipment suppliers, power companies, oil companies, natural gas suppliers, motor companies, universities and any other institutions or organisations to link with groups in other EU countries to form the necessary project or research focused interest which can be the basis for an application for funding under FP-7. This process of building a group focused on a relevant topic is the only way in which funds can be readily obtained from the EU. The opportunity also exists now to influence the level of overall funding which will be allocated to CCS topics in FP-7 and also to influence the guidelines setting out the objectives of FP-7 in the CCS area.

Our links with programmes on CCS in the US and Australia, in particular, through international organisations and treaties may allow us to participate in a minor role in important research. Of particular interest, in this context is the US FUTUREGEN programme on high efficiency power generation, using coal fuelled oxygen based gasification with a combined cycle gas turbine system. The CO_2 will be removed and used for enhanced oil recovery. This programme targets a completed demonstration plant by 2012. It might be considered ill-judged to to duplicate this work by funding IGCC coal-based power stations in the UK. We could gain much by joining the FUTUREGEN programme as a partial funder of the work in return for the research and design data. We, the UK, could also provide some of the technology and possibly even some of the equipment—and we might also obtain some of the associated research contracts. We should consider carefully before supporting the building of expensive IGCC systems in the UK based currently known technology.

Our strength lies in our knowledge of oxyfuel and amine based technology for CO_2 capture applied to PF coal fired power stations. We also have good indigenous technology in hydrogen production on a very large scale. These, together with our ability to demonstrate CCS as a complete system with valuable benefits from CO_2-based EOR, should form the basis for our research contribution. The Government role could be to co-ordinate our efforts in these three areas and help set up the combined industrial/commercial/academic groups needed to secure large scale EU funding. One important programme might be a full scale demonstration of CCS with CO_2-based EOR based on a retrofit programme on a 500MW set at Ratcliffe power station, for example. This would probably cost about $750 million. This is the level of funding required to implement just one of the new technologies under consideration. Given the right incentives, industry and the power companies will provide funds but launching new technology like this requires a grant of probably 50% of the cost for the first installation. If the UK were to take a lead in large scale CCS demonstration there is a good chance that funding could be obtained from the US and possibly also China. Only by globalising our common efforts in this way will we achieve rapid progress, worldwide, in implementing CCS technology.

I would also like to draw to the Committee's attention the formation of a new major activity soon to be launched by the Imperial College of Science and Technology, London, called "The Future Energy Lab". Imperial College is, in my opinion, our major UK technological Institute. It can act as a very powerful focus for future research and development in the CCS area. It would have the ability to co-ordinate R & D in this area in the UK and act in an overall management role with participation from UK industry, commerce and other Universities, etc. It also has established links with overseas institutions particularly in the US.

30 September 2005

Memorandum submitted by Airtricity

1. Introduction

The Environmental Audit Committee has invited organisations and members of the public to submit memoranda setting out their views on this inquiry. This submission concentrates on the likely costs, scale and timescales for developing offshore wind, and suggests policy changes that the UK government could implement to promote the timely development and construction of offshore wind. It is structured as follows:

- Section 2 briefly discusses the requirements for the continued expansion of onshore wind.
- Section 3 sets out views on the required policy framework for offshore wind.
- Section 4 notes some general issues and concerns with respect to new nuclear build.
- Section 5 draws conclusions on some of the specific questions raised by the inquiry.

2. Onshore Wind

The Energy White Paper[1] of February 2003 set out a vision in which renewables and energy efficiency would play a key role in UK energy policy and secure the gap left by the decline of current nuclear and coal generating capacity. It is against this background that the renewables sector in general, and the wind industry in particular, has been evaluating its investment plans and project development strategies.

The stability of the current renewables framework has enabled onshore wind to make a major contribution towards government targets, benefit from technology and cost improvements, and develop an overall infrastructure to support continued development.

Uncertainty regarding the Government's intentions towards new nuclear capacity has the potential to damage further investment in renewables and energy efficiency. Equally, potential changes to the current government and regulatory frameworks to facilitate new nuclear build need to be fully thought through, with regard to both their direct and indirect impact on the renewables sector. Onshore wind is a success story for the UK and has delivered significant benefits. Given the appropriate framework, it can deliver much more. Although not a completely mature sector, onshore wind experience is such that the government is well informed with regard to the likely path of cost curves for the industry, as it develops further. A potential key concern for current and future development will be the coordination, efficiency and timeliness of the overall planning process. Consideration should be given to reviewing the framework applicable to wind project planning, such that each development only has to address truly significant, specific issues. If planning develops on a case-by-case basis, where no "case law" is laid down, and all issues are reopened each time, it is highly likely that the pace of onshore wind resource development will slow significantly.

[1] Energy White Paper: Our energy future—creating a low carbon economy, DTI, February 2003.

3. Offshore Wind

(a) *The cost of offshore wind*

The cost of offshore wind varies from project to project depending on project specifics including water depth, seabed conditions, metocean conditions, distance to shore, and connection point to the onshore grid.

The recent trend has been of increasing costs due to:

— higher world steel prices;
— greater knowledge of contractors (who may have under-priced early projects);
— the more recent Round 2 projects being further offshore and in greater water depths; and
— pressure on turbine supply capacity pushing turbine prices up.

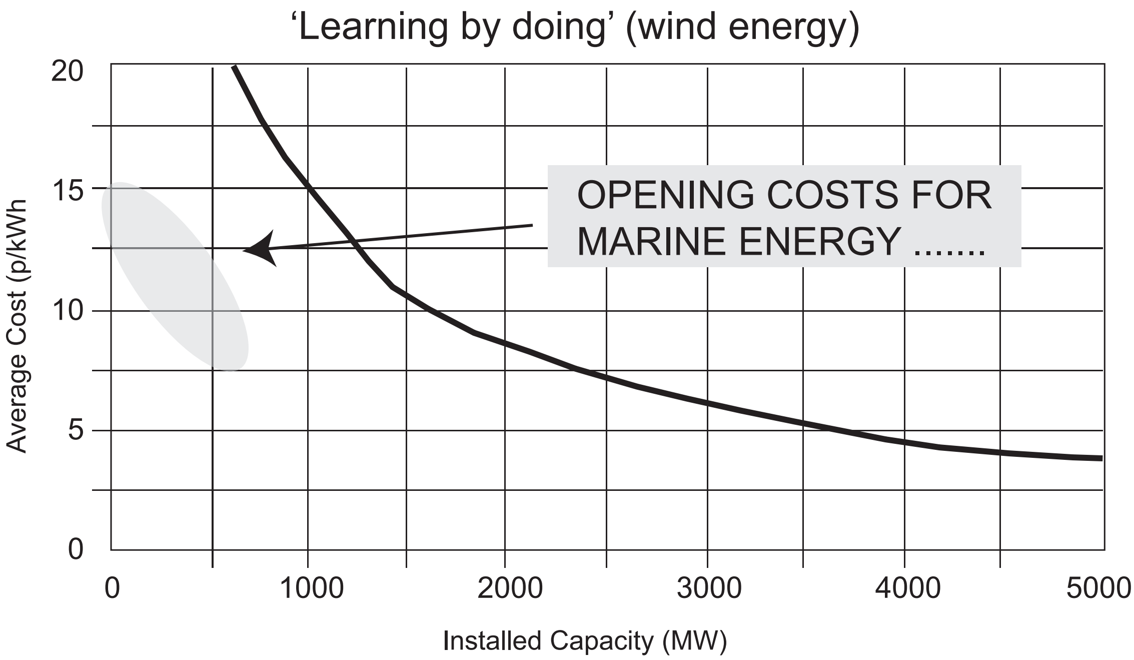
Whilst these high prices may persist in the short-term, in the medium to longer term the trend will reverse:

— economies of scale will enable the same capacity to be built with fewer offshore foundations;
— improved turbine design will lead to higher efficiencies at lower cost;
— experience will lead to lower costs per installed megawatt; and
— the capacity and experience of the supply chain will be developed.

As well as lower costs in the medium to longer term, project capacity factors will also increase due to higher wind resource further offshore and improved turbine design.

Current costs are in the region of £1.2–£1.8 million/MW installed capacity, with capacity factors in the region of 35–40%. A 35% capacity factor with a capital cost of £1.3 million/MW will produce energy at a cost of approximately 8p/kWh. This compares with onshore wind projects that are now producing energy at a cost of 4–5p/kWh.

Currently there is just over 600MW of installed offshore wind capacity within the EU[2] with no offshore wind projects yet commissioned outside of the EU. As more offshore capacity is built, costs will reduce due to the factors listed above. The experience of cost reduction from onshore wind is shown in the diagram below (offshore wind is at the low end of the range of cost levels for marine energy)[3]:



If offshore wind can benefit from a similar rate of cost reduction as that experienced by onshore wind, it should become competitive with onshore wind (and conventional forms of generation) within the medium term.

To date, all offshore wind projects in the UK have been balance sheet financed. Many, if not all of the Round 2 projects, because of their scale and associated capital requirements, will be project financed. Project financing will require a certain long-term revenue stream to underpin the debt in each project. This long-term revenue stream will usually be obtained through long-term off-take agreements with one of the (currently) six

[2] Offshore wind: implementing a new powerhouse for Europe, Greenpeace, 2005.

[3] Harnessing Scotland's Marine Energy Potential, Forum for Renewable Energy Development in Scotland, July 2004.

major electricity suppliers in the UK. However, these suppliers will only be willing to enter into these agreements if there is certainty with respect to the renewables market into the longer-term. The current structure of the renewables obligation does not provide sufficient longer term certainty. The percentage obligation only rises to 15.4% by 2015–16. This may or may not be reviewed. When coupled with the uncertainty surrounding what, if any, arrangements will be put in place at the end of the obligation itself, the level of uncertainty becomes significant.

(b) *The potential scale of offshore wind*

Round 1 projects were restricted to 30 turbines and the two projects constructed to date (North Hoyle and Scroby Sands) are each 60MW projects. Two further projects are under construction (Barrow and Kentish Flats), and these will each be 90MW projects.

The 15 Round 2 projects awarded in December 2003 range from 64MW to 1,200MW, with 10 of the projects between 240MW and 500MW. Together they total over 7GW. However, this is only a small fraction of the total offshore wind resource available within UK waters. The DTI's consultation on offshore wind in 2002[4] noted that within water depths of 5 metres to 30 metres there is potentially 327GW of offshore wind capacity in UK waters, with a further 592GW in water depths 30 metres to 50 metres. This translates into enough capacity, at a 40% capacity factor, to supply the UK's total electricity demand 10 times over.

Whilst it will not be possible, for environmental and other reasons, to develop all of this potential resource, there will remain a vast developable offshore wind resource capable of contributing significantly to the UK's and Europe's longer-term emissions targets.

It is important to note that whilst many other European countries are developing an offshore wind industry (notably Denmark, Germany and the Netherlands), the UK holds approximately 50% of the offshore wind resource of all the EU-15 countries. The UK performance is therefore the key factor in determining whether the EU as a whole will meet its emissions targets.

(c) *Timescales to build*

From initial screening to project commissioning, the time to build an offshore wind project is typically in the region of 5–6 years. This comprises:

- 6 to 12 months site selection and award;
- 18 to 24 months environmental and site surveys and consent application;
- 12 to 18 months engineering, procurement, financing, receipt of consent; and
- 18 to 24 months construction and commissioning.

Given the award of the Round 2 sites at the end of 2003, the earliest conceivable commissioning date for a Round 2 project would be end of 2007, in reality it is unlikely that any project will be commissioned prior to mid-2008.

However, many Round 2 projects are currently experiencing delays:

- Onshore grid reinforcement is required to connect many of the Round 2 projects and this work, as scheduled by the National Grid Company (NGC) will take longer than the construction of the offshore wind projects themselves. In addition, NGC requires project developers to provide financial security for these works, which many if not all will be unwilling to do, prior to receipt of consent for the wind project and probably also its financial close. This will particularly affect those projects in the Northwest and Wash Strategic Environmental Assessment areas.
- Whilst sites were initially awarded at end 2003, there has been a process to allow developers to amend their site boundaries, and in some instances wholesale site relocation, in the light of further information arising from environmental and site surveys. This will have delayed many projects.
- Several projects have received holding objections from statutory consultees whilst solutions are found to potential conflicts with other users of the sea or air, or from environmental organizations. Finding solutions acceptable to all parties has proven to be drawn out and may have delayed many projects.

In addition, the following issues may delay projects further:

- All 15 projects were awarded sites at the same time, and therefore many of them are likely to be submitting their consent applications in late 2005/early 2006. This could be problematic for the consenting authorities and its consultees, if not properly resourced and could lead to delays in receipt of consents.
- Whilst uncertainty with project economics may not have delayed projects to date, if the funding gap described below is not resolved by mid-2006, it is likely to impact on the ability of projects to obtain suitable financing and therefore to result in delays.

[4] Future Offshore: A strategic Framework for the offshore wind industry, DTI, November 2002.

— With respect to the regulation of the offshore grid, a clear regulatory framework is required to avoid delays.

Given the potential for delay in so many areas, it is likely that a significant number of the Round 2 projects will not be commissioned prior to 2011–12.

(d) *Policy changes required to deliver offshore wind*

(i) Project economics

Airtricity generally supports the position promoted by the British Wind Energy Association (BWEA) with respect to the need for additional financial support for offshore wind. The BWEA is seeking an additional £300k–£400k/MW in support through one or more of the following mechanisms:

— Mitigating the offshore grid costs and providing fair and equal treatment with the onshore grid.

— A capital grants program for Round 2.

— Enhanced capital allowances (this is the least preferred mechanism as it disproportionately benefits the incumbent large integrated utilities over the new renewables companies).

Providing this additional support in the short-term should enable sufficient projects to proceed, and therefore initiate the beneficial process of learning efficiencies noted above. In addition the BWEA is seeking greater certainty with respect to the renewables market post 2015–16. This could be achieved either by increasing the obligation post 2015 (to say 20.4% by 2020–21) or by guaranteeing a margin post 2015–16 between the renewables obligation and renewables supplied to avoid the cliff-edge.

Policy mechanisms should be implemented to provide economic support for the offshore wind industry in the short term and certainty regarding the developmental framework, in the longer term.

(ii) Long-term industry

The cost reductions described above will come from the learning obtained during the growth of the industry, economies of scale and the development of the industry supply chain. Currently this is being hampered by the stop-start nature of the framework within which the industry is developing, whereby leases for offshore wind projects have only been awarded on two occasions, in 1999 and 2003, and with no firm plans for a further award round. This will mean that some developers, having successfully developed a site, will have no further sites available for the foreseeable future and are likely to transfer capital and resources to other markets. With regard to the supply chain, installation contractors, turbine and cable manufacturers and the rest of the service providers are unlikely to invest the required capital to facilitate either timely development of offshore wind resources or, achievement of the economies of scale/learning necessary to move the industry to a more economic footing, if they do not have confidence in either the developmental framework for the industry, or the underlying economics.

As noted above, the UK has approximately 50% of the EU-15's offshore wind resource and will therefore be a major influence in determining the size of the offshore wind industry in Europe.

To provide certainty to the whole offshore wind industry, necessary for the required investment in people and equipment to obtain the potential cost reductions, the UK government should institute an on-going process to award leases to offshore wind developers. The appropriate frequency of such awards will need further review, as to whether an annual or longer interval is appropriate.

(iii) Grid reinforcements

The delays to Round 2 projects caused by the financial risks imposed on developers could be solved in a variety of ways, including:

— Incentives could be put on grid companies to complete their works in shorter timescales (to ensure consistency in timescales with those of construction and commissioning of the offshore wind farm).

— Grid companies could have an obligation to connect projects prior to full completion of reinforcements, where this is technically possible, and to manage any congestion issues that arise.

— Grid companies could assume the risk of stranded assets themselves by commencing work without financial security from the offshore wind projects.

However, it should be noted that the mechanism of requiring developers to provide financial security for grid reinforcements is long established and the problems are only now arising due to the compressed timetable between offshore site award (and hence application for connection) and the required connection dates (by 2010–11). If the process were amended to allow more time between site award and grid connection, then risks could be managed more effectively.

Implementing further award rounds soon (and on a rolling basis) would prevent grid reinforcement being a delaying factor in meeting the 2015–16 target.

(iv) Offshore grid

As technology and installation methods improve, sites further offshore will become economic and there will consequently be a need to extend the grid further offshore. This grid will need to be financed, constructed, operated and regulated. Airtricity welcomes the recent DTI consultation on the regulation of offshore transmission and supports a regulated (licensed price control approach) to the development of this grid. However, at present grid companies appear to be doing little to address the issues involved in the planning and development of the grid offshore and it is instead being left to developers to plan their own connections on a (potentially suboptimal) piecemeal basis.

It is important that a single party or consortium of parties is given the responsibility for the offshore grid in a region to ensure that it is planned, constructed and operated at least cost, and to maximize the potential benefits of interconnections between offshore projects, and indeed between countries.

Offshore transmission licencees should be appointed with responsibility for developing and implementing plans for the offshore grid in specific regions.

(e) *New Nuclear Build—Issues and Concerns*

The Committee has requested submissions covering a very wide remit. Detailed information concerning the costs, benefits and timescales associated with new nuclear build will be provided from many sources including those with specific recognized expertise in nuclear issues—we are not intending to make reference to specific data with regard to new nuclear build in our submission.

However, we wish to emphasize the following high-level issues:

- The timescales associated with nuclear plant build—the historic record of significant delays.
- The uncertainty with regard to costs of any nuclear project—the record of cost overrun both in design and operation.
- The need to factor in technology risk—a new generation of nuclear build would use largely unproven technology—experience shows that this has a high risk of underperformance, cost escalation or both.
- The need to properly account for full lifetime costs in any estimation of prospective nuclear projects, ranging from the environmental costs of uranium ore extraction, refinement, through operation, plant decommissioning and long-term waste management.

And the following concerns:

- Nuclear capacity is supposedly characterized as a high capital cost, low operating cost option. The minimum incremental capacity addition (plant size) is usually large (approximately 500–1,000MW). The technology requires virtually continuous (baseload) operation for reasons associated with the physics of nuclear generation. High, sustained output is also necessary to maximise economic returns. The level of incremental capital investment is therefore large. This limits the number of individual market participants who are capable of financing new nuclear build. Given that it is highly unlikely that this would not be their technology of choice for new plant build under present market structures and mechanisms, it is likely that significant changes would be required to market and regulatory structures, market mechanisms and support mechanisms (including any levies, quotas or obligations). This would increase regulatory, government and market risk for the non-nuclear components of the energy mix and could deter investment in renewable projects.
- When the level of nuclear plant on a system increases, other flexible plant has to regulate in order to ensure that supply and demand are dynamically matched. The flexible plant, which is displaced by nuclear, is exactly the same plant required to balance the system when a reasonable level of wind penetration is achieved. Thus nuclear plant can, in certain circumstances, act as a cap on the level of wind that a system can accept.

5. Specific Issues Identified by the Committee

(a) *The main investment options for electricity generating capacity*

Investment options are driven by the needs of the market in the UK. Companies currently in the market, and those seeking to enter, assess the most effective way for them to meet the demands of their customers, given the relevant regulatory, environmental and market structures and the overall objectives of Government policy, which in turn shapes the above. It should therefore be a decision by the market, within an appropriate and consistent framework of incentives, to decide upon the options for capacity. Renewables form a key part of the Government's strategy to address climate change issues. Renewable generation now contributes a significant proportion to the UK generation mix and can contribute further. This has been achieved within the context of a stable and consistent set of policies. Any form of prescription or intervention with regard to generation capacity choice is likely increase the perception of market risk, result in inefficient investment decisions and lead to undesired outcomes.

(b) *The attitude of financial institutions to investment in different forms of generation*

Financial institutions are likely to base their attitude to investment in generation on the following general principles:

- Security and stability of the counterparty to whom any loan is made.
- Ability of the counterparty to redeem the loan regardless of the specific project status (financial strength).
- Technology risk.
- Specific project risk (including market/merchant risk elements).
- Regulatory/government risk.
- Liquidity/tradability of the loan risk on the financial markets.

(c) *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

The impact would depend on exactly how the programme was implemented. There are many variables that would need to be considered. The key driver would be to ensure that the net impact on renewables and energy efficiency was at worst neutral and at best positive. If a private company, with no government incentives or subsidy, initiated the major programme of nuclear investment they would bear the total risks (and any rewards) of the programme. Any government facilitation, intervention or subsidy in favour of new nuclear build would require the place of renewables and energy efficiency in the overall energy portfolio to be properly reviewed and equivalent additional support measures to be put in place in order to ensure a level playing field in the energy arena.

(d) *How does the nuclear option compare with a major programme of investment in renewables, micro generation, and energy efficiency?*

Renewables, micro generation and energy efficiency have many benefits over the nuclear option:

- Renewables can deliver reliably.
- Renewables do not require fuel importation and as such increase security of supply.
- Renewables are not dependent on world fuel prices and therefore provide a more stable price environment.
- Wind is a proven technology.
- The minimum incremental capacity addition is an order of magnitude smaller than nuclear.
- Energy efficiency is a lower cost option than new nuclear build.
- Micro generation could significantly improve overall energy efficiency—it requires the right incentives to be put in place.

20 September 2005

Memorandum submitted by the Association for the Conservation of Energy

The Association for the Conservation of Energy welcomes the opportunity to respond to the Committee's inquiry. In particular we will examine the proposition stated in the opening paragraph: this considers whether investments in a "step change in energy efficiency" would be a more cost-effective means of obtaining the objectives set out in the Energy White Paper.

EXECUTIVE SUMMARY

1. Energy efficiency and energy saving are more cost-effective than the generation of electricity by nuclear power. They must therefore be undertaken first.

2. However, accepting that there will still be a need to generate some electricity, investment in microgeneration is more cost-effective than investment in new nuclear power stations.

3. Taken together, these two cost-effective sources for investment can eliminate the need for further investment in nuclear power stations—on cost grounds alone (ie without even considering such issues as waste, insurance, decommissioning, terrorism and other environmental considerations).

It follows therefore that investing in new nuclear power stations is not a cost-effective option.

Part 1—Energy Efficiency and Energy Saving

The 2003 Energy White Paper began by emphasising that "Energy Efficiency is likely to be the cheapest and safest way of addressing all four [energy policy] objectives"[5] and went on to describe energy efficiency as the " cheapest, cleanest and safest way of addressing our energy policy objectives."[6]

This echoes what the Energy Select Committee said over twenty years ago: "It is our considered opinion that there are now many conservation measures which are so much more cost effective than most energy supply investment."[7]

This was also the view of the Royal Commission on Environmental Pollution in 2000: "There is a strong economic argument in favour of raising energy efficiency."[8]

Yet we are still having to make the same point.

In 1982 the House of Commons Select Committee on Energy stated that they were "dismayed" to find that the Government had "no clear idea whether investing around £1,300 million in a single nuclear plant is as cost effective as spending a similar sum to promote energy conservation."[9]

Subsequently a considerable amount of work has been undertaken to demonstrate that investment in such a plant would not be as cost-effective. Indeed this was the conclusion of the Energy White Paper—hence its description of energy efficiency as the "cheapest" option.

In addition, official sources (see below) demonstrate clearly that Government-backed programmes designed to deliver energy efficiency have done so at a lower cost per kilowatt hour saved than any putative nuclear power investment. There are considerable extra potential electricity savings which could readily be achieved by purposeful programmes, which have been estimated to be again at substantially lower costs than prospective nuclear power stations.

The most recent price given by the Government for the anticipated cost of a new nuclear power station assumes that new build current designs could achieve costs of 3.9p/kWh.[10]

This should be contrasted with the costs which the National Audit Office established as being achieved via the electricity-only saving scheme for residential customers, run by the 14 local electricity companies in Britain. In his report, the Comptroller and Auditor General concluded that the scheme in question (called the Electricity Efficiency Standards of Performance Scheme) was saving electricity—and hence customers' money—at a cost of 1.8p per kWh.[11]

The figures provided for energy efficiency programmes incorporate all relevant transaction costs. In contrast, the conventional means of stating the cost of a nuclear power station excludes many externalities, including land take, insurance, decommissioning and other civil nuclear liabilities. The Nuclear Decommissioning Agency put the total figure for decommissioning existing power stations as £56 billion—or £1,000 for each UK citizen already.[12]

As well as being considerably cheaper for the electricity companies than providing new sources of power, the NAO also noted that "customers benefit from warmer homes, reduced fuel bills, and assisting with the reduction of environmentally damaging emissions."

On 8 December 2003, the European Commission published its draft directive on "Energy End Use Efficiency and Energy Services".[13] Adoption of this directive during 2005—"to encourage good practice in energy efficiency"—is a "priority" of the present UK EU Presidency.

Para 1.1 of the directive states that "it is estimated today that the average cost in Member States of saving a unit of electricity in the domestic sector is around 2.6 euro cents/kWh, compared to the average off-peak price for delivered electricity of 3.9 euro cents/kWh and on-peak price of 10.2 euro cents/kWh."

The directive goes on to require energy suppliers to undertake direct investment comparisons between supply and demand options. Furthermore, by way of explicit acknowledgment of the key role that energy saving has to play, the directive also introduces mandatory energy saving targets.

Much of the evidence that will be presented to the Committee as part of its Inquiry will be restricted to considering exclusively the relative cost-effectiveness of different supply options. However, such an exclusive consideration of "energy supply" evinces a lamentable failure to understand the true nature of the

5 DTI (2003) *Energy White Paper: Our Energy Future* Page 11, paragraph 1.19.

6 DTI (2003) *Energy White Paper: Our Energy Future* Page 32, paragraph 3.2.

7 House of Commons Select Committee on Energy (1982), *5th Report, Energy Conservation in Buildings, (HC401-1)* Page xxxvii, paragraph 66.

8 Royal Commission on Environmental Pollution, 22nd report 2000, page 86, para 6.9.

9 House of Commons Select Committee on Energy (1982), *5th Report, Energy Conservation in Buildings, (HC401-1)* Page xxxvi, paragraph 66.

10 Cabinet Office Performance and Innovation Unit (2001), *Working Paper on Energy Systems in 2050*.

11 National Audit Office (31 July 1998).

12 Nuclear Decommissioning Agency (August 2005) *draft strategy*.

13 European Commission (2003) *Proposal for a Directive on the promotion of End-use efficiency and Energy Services* (COM(2003)739).

marketplace. No consumer has ever sought to buy a kilowatt-hour of electricity or gas or a litre of oil. What they are seeking are the services that these fuels offer: light, heat, and motive power. The critical issue has to be to ensure that these services are delivered at the lowest ecological, social and economic cost.

A report entitled *Renewable Energy*, published in 2004 by the National Audit Office, analysed the cost of various policies to reduce carbon emissions. The Energy Efficiency Commitment (EEC) emerged as the most cost efficient mechanism, followed by the Climate Change Levy.

The EEC scheme requires suppliers of gas and electricity services to achieve agreed terawatt hour (Twh) savings per year, via the installation of energy efficiency measures. Between 2002 and 2005, it saved 87 Twh, with the majority of the savings being of electricity (via installation of A rated appliances, compact fluorescent light bulbs, insulation in electrically heated homes). The Climate Change Levy increases fuel prices to non-domestic consumers, specifically to stimulate investments in energy efficiency measures.

The Government has calculated that the value of the benefit of reducing carbon dioxide emissions is worth between £10 and £40/tonne: Figure 1 demonstrates that installing energy efficiency measures via programmes like this is far more cost-effective than other carbon saving schemes.

Fig. 1 - Cost of different policies to reduce carbon dioxide emissions

Policy instrument	Policy objectives	Cost (£/tonne co_2)
Renewables Obligation	■ Climate change **Subsidiary:** ■ Energy security ■ New technologies ■ United Kingdom industry ■ Rural economy	70 - 140
Energy Efficiency Commitment	■ Climate change ■ Improve energy efficiency ■ Alleviate fuel poverty	Negative - 16
Climate Change Levy	■ Climate change ■ Improve energy efficiency	5 - 11
United Kingdom Emissions Trading Scheme	■ Climate change ■ First mover advantage for United Kingdom firms ■ Establish London as a trading centre	18
European Union Emissions Trading Scheme	■ Climate change ■ Improve energy efficiency	3 - 21

The definitive work on such direct economic comparisons between alternative investment options was undertaken by the Rocky Mountain Institute of Colorado. There, two analysts, Bill Keepin and Greg Kats, published what remains the definitive comparative study.[14] Below is a summary of their work.

They start by postulating that the world's nations have come to an unprecedented agreement. Over 40 years, all present and future uses of coal will be replaced by nuclear power. They make optimistic assumptions about speed of construction of new plant (just six years, not the 15 of Sizewell B). They also price each power station based on French experience, where multiple construction (plus state subsidies) delivered costs 40% of those experienced elsewhere in the OECD.

They followed International Energy Agency forecasts of projected world demand growth to 2025. Accordingly, one new nuclear power station has to be built every 2.4 days, at a cost of $525 billion each year. Consequently, there would be 18 times as many nuclear stations than at present.

But even so, greenhouse gas levels would continue to rise, because nuclear only provides electricity, accounting for one-third of fossil-fuel use—and ignores other greenhouse gases like the direct use of oil and natural gas.

[14] B Keepin & G Kats (1988) *Greenhouse Warning. Comparative Analysis of Nuclear and Efficient Abatement Strategies*, Energy Policy, Vol 15, No 6.

Of course, the scenario is completely unrealistic. Construction costs of nuclear power stations in the UK are always higher than projected. Even if the managerial capacity were available to construct so many plants so fast, the drain of that much capital into nuclear construction would slow, or even stop, the very economic growth that is assumed to require so much power in the first place. Debt levels in the Third World would double. And of course there would be an escalation of the established problems connected with nuclear power: intractable and dangerous wastes, evacuation planning, threats to public health, decommissioning, diversion of fissile materials into bombs, vulnerability to terrorism, and, not least, political unpopularity.

In contrast, Keepin and Kats argue there can be purposeful programmes, involving state-of-the art technologies designed to meet energy needs in the most efficient way possible. Changing every light bulb in America to cfls would close 40 large power plants, and save $10 billion a year. Building every office between now and 2050 following best practice would save the equivalent of 85 power plants and two Alaskan oil pipelines. Double the fleet efficiency of cars, and you cut carbon emissions proportionately. All of this can be done at minimally higher capital cost, but delivering far lower running costs.

Overall, Keepin and Kats conclude that a dollar (or a euro, or a £) spent on efficiency could displace nearly seven times as much carbon as a dollar spent on new nuclear stations.

Naturally electricity saving programmes concentrate upon realising the most cost-effective savings initially. Thus there might be concern that subsequent programmes might offer returns of diminishing cost-effectiveness. Such concerns would appear wholly unfounded, because they ignore both the potential for product improvements, and the economics of relative price effects. The real cost of, for instance, a compact fluorescent lightbulb is now several multiples lower than 15 years ago: this is due both to higher volumes providing economies of scale, and improved product performance. Such market transformation has occurred for many white and brown consumer goods, as well as with industrial motors and refrigeration.

The committee has received evidence previously from the Environmental Change Institute at Oxford University regarding their "40% house" concept.[15] We draw the committee's attention to this work amongst others, simply to demonstrate the enormous amount of untapped, yet cost-effective, electricity saving potential that remains in the residential sector alone.

The American academic who popularised the "negawatts" concept is Dr Amory Lovins.[16] In the context of this inquiry, the conclusion from his book "Natural Capitalism" is particularly worth revisiting:

"Nuclear advocates' last hope is that climate concerns will revitalise their option. Alas, they've overlooked opportunity cost—the impossibility of spending the same money on two different things at the same time.

If saving a kW-h costs (pessimistically) as much as three cents, and delivering a kW-h of new nuclear electricity costs (optimistically) as little as six cents, then the six cents spent for each new nuclear kW-h could instead have bought two kW-h worth of efficiency. The nuclear purchase therefore displaced one less KW-h of coalfired electricity than the same money could have done by buying the cheaper (efficiency) option instead.

That's why the order of economic priority must also be the order of environmental priority; why it's irrelevant whether nuclear power can beat coal power as long as any other option costs still less; and why nuclear power makes global warming worse."[17]

We believe that this shows conclusively that investing in energy efficiency and energy saving is the cheapest way of delivering both carbon dioxide reductions and maximising the use of energy supply. Thus, until all available energy saving and energy efficiency have been undertaken, we should not even consider investment in nuclear plant. Economically there is simply no case for it.

Part 2—Generation

But surely, it will be argued, even if this scenario is adopted as public policy, some electricity must be generated. Energy efficiency and saving cannot eliminate that need.

This is clearly true—but we consider that the emerging microgeneration industry has the potential to offer a more competitive alternative than new nuclear build. Some of this is directly observable even at today's, pre mass-production prices, but there are other, less tangible effects likely to be experienced which are explained below.

[15] University of Oxford Environmental Change Institute (2005) *Research Report 31: 40% House*.

[16] The Wall Street Journal named Dr Amory Lovins as one of 28 people worldwide "most likely to change the course of business". *Newsweek* called him "one of the Western world's most influential energy thinkers". As well as co-authoring *Natural Capitalism—the Next Industrial Revolution*, he has briefed 10 heads of state, held several visiting academic chairs, authored and co-authored 26 books and hundreds of papers and consulted for scores of industries and governments worldwide.

[17] A B Lovins, L H Lovins & Hawken (1999) *Natural Capitalism: The Next Industrial Revolution* James & James (Science Publishers) Ltd.

1. *Cost Comparisons*

British Energy has estimated the cost of building a further 11GW of nuclear capacity at £10 billion, or £833–£1,000 per kW—rather ambitious given that the last station to be built in the UK cost £3,000/kW, over three times as much. By comparison, microgeneration technologies start at around £500/kW of installed capacity.

A recent Green Alliance report[18] gives the cost of nuclear power delivered to grid as anything between 1 and 6p/kWh. Costs associated with transmission and distribution, metering and losses need to be added to this. These typically make up just under 40% of today's retail price of electricity, or around a further 3.5p/kWh. This places the cost of nuclear power, at the point of delivery to the customer, at anything up to 9p/kWh.

According to the Performance and Innovation Unit Energy Review, some forms of microgeneration are as cheap at today's manufacturing prices as 4p/kWh, falling to 2.5p/kWh once in mass production. The bulk of cost associated with transmission and distribution is avoided for microgeneration, because it generates at the point of demand.

2. *The Capital and Energy Markets*

Given the waste processing and decommissioning liabilities associated with nuclear plant, it is widely accepted that the private equity markets will not provide the capital needed for a programme of new build.

Given this, there would appear to be little choice other than for the taxpayer to fund a new build programme directly, or at least to act as a guarantor.

Acknowledging that around £10 billion would be required up-front for a new nuclear build programme, the Green Alliance report examines possible alternative uses for this money in the microgeneration sector:

- — micro-CHP—The price differential between a conventional boiler and a mCHP boiler is £500. If half of the 1.3 million boilers replaced every year were mCHP, 650,000 units could be installed per year at an additional cost of £325 million a year, or £6.5 billion for 13 million units over 20 years. Assuming a capacity of 1kW per unit, this would result in 13GW of capacity. In other words the same capacity would cost half as much, and this is before any cost reductions are factored in for mass production.
- — micro-wind—Once mass production is reached, micro-wind's capital costs would be similar to the £800–£1,000 per kW from nuclear, but it is important to remember that a substantial amount of grid-based investment would be avoided, as well as marginal costs associated with transmission and distribution losses.

A recent Mott MacDonald report for the DTI[19] estimated that 17GW of microgeneration capacity would result in £1.2 billion per annum of avoided costs elsewhere on the network. Scaling this to the 11GW of nuclear under review would suggest annual savings of £800 million per year if microgeneration were deployed instead of nuclear.

3. *Cultural effects*

There is a further, less tangible dimension to microgeneration as an alternative to nuclear. This is the cultural change likely to result from the widespread uptake of microgeneration.

Microgeneration can act as a catalyst for cultural change in the way consumers view their use of energy. A consumer who installs, for example, a micro-wind turbine experiences a daily reminder that they are "doing their bit", and sends a clear and visible signal to neighbours. The microCHP whose prominent display panel in a kitchen or hallway consistently informs the customer that they are generating their own power (and how much) will create interest with house visitors and within a family. Moreover, consumers who take up microgeneration are subsequently likely to alter their behaviour in other ways—and begin to realise just how efficient and effective the other energy efficiency measures referred to above are. They become more likely to insulate their home properly, turn off unwanted lights, perhaps even cut down on car journeys, and so on.

Although the committee's questions primarily relate to hard-and-fast cost comparisons, we believe that the committee should take these secondary effects into qualitative consideration. They might be difficult to quantify, but a cultural change of this nature is likely to prove critical in transforming the public's attitude to climate change and energy issues. This is certainly not the case for nuclear power.

20 September 2005

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[18] Green Alliance (June 2005), *Small or Atomic? Comparing the finances of nuclear and micro-generated energy.*

[19] Mott MacDonald report to DTI (September 2004), *System Integration of Additional Microgeneration.*

Memorandum submitted by the Association of Electricity Producers

The Association's members include large, medium and small generating businesses, representing between them virtually all of the generating technologies used in the UK and the majority of the UK's power production. Members operate in a competitive electricity market and they have a keen interest in its success—not just in delivering power at the best possible price, but in meeting environmental requirements and expectations in respect of security and reliability of supply.

The Association welcomes the opportunity to respond to the Environmental Audit Committee's inquiry.

The "Generation Gap"

The Association takes account of the findings of, for example, the Secretary of State for Trade and Industry's Annual Report to Parliament on Security of Gas and Electricity Supply in Great Britain, National Grid's Seven Year Statement and its Winter Outlook Report and the work of the Joint Energy Security of Supply Working Group ("JESS"). We do not address in closer detail the idea of a likely shortfall in electricity generating capacity because, through the operation of the wholesale electricity market, we expect new generating capacity to be brought on line to replace power stations that are taken out of service. The Committee should note that the industry wants to provide new generating capacity, but that the timing of new investment is influenced not only by fundamental market signals, but also by the way in which electricity companies judge political and regulatory risk. Today, such risks are particularly significant in the area of environmental policy.

The mix of generation technologies can be expected to change in the future. The schedule for phasing out nuclear power stations, for example, is a matter of public record, although it may be subject to amendment depending on the outcome of applications for life extensions for specific plant (eg the recent case of Dungeness B). The future for coal plant is less easy to forecast because it will depend partly on the way in which Government implements the Large Combustion Plant Directive (LCPD) from 2008; the generating industry has been waiting since November 2004 for the European Commission to comment on the Government's proposals for implementation of the LCPD. Plant that opts out of the LCPD can run for a maximum of 20,000 hours between 2008 and 2015, but must close after that. The future development of the climate change agenda at UK and EU level and in particular, uncertainty about the way in which Phase 2 of the European Union Emissions Trading Scheme (EUETS) is to be implemented, also have a major influence on companies' investment prospects.

Electricity demand appears to be growing at, typically, about 1.5% per annum and this is roughly equivalent to the output of an extra medium to large power station, each year. Rising prices and energy efficiency policies may temper demand, but, we note the forecasts of rising demand, reflected by system users' expectations, in National Grid's Seven Year Statement 2005.

Financial Costs and Investment Considerations

An ageing portfolio of coal and oil fired power stations and the steady retirement of nuclear stations suggest a massive requirement for investment in new power stations in the next 10 years. If the UK is to make effective progress toward its aims under the Kyoto agreement and its 2020 and 2050 goals, low or zero carbon emissions technologies will be required for the new power stations. There is a wide range of technology options available, but, in today's market and with present emissions reduction measures, very few of those options make business sense to companies that might wish to invest in low carbon electricity production.

One prominent option for new power plant is the Combined Cycle Gas Turbine (CCGT). CCGTs are often the most economic choice and they have contributed to significant cuts in emissions in the past, but, replacement of nuclear with gas-fired plant has and will continue to contribute to rising emissions and also lead to a high degree of UK economic dependence on gas. That outcome would make it more challenging to achieve the Government's other energy policy goals.

Companies are already investing substantially in renewable energy technologies, supported by the Government's Renewables Obligation, but many would like to consider a wider range of options to achieve greater reductions in emissions and to diversify their portfolio of generating plant. This could include new coal and gas plant with carbon capture and storage, new nuclear capacity, new renewable technologies such as wave or tidal power and the increased use of biomass.

Since the privatisation of the UK electricity industry some 15 years ago, power stations have been funded not by public corporations underwritten by Government, but by private investors. The UK has a remarkably open and competitive market, but, the way in which Government and regulators exercise their influence over it is critical to investors' confidence—it affects their willingness to make the necessary substantial, long-term investment in the UK's generating industry. Capital will be deployed where returns look most attractive and where risks are considered to be manageable. Those who invest in the market choose fuels and technologies that they expect to be competitive and capable of operating within the constraints set by Government and regulators. Present policies suggest that, in the period to 2015, the majority of new generating capacity will comprise CCGT and offshore wind.

The generating industry requires an environment in which companies can innovate and invest in a range of low carbon technologies which reduce emissions, maintain security and deliver competitive prices. In that context, the present range of options, which is largely dictated by short term costs, makes the choice of technologies somewhat narrow. A wider range of options could cut the cost of reducing carbon emissions and help maintain security of supply through greater diversity of fuels and technologies. To that end, the UK's competitive energy markets should be complemented with durable, market-based policy mechanisms designed to provide investment incentives to meet the Government's goals. Those incentives should have timescales consistent with the periods over which investment returns are made in the electricity generating industry.

The Renewables Obligation is proving successful in promoting investment in renewable energy and stability in that mechanism is crucial to continued investment. Its status as a primary policy instrument should be underlined by Government. Government also needs to continue to address obstacles to the growth of renewable energy such as planning permission and the availability of suitable electricity distribution network infrastructure.

The Attitude of Financial Institutions to Investment in New Nuclear Power

The financing of nuclear power is more challenging than that of most other generating technologies. Nuclear projects face a stringent and time consuming process for planning consent and approval of reactors, high development costs and a lengthy timescale for construction. In a capital market where payback periods are critical, these amount to major obstacles. There are steps that the Government should take to remove or reduce these barriers, so that new nuclear power can compete fairly with other technologies for private investment capital. The Government should:

- make clear that it would welcome the construction of new nuclear power stations;
- ensure that planning consents for such stations are subject to the same considerations that would face an application for any other large, industrial facility—thereby eliminating the risk of additional delay for new nuclear power stations, reducing development costs and the possibility of delay in returns to investors;
- minimise the time taken for licensing of new reactors by making clear that technology which had been the subject of a robust approval process elsewhere (perhaps within the EU) would not be subject to re-examination in the UK—for example by ex-ante licensing of designs;
- ensure that there are no unnecessary barriers to the future use on commercial terms of existing nuclear power generation sites; and
- decide, as soon as possible, on a solution for the longer-term disposal of nuclear waste.

If new nuclear power is to be developed in the UK, the Association would expect it to be financed on a commercial basis which, other than through normal competition, did not disadvantage investments in other generating businesses.

Government Financial Support for Nuclear New Build

The Association considers that it would be beneficial, in terms of diversity, security of supply and reduction of greenhouse gas emissions, if nuclear power were to continue to form an important part of the UK's fuel mix for electricity production, but, the Association has not made any proposals for Government to give financial support for new nuclear power.

How the Nuclear Option Compares With a Major Programme of Investment in Renewables, Microgeneration, and Energy Efficiency

The Government must assure itself that its Climate Change Programme (CCP) provides a coherent suite of policy instruments to define the UK's strategic approach to climate change, taking account of the objectives set out in the Energy White Paper. The Association will expect the CCP to give sufficient clarity about the future of the carbon market to reduce investment risks, particularly for large capital projects. We await the publication of the results of the CCP Review at the end of the year with keen interest.

Nuclear Waste

As stated above, the Government should decide, as soon as possible, on a solution for the longer-term disposal of nuclear waste.

21 September 2005

Memorandum submitted by Atris Business Innovations

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

Phase out of nuclear power will reduce UK generating capacity by some 12GW. Under current policies, the gap can be filled with new gas-fired generation at relatively short notice. Gas is a traded commodity, and can be purchased by those willing to pay the most.

However, a shortfall in non-gas generating capacity will have an impact on both global and UK gas prices. It is therefore unwise to rely on gas to supply such a large proportion of the UK's electricity.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

— What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

Covering the major sources of supply:

Nuclear

Nuclear plant based on AP-1000 would provide electricity at 2–3p per KWHr, based on manufacturers estimates.

The fact that the industry has significantly under-estimated costs does not mean they will do so again. A few decades ago, underestimation of capital projects was routine (recall the Humber Bridge). Estimation techniques have approved across all structure builds to the point where a 20% over estimation is considered a disaster.

Furthermore, early UK reactors were pioneering—there was no previous experience of nuclear power.

Hence one can assume that the BNFL-Westinghouse figures are broadly accurate, which makes the UK White Paper plainly wrong to rule out nuclear power on grounds of competitiveness.

Gas

Gas prices are quoted in million BTU, and currently stand at about $8. This is equivalent to 45p per Therm, or 1.54p per KWhr.

A chart here http://www.oilandgas.org.uk/issues/gas/ukooaresponsegasprices.pdf gives historical figures between 11 (1996) and 40p (end 2004) per Therm.

It seems that the latest gas turbines are about 50% efficient. So the fuel cost of gas electricity is currently about 3.1p per KWhr, and has varied between .75p and 2.75p. To this needs to be added capital and non-fuel operating costs. It appears the cost of gas-generated electricity is currently about 4p per KWhr. On top of this need to be added the cost of carbon credits.

The industry predicted stable or falling prices in 2004 (see http://www.oilandgas.org.uk/is sues/gas/ilexreport.pdf). Since then prices have risen. The gas industry has an incentive to predict falling prices to prevent investments in wind and nuclear.

If one assumes gas prices stay at $8 (and given no one really has a clue here, it seems prudent for a mid-case scenario, though over a period of decades, prices will probably rise substantially), then gas is not a competitive choice for electricity generation. This is bad news for the UK, which has put most of its eggs in the gas basket.

Offshore Wind

Estimates range from 3p to 5.5p per KWhr (Royal Academy of Engineering). Atris has not studied these figures in depth, but would assume that with sufficient innovation from the offshore industry, prices could be towards the lower end of this scale.

A critical area for wind electricity generation is the development and deployment of small-scale gas powered fuel cells, providing Combined Heat and Power. It is likely that within a decade, these could be a wide spread alternative to domestic and office boilers. They will in effect produce electricity as a by-product of heat. Hence, when a building needs heat, they can produce electricity at a cost of the price of gas. In summer, when the heat is wasted, the electricity is far more expensive. However, widespread deployment of these would provide a huge source of standby generating capacity. This in turn would enable wind energy to be deployed more widely.

On shore wind may be cheaper than offshore wind, but has limited scope to make a major contribution to the UK's energy supply.

Severn Barrage

This has been assessed for the DTI. Costs are estimated at under 6p per KWhr. This is not economically viable by itself. However, in the light of other benefits, the scheme should certainly be considered.

— With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience?

Past experience cannot be used as a guide. If it were, no suspension bridge would ever have been built after the Humber Bridge.

What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

The costs mentioned above have been internalised. The Government should raise a levy on nuclear power to fund the decommissioning costs no one can ensure that operators will remain solvent over 60 years.

— Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

It is feasible, however, wind turbine manufacturers are struggling to meet existing demand. 25GW of offshore capacity, providing an average of 10GW, by 2030 is quite feasible.

— What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

As mentioned above, domestic scale fuel cells providing CHP would be of immense value. In Winter, they will provide electricity at a marginal cost of the price of gas, which is currently about 1.54p per KWhr. Where the heat is not used, one has to account for the generating efficiency. If this is 40% (a likely figure for gas powered fuel cells) then this is 3.85p. This latter figure is not competitive for base load electricity, but may provide highly valuable, immediately available capacity.

3. *What is the Attitude of Financial Institutions to Investment in Different Forms of Generation?*

— What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

Financial institutions are understandably nervous about the scale and uncertainties. However, it is likely that large players such as Eon and EDF could obtain sufficient finance.

— How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

Financial Institutions, Constructors and Operators should be able to bear the construction and operating risks, and most of the revenue risks. However, the Government needs to remove some of the regulatory risks.

In particular, costs and risks before construction need to be reduced. The planning process needs to be simplified significantly—there can be no repeat of the Terminal 5 enquiry costs.

The Government should also bear any exceptional security costs required during construction and operation, and protect constructors, operators and investors in the event of "animal rights" style protests. As with "animal-rights" protests, it is society, rather than the generator that is largely responsible for these costs.

— What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

Probably none. There is a need for about 40GW of new generating capacity over the next few decades. Renewables, Nuclear, and Energy Efficiency should all have a role. At present, gas is so dominant, that any investment in nuclear will be at the expense of imported gas.

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

A number of benefits:

— Security of supply for a period of 60 years

— Reduced CO_2 outputs, including the ability to meet Kyoto targets and longer term targets.

— Improved Balance of payments. On current policies, by 2030, gas imports will cost several tens of billions of pounds per year.

— Reduced funding to oil exporting countries. A lot of this money is used to fund terrorism, or to pursue aggressive foreign policies, or to delay sensible economic reforms.

— The ability to meet rising demand for electricity. Even with conservation measures, demand for electricity is unlikely to fall. If transport moves from oil to electricity, then demand could even rise.

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

Each GW of average output will reduce CO_2 emissions by about 3 million tons per year. This will continue over its 60-year operating life.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

By 2010, the UK will be hugely dependent on gas supplies. By 2020, this is likely to come in large part from the former Soviet Union and the Middle East. Neither of these areas is noted for its stability. Gas from the former Soviet Union will come by pipeline, and pipelines are very hard to secure. It might be that the easiest way to impose terror on Britain in 2020 will be to blow up a pipeline in Eastern Europe.

Beyond 2020, it is impossible to predict the prices of oil and gas. However, there are some commentators who believe that oil production will peak within a decade. If this is the case, then the price of oil would increase to well over $100 per barrel. The price of gas would follow. The lights might stay on, but electricity generation from gas might cost over 10p per KWHr.

The scenario enclosed with this response would make such a threat less severe, and therefore less likely [not printed].

— Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

For the reasons above, yes. As long as nuclear power stations and waste storage sites are well guarded, then the security is improved over a scenario relying on gas imports.

Gas pipelines and LNG terminals are much easier terrorist targets than nuclear power stations, and as such would produce a higher security risk than the alternative nuclear plants.

It goes without saying that nuclear materials need to be fully controlled and accounted for, and the whole nuclear fuel cycle needs to be managed in a secure manner.

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

On current trends, without nuclear, UK generation in 2030 is likely to be 20% renewables, and 80% fossil fuel.

A build of eight reactors (AP 1000) would provide about 20% of the UK's capacity. The mix would then be 20% renewable, 20% nuclear, 60% fossil fuel.

The attached scenario proposes generation to be only 4% fossil, with 30% renewables, and 66% nuclear. In this scenario, should renewables be more cost competitive, then they can take share from nuclear [not printed].

Given the current dominant role of gas, nuclear build up to 66% of capacity is unlikely to have an impact on renewables.

Energy efficiency is not directly related to generation mix, and should be encouraged regardless of supply policy.

D. Other Issues

6. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

This is not an issue. CO_2 payback is within months of operations, and mining produces much less than 1% of the CO_2 saved.

The suggestion that nuclear power stations, or wind turbines, cause CO_2 are smokescreens for other objections.

7. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

No. There are already scientifically acceptable solutions to the problems of waste. Public acceptability will be harder to achieve, but we have this problem whether we proceed with new nuclear build or not. Dealing with our current waste is a big, though manageable problem. Adding the waste from eight, or even 36, new reactors would not add significantly to this problem.

17 August 2005

Memorandum submitted by BP

Summary

1. BP is not a part of the nuclear industry, but its potential contribution cannot be ignored. Whenever a potential means of reducing CO_2 emissions is rejected, it becomes more difficult to achieve the desired environmental objective.

2. BP's biggest contribution to "keeping the lights on" still lies in its core and traditional business of finding and producing oil and gas. The opportunities for increased gas use to reduce CO_2 emissions should not be forgotten. The displacement of coal-fired generation by efficient gas-fired generation can reduce CO_2 emissions by more than 50%.

3. BP believes that renewable forms of power generation can make a substantial contribution to future energy requirements at a reasonable cost and with limited impact on the environment.

4. BP's expertise in the renewables sector lies essentially in solar, and to a lesser but growing extent, in wind. For the UK, wind is currently the most favoured option.

5. It is also possible to go a substantial step further with power generation from both gas and coal by using CO_2 capture and sequestration technology. This can prevent the release of more than 90% of the CO_2 resulting from fuel combustion at the power station.

6. BP's and partners' Decarbonised Fuels Project (known as DF1) based on the Peterhead Power Plant and the UKCS (United Kingdom Continental Shelf) Miller Field presents an immediate and effective way of establishing the necessary large-scale technology demonstration of CCS. It would produce significant environmental benefits by reducing emissions of CO_2 by 1.3 million tons per year, the equivalent of removing 300,000 cars from the roads. Indeed, in terms of the immediate future, this single project would provide around 350MW of clean electricity—enough to provide power for all the homes in a city the size of Glasgow or Manchester.

7. Policy makers should realise that any credible policy to reduce CO_2 emissions must embrace CCS as part of the portfolio, as recognised by the IPCC special report on CCS; and that this ought to be acknowledged in any fiscal or regulatory regime designed to assist low carbon or carbon free energy to compete with fossil fuels.

Introduction

1. Most are agreed that if the world wishes to guarantee security of energy supplies, and in a way which is consistent with environmental objectives and principles, it cannot afford to forego lightly the potential offered by either nuclear, renewables—or, not mentioned specifically in the subject of this Inquiry but undoubtedly of equal significance, Carbon Capture and Storage (CCS).

2. BP is not part of the nuclear industry. But we have always acknowledged its potential contribution. When in November 2003, Lord Browne of Madingley, BP's group Chief Executive, discussed the necessity and challenge of stabilising atmospheric concentrations of greenhouse gases at around 500–550 parts per million, a number of options were identified as a means of reaching this goal. One of these options was an increase in nuclear capacity: 700 1GW nuclear plants, representing a 4% per annum increase in nuclear

capacity, would contribute 1 Giga tonnes per annum of avoided emissions of carbon by 2050. To reach the desired atmospheric contributions mentioned above, the world would need to achieve up to 7 Giga tonnes per annum by 2050.

3. It is clear that whenever a potential means of reducing CO_2 emissions is rejected for whatever reason, it becomes more difficult to achieve the desired environmental objective. So if, for reasons such as cost, waste management, safety or security, the nuclear option is judged unacceptable, other options (such as increased natural gas, much lower speed limits, more renewables etc) would have to contribute even more. It is for policy makers to guide these choices—whether they wish to be neutral, or favour one against another. Industry can only explain the options and associated costs: and then, deliver.

4. BP's biggest contribution to "keeping the lights on" still lies in its core and traditional business of finding and producing oil and gas. The importance of this role is highlighted by the concern regarding winter gas supplies in the UK, an issue that BP is helping to address through our North Sea operations and our interest in LNG import terminals. Although there is increasing attention on possible uses of oil and gas in forms which avoid incurring environmental penalties, the opportunities for increased gas use to reduce CO_2 emissions should not be forgotten. The displacement of coal-fired generation by efficient gas-fired generation can reduce CO_2 emissions by more than 50%.

5. It is also possible to go a substantial step further with power generation from both gas and coal by using CO_2 capture and sequestration technology. This can prevent the release of more than 90 per cent of the CO_2 resulting from fuel combustion at the power station. BP and partners are developing a large-scale generation project with CCS at Peterhead in Scotland (entitled DF1). The potential contributions of CCS and renewables to Britain's energy future are the subject of this memorandum.

The Scale of the Problem

6. The consensus seems to be that electricity demand will continue to grow, but at a slower rate than GDP growth. It is also expected that some existing nuclear and coal-fired generation will shut for either safety or environmental reasons. These factors mean that new power generation will be required. Some would like this to be filled by renewables. However, combining demand projections from sources such as National Grid combined with realistic closure assumptions for existing power stations, indicate that the rate of renewables development—as implied by the Renewables Obligation mechanism—is insufficient to meet demand in the medium term (even if this target of renewables expansion is achieved).

7. BP believes that renewable forms of power generation can make a substantial contribution to future energy requirements at a reasonable cost and with limited impact on the environment. This is particularly true for optimally sited wind power, where the costs are converging on those of thermal generation. However, permitted locations for onshore wind are limited, and the problem of intermittency is real and significant. Additionally, both onshore and offshore wind have power transmission issues given their distance from the electricity demand centres.

8. The factors limiting the rate of renewables development and the issues associated with intermittency point to a need to develop other options for meeting future energy requirements in a sustainable way. It is also the case that low-carbon generation is needed very soon if the UK is to achieve its 2010 targets. A calculation of the required reduction indicates that it would require the replacement of 135 TWh of coal-fired generation with low carbon electricity.

The Contribution Offered by Renewables

9. BP's expertise in the renewables sector lies essentially in solar, and to a lesser but growing extent, in wind. For the UK, with its good wind resource but poor insolation, wind is currently the most favoured option. As noted already, ideal locations for onshore wind are limited, and the public acceptability of onshore wind farms is becoming a limited factor.

10. Whatever form is considered, it is a reality, both in the UK and elsewhere, that the expansion of renewable energy capacity is dependent upon the fiscal, regulatory and incentive mechanisms in place. BP believes that there is a need for governments to play an enabling role, including market-based support mechanisms. There is no inherent or principled conflict between assistance for immature technologies and liberalised and competitive energy markets—provided that the assistance doesn't seek to "pick winners" and is relatively neutral as between different options for reducing CO_2 emissions.

Carbon Capture and Storage

11. Although they offer tremendous scope for growth, the issues confronting renewables suggest that alternative low-carbon solutions are also necessary. The need for large-scale, low-carbon generation options, which can be brought online quickly, is the main driver for BP's development of a hydrogen burning power station at Peterhead in Scotland, with associated carbon capture and sequestration. This DF1 project builds from a range of proven technologies, has costs comparable to other low-carbon technologies deployable in these timescales, and could be replicated to reduce significantly UK CO_2 emissions. Indeed,

it could be brought online in time to contribute to meeting the UK's 2010 CO_2 emissions target. The potential offered by CO_2 Capture and Storage (CCS) is increasingly recognised, as evidenced by the recent IPCC Report. CCS needs to be seen as complementary to both energy efficiency and renewable options for power generation.

12. The United Kingdom is especially well placed to explore the potential of CCS. The North Sea basin is ideal for large scale storage. As a result of historical policy frameworks, the geology under the North Sea is very well understood and there are sound grounds for confidence that UKCS oil and gas fields are well suited for storing CO_2 and allowing Enhanced Oil Recovery (EOR). In addition, the North Sea basin has large deep saline aquifiers which offer the potential of excellent CO_2 sites. Indeed, together the oil, gas and saline aquifiers have adequate capacity to store all of the CO_2 produced from power generation in Europe for some 50 years. Finally, recycling the North Sea pipeline infrastructure could play an important part in enabling cost effective access to these reservoirs. But much of the existing infrastructure which can be utilised for CCS will be decommissioned over the next 20 years, so the UK's window of opportunity to gain material benefit from CCS technology will close as that infrastructure is removed.

13. The inherent advantages of the North Sea in terms of storage and infrastructure not only provides the UK with an opportunity to achieve significant and rapid reductions in CO_2 emissions—DF1 alone would reduce them by 1.3 million tons annually, the equivalent of removing 300,000 cars from the roads. But in addition, higher employment and enhanced energy security would be one of the consequences of the widespread deployment of CCS in the North Sea.

The Technology

14. The technology is developing rapidly, and has three elements: Capture; Transportation; and Storage. When integrated, these can be used to generate "green" electricity using CO_2-free Hydrogen.

15. "Capture technology" is already available, but for the most part it has only been tested at relatively small scale (although DF1 provides the first opportunity of demonstrating the technology in association with a large power plant in operation). In respect of "Transportation", the oil and gas industry has over 30 years experience in transporting large volumes of CO_2 in pipelines and ships. And in terms of storage, the oil and gas industry has over one hundred years of experience identifying and managing fluids in the deep sub-surface. [For further details on the technological aspects, we would refer the Committee to BP's submission to the Science and Technology Committee's accompanying and simultaneous Inquiry into CCS.]

The Costs

16. The costs of power generation using H2 are competitive with those of renewables and nuclear, but not non-decarbonised fossil fuels. Current estimates of the incremental costs of generating power from H2 (as against fossil fuels) are $55–65 per megawatt hour ($/MWh), which is similar to the level of support offered to renewables under the Renewable Obligation Certificate (ROC) scheme. It is expected that technology costs of CCS will reduce over time, and will require diminishing support. If so, the competitiveness of CCS will progressively increase.

17. Infrastructure costs for moving CO_2 are a significant component. But some of this cost can, as with DF1, be offset if the re-use of existing infrastructure is possible and encouraged. Equally, were the United Kingdom to become a global leader in the export of technology and expertise, this would further help to offset the initial costs of developing CCS technology.

BP's DF1 Project

18. Against this background, it may be helpful to describe a little more fully the DF1 Project, which has three main components:

- the generation of "carbon free' electricity" through the conversion of an existing gas-fired power station near Peterhead in Scotland to run on hydrogen;
- the manufacture of hydrogen—in order to supply the power station—by reforming North Sea gas and capturing the resulting carbon dioxide;
- the transportation of the captured carbon dioxide via an existing offshore pipeline to the Miller oil and gas field in the North Sea—and injecting it into the reservoir to recover additional oil reserves and to extend the productive life of the field by about 20 years.

19. This project offers an immediate and effective way of establishing the necessary large-scale technology demonstration and of helping to meet current emissions targets. When completed, it will set several technology milestones including the:

- largest carbon dioxide EOR project in the North Sea;
- first carbon dioxide pipeline in the North Sea;
- largest hydrogen-fired power generation facility in the world;

— largest Auto Thermal reformer for generating hydrogen.

20. There is no single solution which can by itself deliver the world's CO_2 targets, but there is a portfolio of technologies that have been demonstrated at scale, and which collectively offer the opportunity to make the necessary reductions over the next 50 years. Because the world will be dependent on conventional hydrocarbons for the next 50 years, hydrocarbon-based technological solutions for climate change will be one of the major contributors to stabilisation. DF1, for example, will reduce carbon dioxide emissions by some 80 to 90% for each unit of electricity produced. Indeed, if applied to only 5% of the new electricity generating capacity which the world is projected to require by 2050, the world would have the potential of reducing global CO_2 emissions by around 1 billion tonnes a year.

21. There are also security of supply implications. The project will prolong the life of the Miller Field through enhanced oil recovery and through the postponement of abandonment (which could eventually be imitated throughout the North Sea). But more important, it demonstrates a viable technology pathway for clean energy production from a broader range of primary energy sources (eg coal, biomass) which would improve energy security.

22. In terms of the immediate future, this single project would reduce emissions of CO_2 by 1.3 million tons per year (the equivalent of removing 300,000 cars from the roads) and provide around 350MW of clean electricity—which is enough to power all the homes in a city the size of Glasgow or Manchester (250,000 homes).

23. DF1 (and other CCS projects) has one other major environmental benefit. It does not require back-up to address the problem of the intermittency of wind or sun. It provides base load capacity, and although it may not be totally carbon free, it provides virtually carbon free energy for 100% of the time.

The Role of Government

24. As stated above, the costs of CCS are similar to renewables. The time has arrived, therefore, to consider seriously whether a Climate Change Policy should not seek to be rewarding low carbon (or carbon free) energy on an objective, impartial basis rather than through the "picking of winners" as exemplified by the current policy which favours renewables. This in no way questions the role of renewable energy initiatives. BP is involved in this area as well, and there is no doubt that a variety of carbon reduction strategies and technologies will be required in order to reduce significantly green house gas emissions.

25. But the opportunity offered by DF1 must be instantly grasped if it is to be realised, and therefore the implications for public policy must be recognised equally quickly. This is because DF1 offers the possibility to prove the concept of CCS in the UK and North Sea in a relatively short time frame. This is a critical aspect, for without such timely large scale industrial demonstrations, the UK is in danger of missing the window of real opportunity for this technology in the North Sea. Hence, it is necessary that incentives should be in place quickly which are equivalent to those currently available to no-carbon options. This is not merely to facilitate DF1; and it is not just to demonstrate the technology, important though this is. DF1 also offers the opportunity to develop the UK's policy instruments for cleaner energy. That is why it would be wrong, in policy terms, to approach DF1 as a single stand-alone project. Rather, DF1 should spearhead a policy approach which assures future investors in CCS of a consistent and sustainable approach to their investments.

26. There are other issues, in addition to incentives, where government has a role to play. For example, provisions of both OSPAR and the London Convention will need to be discussed. The rules of the European Emissions Trading System (EU ETS) will need to clarified. And new regulations and permits will also be required embracing a number of areas, including approvals for new plant onshore (for pre-, post- or Oxy-firing technology); for pipeline access to move CO_2; and for injection of CO_2 offshore geological structures under the seabed for EOR and ultimately for storage.

27. But over the next 12 months, as UK Energy Policy evolves, it is vital for policy makers to recognise that any credible policy to reduce CO_2 emissions must embrace CCS: and that this ought to be acknowledged in any fiscal or regulatory regime designed to assist low carbon or carbon free energy to compete with fossil fuels. BP anticipates that over time—and given increasing scale, experience and technological expertise—the cost of schemes like DF1 will reduce. But that is not the case today, even though CCS is well placed to argue that it is both commercially and environmentally on a par with (if not ahead of) any existing alternative. Obviously, a properly functioning Emissions Trading System would be of enormous benefit to CCS projects—although the specific European system is currently insufficient, even if the rules were to be clarified, because it fails to provide a framework of sufficient duration and the current (and indeed, forecast) level of carbon price is inadequate to encourage business to invest the very large sums required.

Conclusion

28. There is a wide range of solutions to both the issues associated with energy security, and demands for carbon-free energy. BP strongly supports the ongoing development of renewables to contribute to meeting future energy demand and the security of supply. Moreover, the option of meeting future energy needs through fossil-fuelled generation without the associated carbon emissions can only add to energy security. Such power plants, based on coal or gas both of which have substantial reserves internationally, are controllable and immune from the vagaries of the weather.

29. In addition, we believe there to be huge potential for CCS to enable the achievement of apparently conflicting goals at reasonable cost. It is estimated that up to one third of the required reductions in global CO_2 emissions could be made by CCS technology. CCS is uniquely placed to help build a bridge to a low or no carbon energy future in the next 50 to 100 years.

30. The best policy framework to support these and other options should ideally be non-discriminatory between different solutions. There needs to be a mix of measures which together provide a level playing field of support and incentives for low and zero carbon energy. As has often been recognised, the temptation by government to "pick winners" should be resisted in favour of providing a secure long-term level of non-discriminatory support for anything which helps to both reduce CO_2 emissions and, in terms specifically of security of supply, increases the range of energy sources available.

5 October 2005

Memorandum submitted by the British Hydropower Association

I am responding to the Committee's call for evidence on behalf of the British Hydropower Association The British Hydropower Association is the trade association for the UK hydropower industry. It represents about 100 companies with a wide range of interests: consulting engineering, manufacture, design, investment and operation as well as specialist service providers. There is a long established hydropower manufacturing industry in the UK.

From the single renewable technology represented through the BHA, we are not in a position to comment directly on the three inquiry issues as set out in the consultation paper. However, some general comments on the place of hydropower in the UK generation portfolio and its potential for the future might be of value to the Committee in their deliberations.

Hydropower Potential

Hydropower is a long established and proven technology. It is innovative and the industry continues to develop increasingly sophisticated design, development and implementation solutions to meet site specifications sensitively and to put in place measure to mitigate real and potential environmental impacts. Hydropower accounts for about 40% electricity that is generated from renewable sources at present in the UK. We recognise that, as a mature renewable resource, the contribution hydropower can make to new generation capacity towards meeting the Government's targets for the proportion of electricity supplied from renewable sources by 2010 will be limited. However there remains considerable hydropower potential that could be tapped—2GW–2.5GW (500MW large, 1'5GW small and 200–500MW micro). Much of this potential is in the many abandoned or disused former mill sites and in retro-fitting plant in association with river and water utility infrastructure. The BHA believes that the sensitive development or re-development of hydropower at such sites would aid both urban and rural regeneration, contributing towards sustainable development. The principal factors limiting the development of many hydropower projects are the availability of financing and planning constraints.

Financial Constraint

The high up-front costs of hydropower projects make financing difficult. This is despite hydropower having a long payback period coupled with low maintenance costs. Measures that would increase financiers' and suppliers' confidence in the market could help to make finance available for new renewable energy developments, including hydropower. Under current market conditions suppliers are not prepared to offer long term Power Purchase Agreements (PPAs) at a price that enables the financial viability of a new project but, without a long term PPA which would ensure a guaranteed income for the project, financiers are unwilling to provide backing. Difficulty in securing finance is exacerbated by uncertainties in the market for Renewable Obligation Certificates (ROCs); measures that would reduce this uncertainty would have a positive impact. The apparently annual reviews of the Renewable Obligation do not help.

Planning Constraints

Planning is another significant obstacle to the development of renewable energy. The uncertainty caused about the time taken to process applications and to secure planning consents can add to the overall cost of developing a project and for smaller projects it can inhibit development. Additionally, there are several agencies that need to be consulted (local planning authorities, environment agencies, conservation and fisheries authorities, etc) and there are concerns about hydropower receiving consistent and appropriate guidance across the regions.

Pumped-storage

On strategic benefits, the BHA believes that hydropower plays a valuable, indigenous power resource and deserves to play a full role in the energy mix. Additionally the BHA believes that more consideration should be given to the development of pumped-storage hydropower. Pumped-storage is a variant of traditional hydropower, comprising an upper storage reservoir connected to a lower storage reservoir allowing off-peak power to be used to replenish the upper reservoir ready for use at times of peak demand. In this way pumped-storage can play a valuable role in managing load demand and supply. It is the only proven technology for large-scale energy storage and the UK has several pumped-storage plants include the world' largest, Dinorwig. The BHA believes that smaller pumped storage facilities should play a valuable role in association with intermittent wind power enhancing its efficient use.

If the Committee needs further information on hydropower and pumped storage hydropower we should be very happy to help.

22 September 2005

Memorandum submitted by the British Nuclear Energy Society and the Institution of Nuclear Engineers

1. Introduction

The BNES is the leading "Learned Society" for Nuclear Energy. The Society functions almost completely by the contributions of volunteers who provide their experience and dedication to provide information to members UK, worldwide on Nuclear Energy issues, to provide opportunities for members to publish and present papers, meet and debate issues locally, nationally and internationally, to promote nuclear energy specific training in the UK and to promote increased public understanding of the issues surrounding the use of nuclear energy.

The Institution of Nuclear Engineers (INucE) is a professional body representing a broad cross-section of nuclear engineers engaged in various aspects of nuclear technology, predominantly in the UK, but also in the USA, South Africa and Asia. Our members are involved in many aspects of the fuel cycle from fabrication, through operation of nuclear power plants, to decommissioning and waste management, as well as regulation. Our mission is to promote the highest professional and safety standards for the nuclear industry.

The BNES and INucE collectively represent the largest body of nuclear professionals associated with the UK's nuclear industries and we welcome the opportunity to contribute to the Environmental Audit Committee's enquiry. While we fully support the need to include renewables in a balanced portfolio of energy options for the UK, our response is primarily focused on making the case for new nuclear build in order to enhance security of supply and reduce our carbon emissions in the medium to long term. We would be pleased to provide further evidence both orally and in writing should the Committee so wish.

BNES/INucE believe the Inquiry is timely in view of our long held concerns and those increasingly being expressed publicly by others regarding the realism and robustness of the current UK energy policy. The Energy Sector has long time horizons. Ensuring adequate short-medium term robustness in energy supply is vital for Government as should be long term strategies which are robust, flexible and provide executable options for them and future administrations. For some of the "big ticket" generation technologies such as nuclear, plant is expensive and designed for lifetimes of up to 60 years. Investors need confidence that policy will stand the test of time.

It is but 30 months since the BNES and INucE welcomed the publication of an Energy White Paper, which promised to set a pathway towards balancing the four "pillars" of:

— putting the UK on a path to cut CO_2 emissions by 60% by 2050 and make real progress by 2020;
— maintaining reliability of energy supplies;
— promoting competitive markets; and
— ensuring adequate and affordable heating for homes.

However, there was major disappointment with the actual product which purported to keep the nuclear option open yet neither took, nor indicated plans to take, practical steps to do so.

Nuclear energy was acknowledged in the report as having an important role to play in carbon free electricity production. The White Paper indicated it MAY be needed in future if carbon targets couldn't be met by the other means to which priority was given. Investment in nuclear "new build" was clouded by two issues (perceptions on waste and economics) and the requirement was identified for a further White Paper before nuclear could be considered for a role in the UK's future energy mix.

The challenges being made now to the validity of the policy enshrined in the White Paper, from many respected quarters, indicate that in its formulation, too much weight was given to short term issues and too little to the risks attached to the policy in view of the scale of the challenges ahead in delivering the "4 pillars".

BNES and INucE welcome the focus brought to several of the key issues by the EAC Inquiry. We believe that it is now timely to raise these complex topics and assess them objectively.

It is our view that the EAC Inquiry can make a major contribution to Energy and Environmental planning. It is also our view that a way forward needs to be found to ensure nuclear energy can once again become an executable option for the future.

2. Response

A. The Extent of the Generation Gap

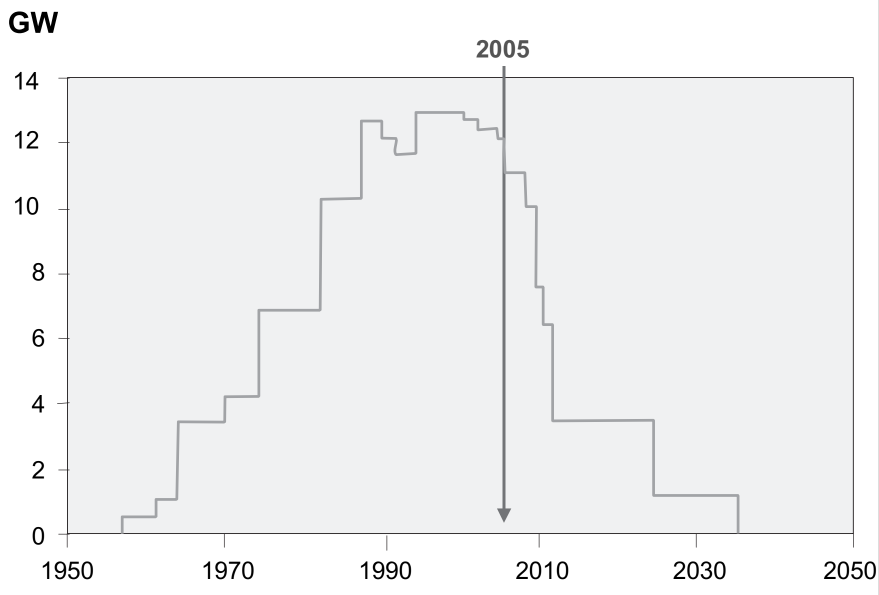
1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

The fall off in electricity generation contributed by the UK's nuclear fleet is shown in the figure below. From its peak in the mid 1990's of just over 30%, the capacity attributable to nuclear will drop to just 3% early in the 2020's when the only remaining operating unit will be Sizewell B.

All the Magnox stations are scheduled to retire by 2010, Wylfa being the last one. It has been stated that there is no prospect of life extension for these units, with their lifetime being determined by the life of the Magnox reprocessing operations at Sellafield, scheduled to conclude in 2012.

The Magnox reactor retirements are due to be followed soon after by the AGR's of British Energy. Although Dungeness B has just been granted a 10yr life extension, being the least "worked" unit in the fleet, this is not the case for the other AGR's where life extensions are much less certain.

As far as Sizewell B—a Westinghouse designed PWR—is concerned, there is no reason why it should not benefit from life extension to 60 years, beyond its original design life of 40 years, in line with accepted international norms for similar designs.



UK NUCLEAR POWER CAPACITY

Set against the more recent projections as listed below, the decline in the UK's nuclear capacity will have a major negative impact on overall supply and carbon emissions from the electricity sector.

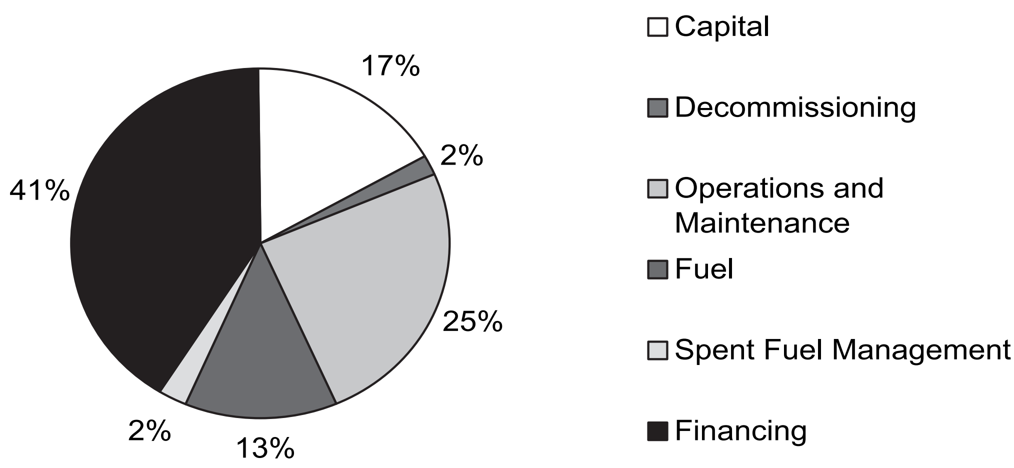
- The UK is now once again a net importer of gas, and is set to be importing around 80% of its gas requirements by 2020.
- By this time, current plans indicate that gas-fired power stations will provide two thirds or more of the UK's electricity.
- Substantial amounts of baseload coal and nuclear capacity are scheduled to close over the coming decade.
- Electricity demand is growing at around 1–2% annually.
- Carbon emissions have risen in each of the past two years, despite the need to put the UK on track for making substantial cuts.
- Focus on renewables brings new issues of intermittency which need to be managed.
- UK geography means that we have limited connections with other nations, so opportunities to import fuel supplies or power in times of shortage are limited.

B. Financial Costs and Investment Considerations

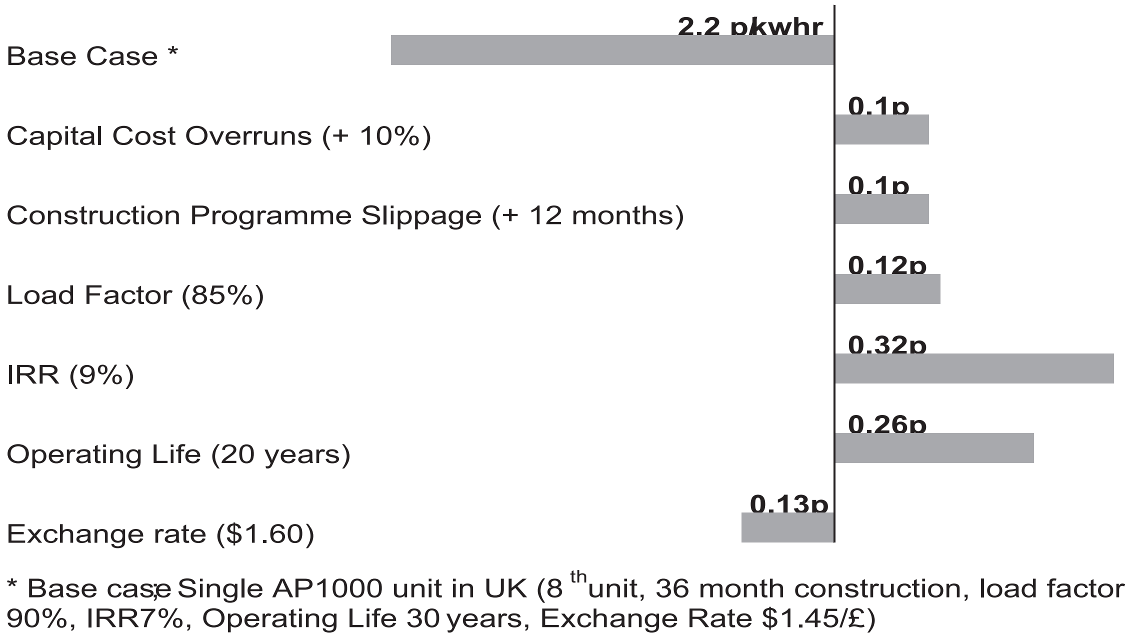
What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of differing generating technologies?

Costs

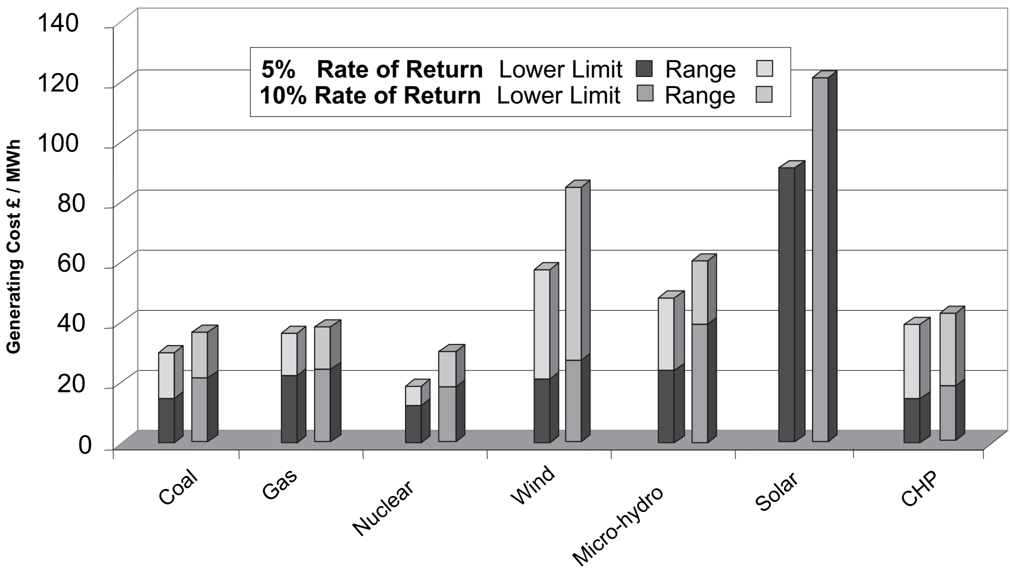
Nuclear generating costs are dominated by the cost of capital and its financing.



We show illustratively the situation for AP1000 but the effect is indicative of any modern LWR technology. Many studies carried out worldwide indicate the cost/kW installed (or "overnight capital cost") lies within a consistent band. Currently competitive advanced systems can be delivered for US$2000/kW. This yields a generating cost of 3p/kWh at 8% but 4p/kWh at 15% rate of return on investment. Sensitivity of generating cost to a number of parameters is illustrated below, other factors such as load factor, economic life, construction period etc all impact on the generating cost.

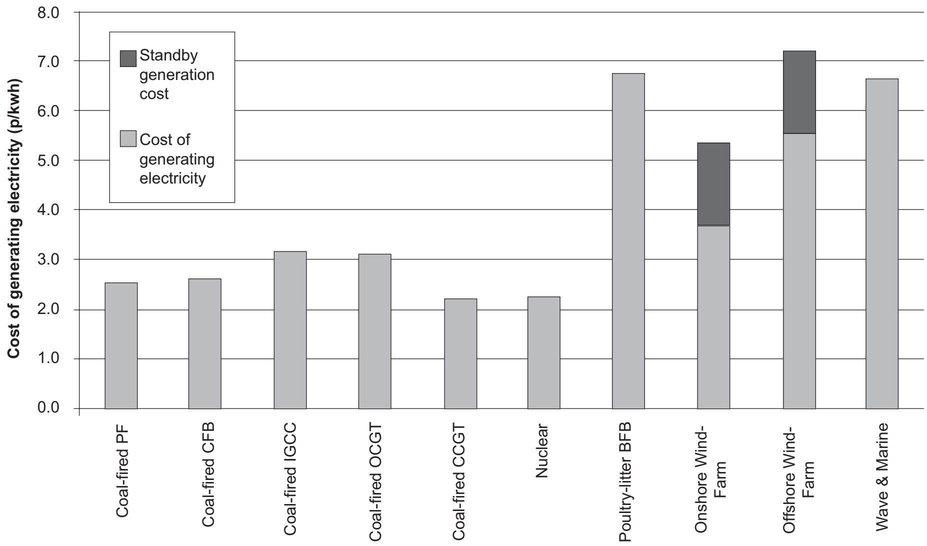


Recent studies into the relative economics of nuclear and other alternatives have shown nuclear to be very competitive. One such international study from OECD[20] is summarised in the following chart. It shows that nuclear is extremely competitive with other generation options.

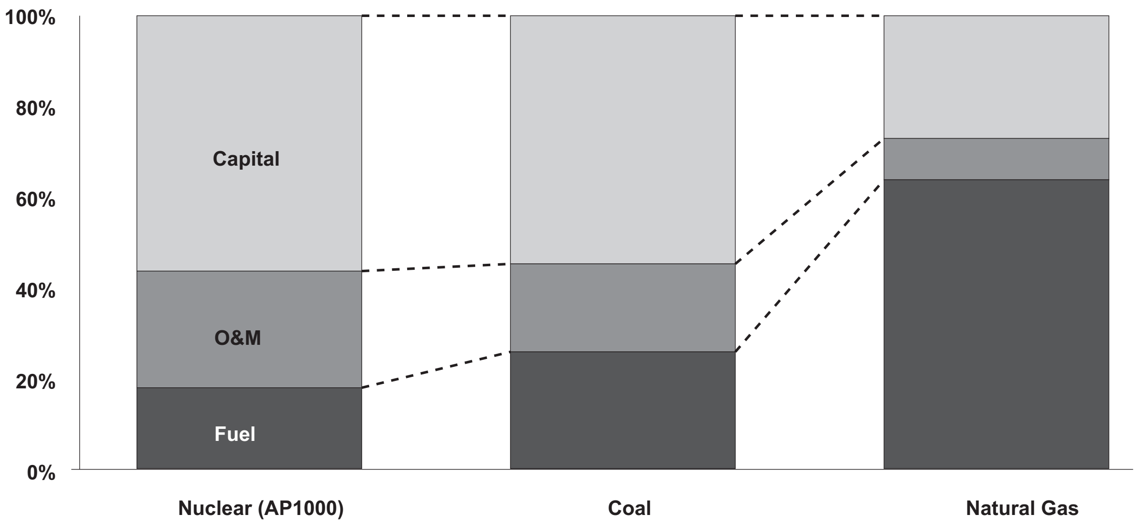


[20] *"Projected Costs of Generating Electricity"*; OECD/NEA/IEA; 2005.

A corresponding UK study by the Royal Academy of Engineering[21] came to a similar conclusion (the darker elements shown for wind represent the costs of backup generation due to intermittency):

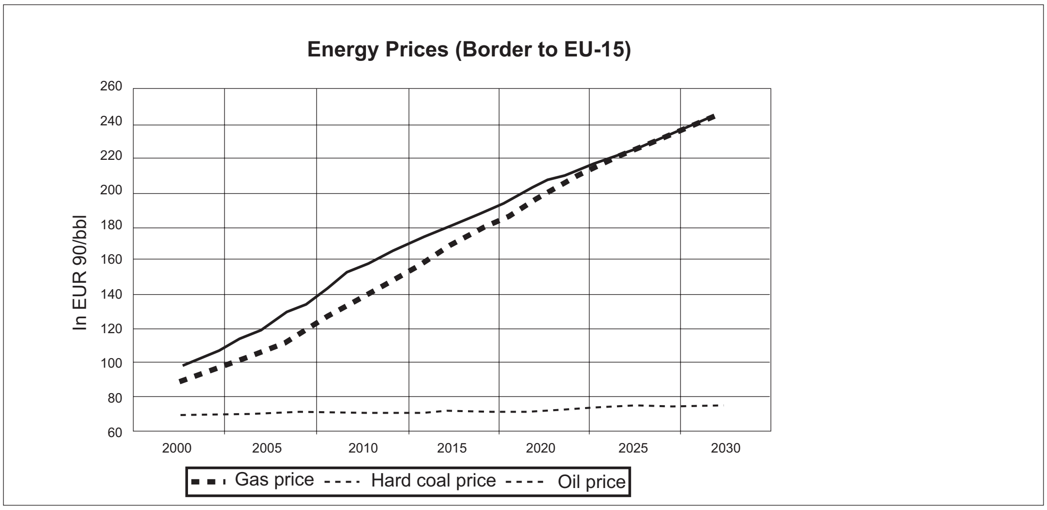


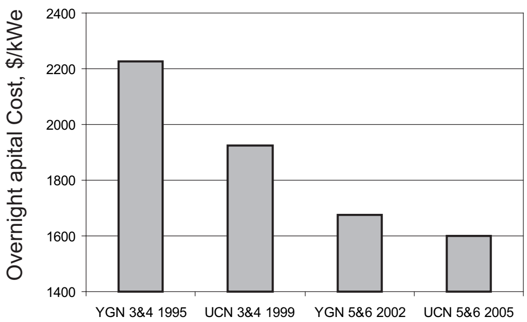
One point which is very important to note with respect to nuclear generating costs is the relative insensitivity to the price of the raw fuel. Costs of the raw material (uranium) only account for around 5% of the total generating cost and the overall fuel contribution (allowing for enrichment and fuel fabrication) is typically around 15–20%.

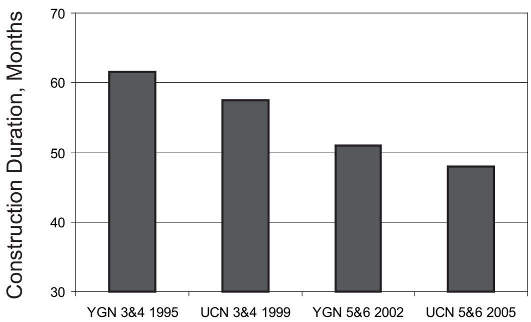


In this context it is helpful to consider the likely trends in fossil fuel prices. The following chart shows projected cost of gas, oil and hard coal in Europe over the coming decades. Recent increases in gas and oil prices are already impacting on the UK's economy and the projected increases in the EU will compound the effect oil and gas will have on economic stability.

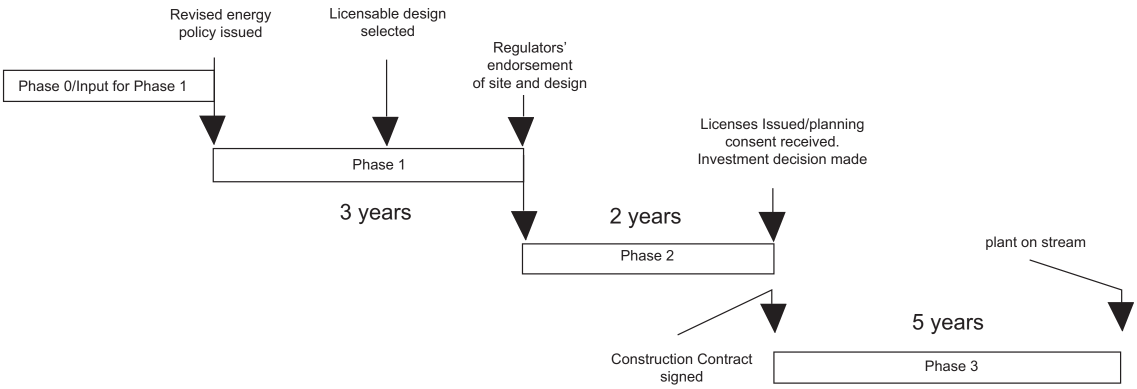
[21] "The Cost of Generating Electricity"; Royal Academy of Engineering; 2004.







Regarding timescales for introducing new nuclear stations, international experience with standard designs (France, Japan, Korea, China) indicates typical construction times of five years for the first unit with timescales for subsequent units in a series of the same design being 36–48 months depending on the design, local circumstances and whether built in pairs or as single units. The following charts illustrate the substantial improvements in capital cost and construction schedule achieved in South Korea through series build of near-identical stations.



As shown in the figure above, one important factor to take into account for nuclear generation compared with other forms in the UK is that nuclear has a unique hurdle to overcome prior to implementation being possible. Notwithstanding approvals through the "normal" planning process of approximately two years which would apply to large scale deployment of any generation technology, nuclear technology has to undergo regulatory assessment, or licensing, of the design for utilisation in the UK. This process would typically take three years (assuming that the design being assessed has already been approved elsewhere in the world). Arguably nuclear also has a second hurdle in that the 2003 White Paper indicated a further White Paper would be required before any consideration could be given to nuclear energy having any place in the UK's future generation mix.

The timescale impact of this second hurdle would be determined by Government but it is difficult to imagine a consultation, evaluation and White Paper production being completed in less than around nine months. Thus, even in the most optimistic circumstances, if a decision to proceed were taken now, it would be 2015 before electricity would be delivered to the grid. This means that preparatory steps such as licensing need to be taken now. This does not in any way imply a commitment to build new nuclear plants, but it does ensure that the timeline illustrated above could be achievable and that new plants could be built on a timescale to match closure of some of the retiring stations. This process is relatively low cost (around £10 million) but would have the added benefit of ensuring skills and capabilities within the UK's nuclear regulatory body were up to date with international best practice.

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience?

With hindsight, UK past experience contains a number of case studies in how nuclear projects should not be delivered. International norms over the past 10–15 years are a much better guide and give confidence to any figures and timescales quoted.

The UK (for what appeared to be very good reasons at the time) chose to concentrate on the gas cooled Magnox system. All the 11 reactors built were different. There was almost no benefit in learning from experience or series build. Different consortia were used to design and construct the different units. A similar path was followed for the AGR's where again there the temptation to "improve" the design after each round of building proved to be irresistible.

Historical cost overruns for both systems can be attributed inter alia to:

— "design as you go" approach;

— delays in approvals processes;

— "preference engineering" (the regulators asking for systems to be made similar to what they were familiar with, rather than simply assessing whether a system met the safety criteria or not);

— little prospect of modularisation of major components and a very high degree of on site build;

— a "cost plus" culture in regulated markets, which drove suppliers towards overruns and overspends;

— changing political/legislative/regulatory requirements.

This contrasts heavily with international best practice which is to adopt a proven international design, to resist the temptation to make it "better", and to build a number of identical units as a series.

Both the Magnox and AGR systems have however in general worked well, with good safety records, delivering reliable carbon free baseload electricity for the UK. Also Sizewell B which turned into a one-off imported design with significant redesign during the licensing approval was completed within budget and schedule.

Now however, there is an increasing body of international evidence to give confidence that construction and operating costs for future nuclear plant are predictable. This includes:

— In countries such as France, China, Japan and South Korea, the nuclear industry has demonstrated a good track record of delivering modern designs on time and within budget.

— Nuclear plants around the world show very good operational performance. (There has been significant improvement in nuclear plant reliability over the past 10–15 years, with typical load factors in the 80–90% range. Sizewell "B", which is the nearest equivalent UK plant, has delivered similar levels of reliably over its first 10 years of operation).

— Consolidation of nuclear reactor vendors through the 1990s has led to the development of "standardised" internationally recognised advanced designs. As these designs incorporate many years construction and operating experience, utilise proven technology, and robustly address the regulatory issues that were previously of concern, there is much more confidence in construction times and operational performance than hitherto.

— Development of improved materials for construction, and better operational management, allow more reliable operation at high levels of output.

— Reactors are now designed for improved maintainability which reduces operating costs and increases overall output.

— Modern reactors make very efficient use of the fuel, and so produce much less waste than earlier designs.

— Modern designs incorporate fewer components than older reactor concepts which, together with modern construction techniques such as modular construction, makes today's plants more straightforward to build.

— Modern reactors are designed for safe, cost-effective decommissioning.

What are the hidden costs (eg waste, insurance, security) associated with nuclear?

There are no "hidden" costs in any of these areas.

Calculations of generating costs include allowances for waste management, decommissioning and waste disposal. From the earlier breakdown of total generating cost, it can be seen that such costs are a relatively small proportion of the overall generating cost—typically less than 5% of the overall cost in total.

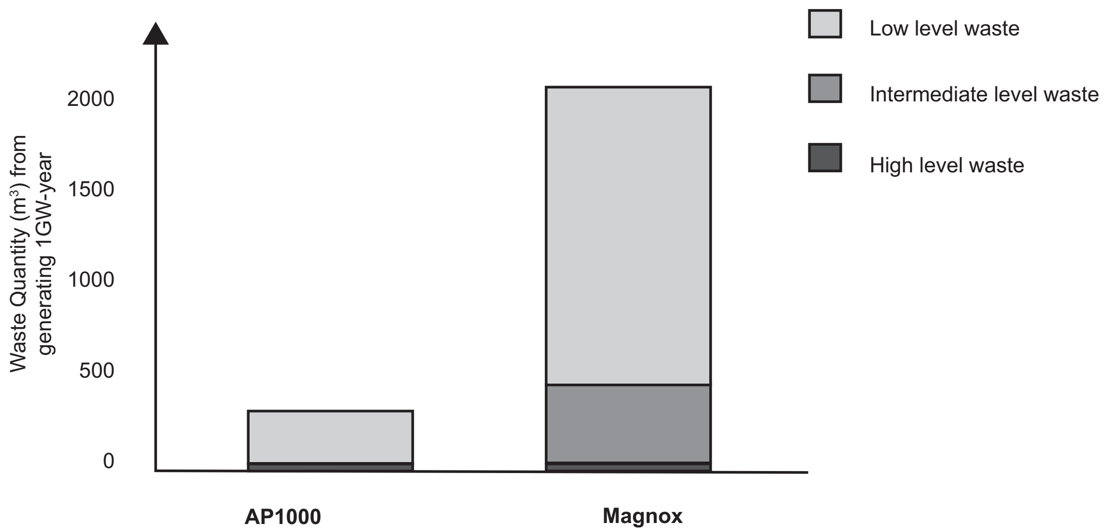
As far as insurance is concerned cover is provided on a commercial basis against a requirement set according to the international Paris Convention. In the UK this is set out in the Nuclear Installations Act. The current limit of liability is £140 million, but this figure is shortly set to rise to €700 million.

Security measures are set by the Office of Civil Nuclear Security (OCNS) under the Nuclear Industry Security regulations (2003) and follow international guidance. All security costs are covered by the generating costs as part of operations and maintenance and currently amount to around 1.5% of the operating budget. For new stations, where robustness of design ensures that security issues are satisfactorily addressed, costs would be similar to those for existing stations.

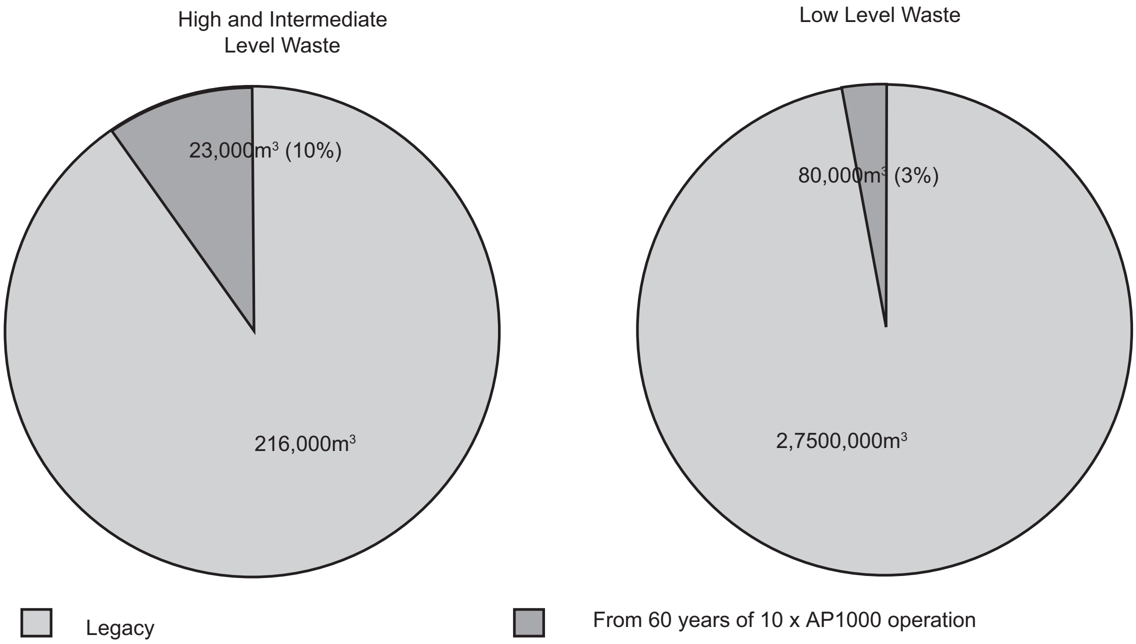
How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy?

They do not. Future waste management costs are a very different consideration from the costs of dealing with the historic legacy which was in the main generated under a very different nuclear industry and energy market framework. The existing UK legacy should not be used to deny future generations the benefits of reliable carbon free baseload electricity from new nuclear power plant.

The Magnox system is very fuel intensive. This, together with the extensive prototypic radiochemical plants constructed at Sellafield and Dounreay in the period from the late 1940's to the early 1980's in support of a reprocessing and fast reactor fuel cycle, is largely responsible for the UK extensive legacy waste and its high cost. The figure below shows the differences between wastes arising from a modern LWR like the AP1000 compared with a Magnox unit of equivalent output.



Overall it is vital to put potential waste arising from new build into context both in terms of volume and in the difficulty of dealing with it compared with the existing inventory.



If 10 new reactors were built to replace the UK's retired and retiring fleet of 11 Magnox and 7 AGR stations, less than 10% would be added to the existing inventory of high and intermediate level waste. Less than 3% would be added to the low level waste inventory. Furthermore the type of waste produced by modern reactors is much easier to deal with and there are internationally accepted, well engineered norms for its containment, handling and storage. The reactors themselves are also much easier to decommission, having been designed with this in mind.

How confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

With or without any further reactors, the UK will need a long term management route to be identified for the baseline high and intermediate level waste inventory of 478,000 m^3. The Committee on Radioactive Waste Management (CoRWM) will recommend the long term management route(s) for UK waste and spent fuel to Government next July. The work they have published to date suggests that deep disposal or interim surface storage will be the preferred route.

The latest cost estimate from the NDA for management of the legacy is around £56 billion (undiscounted total costs)[22]. A large proportion of this cost relates to the safe and effective retrieval of wastes from their current storage, rather than directly to the treatment and management of the wastes.

International experience shows that waste management costs from current power generation are a relatively small part of total nuclear fuel cycle costs.[23] There are well-established approaches to funding it in most countries. Funds set aside now, and in the future, would be expected to earn reasonable rates of interest for many years before significant draw-downs are required (eg for a geological repository, which may not need to be in operation for decades). As a result, the contributions required today can be modest. As examples, the USA levies 0.001 USD /kWh (€0.0008) on nuclear electricity production. This has led to a fund of $26 billion paid to the US Treasury. Sweden levies 0.01 SEK (€0.001), Japan 0.13 Yen (€0.001) and the Czech Republic 0.05 CZK (€0.002). The size of the payments are generally kept under review and increased or decreased if necessary, based on best estimates of future costs. The money that accumulates is available to pay for the packaging, transport and disposal of spent fuel and Intermediate Level Waste.

Some countries without such levies require the waste producers to set funding aside. For example, Switzerland has a government controlled trust fund. Germany, where the funds already total ~€25–30 billion, leaves the fund with the power utilities.

In Sweden a fund established in 1982 covers spent fuel encapsulation and disposal, nuclear power station decommissioning and waste disposal, along with the R&D necessary to implement all these activities.[24] The fund is invested in the National Debt Office and overseen by a board appointed by the government. The amount of money that each contributor pays from year to year varies, depending on the most recent estimates of future costs and how well the investments made by the fund have performed. Cost estimates

[22] *"NDA Draft Strategy—Appendix 4"*; Nuclear Decommissioning Authority; 11 August 2005.

[23] Typically, the back-end costs of nuclear electricity generation are only about 5 to 10% of the total costs—about half the fuel costs, for example *"Nuclear Electricity Generation: What Are the External Costs?"*, NEA, 2003 ISBN 92-64-02153-1, OECD/NEA, Paris http://www.nea.fr/html/ndd/reports/2003/nea4372-generation.pdf

[24] *"Plan 2003. Costs for management of the radioactive waste products from nuclear power production"*. Svensk Kärnbränslehantering AB, July 2003. SKB Report TR-03-11. http://www/skb.se

are produced by the implementer, SKB, and submitted to the regulatory authority, SKI, for review. Utilities must provide guarantees to compensate for any fees which might not be paid into the fund if reactors are shut down early (as is present Swedish government policy) and if the costs of waste management prove higher, or are needed earlier, than currently expected.

A similar model in the UK might be to require the operators of new nuclear power stations to pay into a central fund, administered (directly or indirectly) by the government. For a single reactor of 1,000MW output and a life of 60 years, the total fee paid, if the levy was set at 0.1p/kWh, would amount to about £500 million, before accumulation of interest over the life of the fund.

For comparison, the estimated cost of the Finnish spent fuel storage and disposal programme, to accommodate the fuel and waste from four nuclear power stations is about £850 million. Sweden estimates[25] that its spent fuel encapsulation plant will cost about £600 million and the spent fuel repository about £1,100 million. This assumes that the 11 operational reactors operate for 40 years. Together with the two reactors that have already closed, Sweden's total nuclear installed capacity amounts to about 10GW, a very similar value to that of the UK which totals almost 14GW for historic stations and those that continue to operate.

What is the attitude of financial institutions to investment in different forms of generation?

In terms of scale, investment in new nuclear plant is not unique in the energy infrastructure sector. Gas pipelines and oil platforms and LNG facilities can actually cost more depending on the installation and location.

Financial institution appetite and requirement for rate of return is therefore highly dependent on the perceived risks. Where there are unresolved policy, planning and regulatory issues, as is the case in the UK currently, then it is difficult to begin to argue the case for progressing any investment at all. If however, as for example in Finland, Parliament has decided as a matter of policy that a country will have nuclear in its forward energy mix, an international design has been chosen and has regulatory approval, a price has been agreed, the public have volunteered to host the reactor in their community, waste policy has been determined and the liabilities for the utility are clear, financing can and has been secured from commercial sources.

If waste policy is clear and the utilities' obligations determined at the outset; if a design has generic approval; if the planning process is well defined and appropriately streamlined, then risk becomes easier to assess and accept.

For nuclear energy in the UK clarity in waste policy is essential as it is currently a significant deterrent (without a statement of policy the owner's liability is potentially uncapped). Recognition of the fact that nuclear is carbon free would have a further significant impact if due credit were given.

Recent analysis by PricewaterhouseCoopers[26] concluded that new UK nuclear plants would be readily financeable in principle on a "project finance" basis, but that a somewhat higher cover ratio would be required than for a conventional project due to the risks of construction overrun and regulatory issues. PWC further concluded that once the project was underway, it would show resilience to price fluctuation risks, because of the low variable cost component. This in turn would enable attractive offtake contracts to be developed.

How much Government financial support would be required to facilitate private sector investment in nuclear new build?

Provided the right market framework is in place then it will not be necessary for Government to provide direct financial support. Clarity in the previously mentioned waste policy is essential as is a declaration of nuclear's acceptability as a component of the UK's future energy mix.

Credit as a non carbon contributor and clarity of the long term market for carbon dioxide allowances would increase the chances of nuclear energy being successfully delivered within the private sector.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

Nuclear is an energy dense, reliable baseload technology. The whole of the UK's wind energy fleet—both on and offshore—last year generated 1.9TWh of electricity.[27] This is slightly over half the annual output from a small Magnox station such as Sizewell A. This is not intended to be a negative comment with respect to wind, but rather an attempt to put into context the extent of the challenge in dealing with the generation gap if new nuclear stations do not replace the retiring ones.

[25] http://www/skb.se

[26] *"Financing New Nuclear Power Stations"*—Paper presented at BNES "Fuel for Thought" Congress, Newport, July 2005.

[27] Digest of UK Energy Statistics –DUKES—Table 7.4.

So important are the challenges before us to have cost effective, carbon free, secure, affordable energy that we need to ensure all such technologies can contribute to their full potential. It is also important to ensure that a balanced portfolio is available. Furthermore it is wrong to treat generation (of any form) as an "either/or" with energy efficiency. Energy efficiency is important in its own right, irrespective of the means selected to deliver the electricity which is needed by the nation. Appropriate incentives and mechanisms should be put in place to improve prospects to deliver energy efficiency insofar as this is cost effective. Equally it is wrong to treat nuclear and renewables as an "either/or" choice. Both are needed. If it wished, Government could set minimum amounts for each technology as it has done by setting the current 2010 target of 10% via the renewables obligation (RO). A similar obligation approach for nuclear—alongside the RO—could ensure both had a firm place in the generation mix, without the technologies necessarily having to compete.

C. Strategic Benefits

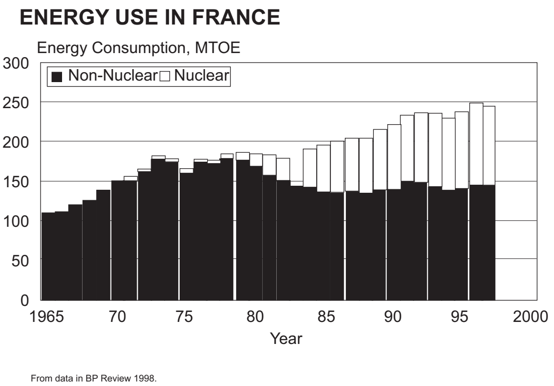
If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?

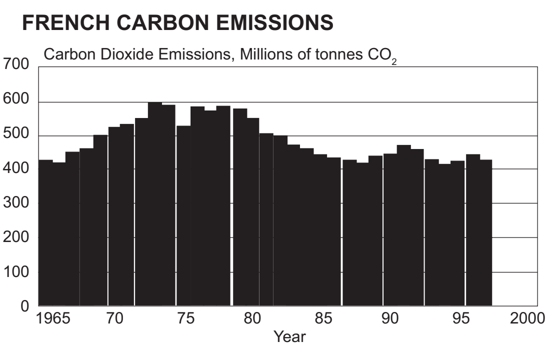
The following aspects of nuclear generation contribute to the overall public good:

- reliable secure baseload electricity over an operating life of typically 60 years;
- provision of very substantial quantities of virtually carbon-free electricity;
- easy maintenance of strategic fuel stocks (it is possible to store a year's fuel requirements for a fleet of 10 modern reactors in a building no larger than a small house);
- major improvement to the UK's balance of payments as a result of significant reduction in the volume of gas needing to be imported.

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

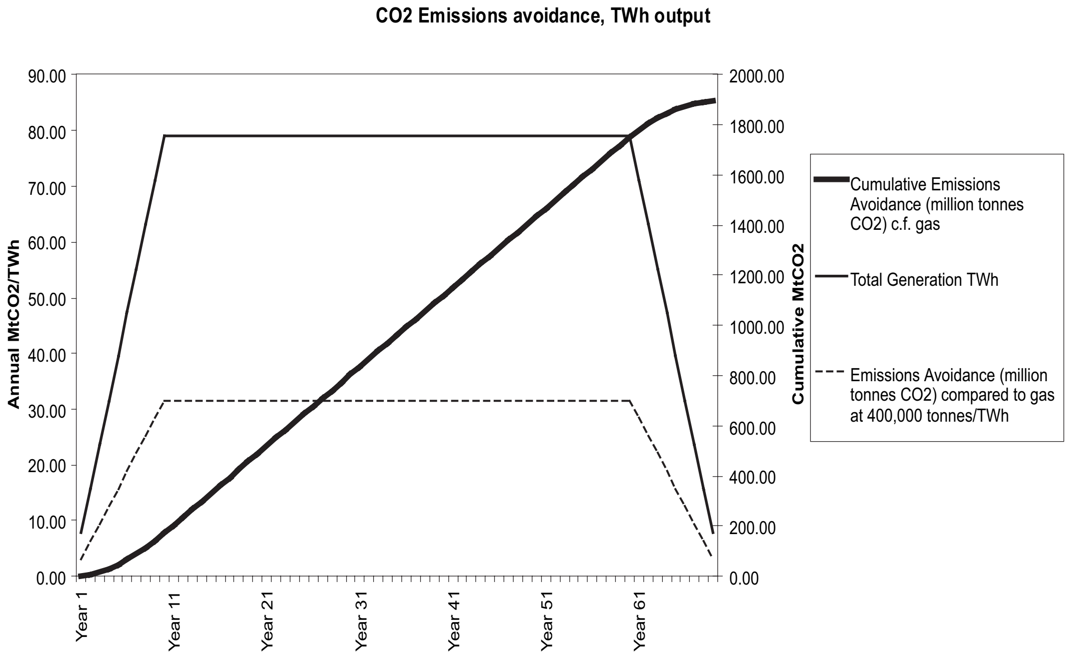
The significant contribution nuclear power makes to reduced carbon emissions can be seen from the French data (see charts below). This shows a major reduction in French carbon dioxide emissions, which maps exactly onto the increasing usage of nuclear energy in France. If new nuclear plants were to replace retiring nuclear stations in the UK, which would otherwise be replaced by gas-fired stations, then it is estimated that carbon emissions will be reduced by 3 million tonnes of carbon dioxide per year over the next 20 years. However, in the short term carbon dioxide emissions are likely to increase as coal and gas plants take up the demand previously met by nuclear plants which are closing.





The contribution made by nuclear new build in the UK would depend on the scale and timeframe of any new build programme. The contribution would also depend on what assumptions are made regarding what type of generation is being displaced by the nuclear generation.

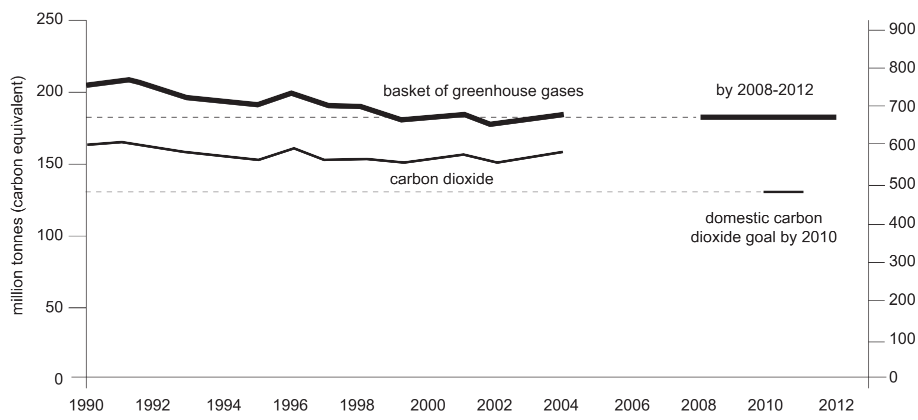
An illustration of what could be achieved is shown in the graph below. This assumes 10 new 1GWe nuclear power stations are built on a timetable of one new power station per year, with each station operating for 60 years. It has been assumed that the nuclear power stations will displace gas-fired generation, with emissions of 0.4 $MtCO_2$/TWh.



At their peak, for 50 years, these plant would generate 79 TWh annually, avoiding the emission of over 31 $MtCO_2$ each year. Over the entire 70 years period shown in the chart, these nuclear stations would avoid the emission of nearly 1.9 billion tonnes of carbon dioxide.

In comparison total UK carbon dioxide emissions for 2004 were around 580 million tonnes.

To put the scale of the challenge into context in percentage terms—the UK has a target of cutting carbon dioxide levels to 20% below 1990 levels by 2010. Yet—with just six years to go, in 2004 the reduction in emissions had only reached 4.2%, so more than three quarters of the savings still need to be made. Indeed emission have risen in each of the last two years, and are now higher than at any time since 1996, as illustrated in the following chart[28].

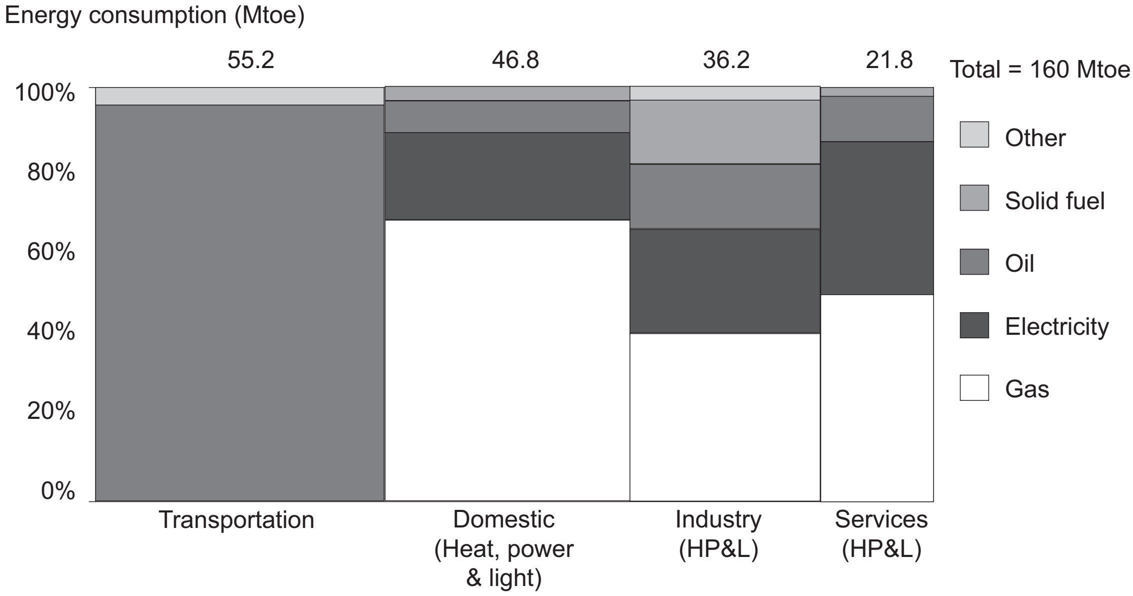


Note: Estimates for 2004 are provisional

Source: netcen

Looking to the longer term, it is important to think beyond purely the electricity sector, when looking at carbon emissions. The following chart shows a breakdown of total UK energy usage:

[28] *"Second Annual Report on the Implementation of the Energy White Paper"*; DTI/DEFRA; July 2005.



It can be clearly seen that, even if all the carbon emissions associated with electricity production were removed, more must be done if the UK is to get close to the target of a 60% overall reduction by 2050. Transport is one of the biggest contributors to emissions, and if a 60% cut is to be realistic, then major changes in the way we look at transport have to take place. The most credible approach is a move to hydrogen-powered vehicles, where the hydrogen itself is produced from a much larger electricity sector—fuelled by nuclear, renewables and fossil plants with carbon capture technology. This allows both the maintenance of viable transport systems and the achievement of major cuts in CO_2 emissions.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)

Reliable baseload generation is a key feature of nuclear energy—nuclear stations operate round the clock, day in and day out, irrespective of weather conditions. Apart from a periodic and predictable maintenance shutdown, the stations operate continuously at full power, providing the kind of baseload power a leading 21st century economy demands.

Modern nuclear power stations need to be re-fuelled only at infrequent intervals, typically every 12 to 18 months. Even if a refuelling could not take place as scheduled, the reactor could continue to operate for several months, albeit that the maximum power output would slowly decline. Considerations of fuel availability are therefore very different for a nuclear station than for a coal or gas-fired station, where a continuous supply of new fuel is required in order to generate electricity.

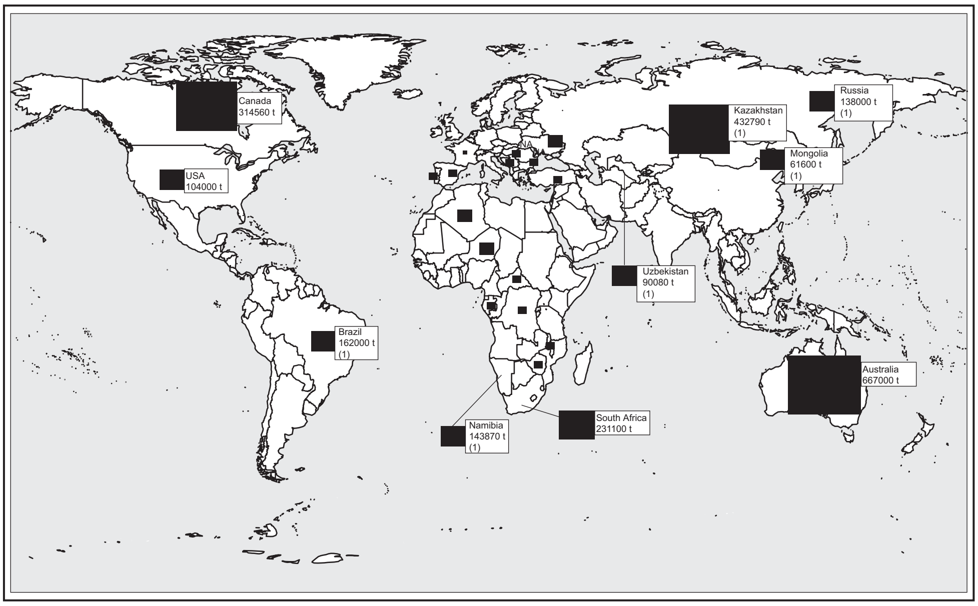
Furthermore, it is highly credible to retain strategic long-term stocks of nuclear fuel, just in case there ever were to be any sustained disruption to supply. The fabricated fuel to supply a fleet of ten new reactors (enough to supply 20% of UK electricity needs) for a year would occupy only around 100 cubic metres. This fuel could therefore be stored in a building no larger than a very modestly-sized house.

Nevertheless it is still sensible to consider the availability of uranium supplies and to ask whether this represents a realistic risk of interruption that might lead to loss of power production.

Uranium is ubiquitous on the Earth, indeed it is approximately as common as tin or zinc.[29] Uranium ores are found in plentiful quantities in many countries. In particular, Australia and Canada are both major exporters, as well as both having long histories of political stability. Additional reserves are known to exist in Kazakhstan, South Africa, Namibia and Russia.

[29] *"Supply of Uranium"*; World Nuclear Association Information and Issue Brief; August 2004 (http://world-nuclear.org/info/inf75.htm)

World Uranium Resources (RAR)
[t U] Reasonably Assured Resources as of 1/1/2001, Cost range US$80/kg U or less (OECD 2002)



(1) In situ resources
t=metric tonne NA= Data not available

KNOWN WORLD URANIUM RESOURCES[30] [1000 tU]

			Cost Category		
Resource Category	*$0-40/kgU*	*$40-80/kgU*	*$0-80/kgU*	*$80-130/kgU*	*$0-130/kgU*
Reasonably Assured Resources (RAR)	>666	>555	2,340	718	3,220
Estimated Additional Resources—Cat.I (EAR-I)	>257	158	745	244	1,079
TOTAL	>923	>713	3,085	962	4,299

Independent assessment[31] puts the total scale of conventional uranium resources at around 11 million tonnes, enough to last for around 170 years at current consumption rates (much longer than the corresponding figures for oil and gas). This would be enough to provide a lifetime's fuel for all of today's nuclear reactors worldwide, plus all those which might be built as far ahead as 2050, even in a scenario where world nuclear capacity were to triple to 1,200GW by that date.

Uranium ore is imported to the UK, and other countries where nuclear fuel assemblies are manufactured, where it is refined, enriched and converted into finished fuel. The transport of uranium ore does not require specialised ships or import facilities.

The diversity of source countries, the fact that several of these nations have long and stable political histories, the excellent track record of supply reliability, and the fact that there are few infrastructure considerations means that sufficient supplies of uranium to the UK can be considered to be assured.

The quantities of fuel involved for a nuclear plant are much lower than for fossil-fuelled stations. Whilst a coal-fired power station might consume several million tonnes of coal in a year, a modern 1 GW nuclear station will typically require a few tens of tonnes of fabricated fuel for each re-fuelling operation. As noted earlier, this might take place only every 12 or 18 months. Finally, again as noted earlier, nuclear energy also provides valuable cost stability, as well as supply reliability. This is because the cost of raw uranium ore accounts for only 5–10% of the overall generating cost of electricity from nuclear stations, whereas the cost

[30] "World Uranium Deposits", www.antenna.nl/wise/uranium)

[31] *"Uranium 2003—Resources, Production and Demand" (The "Red Book")*; OECD. [Resources with estimated costs lower than $130 per kg—a level which would have little impact on overall generating costs of nuclear electricity].

of gas-fired generation is dominated by the cost of the gas (which accounts for 60% or more of the full generating cost). Increases in global market prices for fuel therefore have a much greater impact on the costs of gas-fired generation than they do on the costs of power from nuclear.

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

In today's society there is a wide range of potential terrorist targets and it is important that the Government and organisations alike consider the possible threats, consequences and contingency plans that may prove necessary. The potential targets include many aspects of the nation's activities on which we depend for everyday life to proceed as normal. These therefore include—amongst others—public transport systems, iconic and political targets, and components of the infrastructure that provide important services to the public and industry. This includes the energy and utility industries, in the form of fuel import facilities, pipelines, storage facilities, power stations and transmission systems and in this context, it is appropriate to consider the physical security of nuclear power stations, as one component of the national security assessment.

Government aims to ensure the security of nuclear material, nuclear licensed sites, sensitive nuclear information and those working in the industry. These objectives are overseen by the government's security regulator Office for Civil Nuclear Security. The Director makes an annual report to the Minister on these matters. In his 2005 report[32], the Director continues to affirm confidence in the security provisions of the nuclear industry and that the security measures applied are proportionate to the threats faced.

Nuclear power stations are amongst the most robust civil structures in the world and have a multi-layered defence against possible terrorist attacks. They are also subject to rigorous security arrangements that include security vetting of all staff and contractors, identity management and access control. As a result, their potential vulnerability to terrorist or other malicious threats is minimised.

Modern reactors are built with massive reinforced concrete shields and are designed to safely withstand extreme events, both natural and manmade. Their structural resilience to earthquakes and the thickness of the shielding make them extremely robust against possible attack, for instance by hijacked passenger aircraft. Detailed analysis has shown that penetration of the radioactive core by an aircraft under such circumstances would not take place.

In addition to their physical robustness, modern nuclear reactors are protected by extensive safety systems. The extent and number of these systems is such that several systems would need to be damaged, and no action taken by operators or emergency responders, before a significant release of radioactivity to the environment might occur. The design is such that it is difficult to defeat or damage enough of the systems to bring about a major release of radioactivity. Emergency arrangements are in place to immediately shut down reactors in the event of a heightened terrorist threat against them. These arrangements are regularly tested.

D. Other Issues

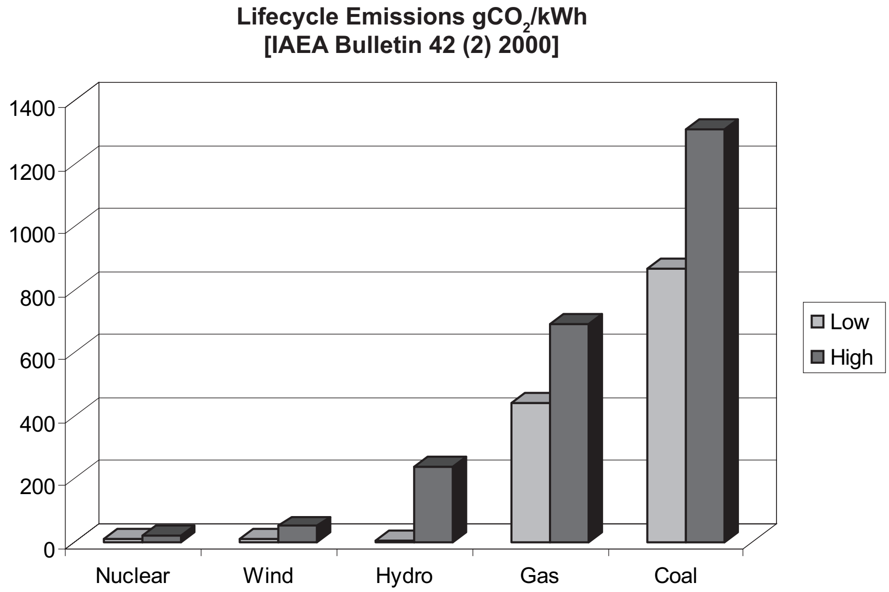
How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?

Nuclear energy is a very low carbon form of generation. Its lifecycle emissions per kilowatt-hour are similar to those from renewable generation. This is the case even when emissions across the full lifecycle of the nuclear industry are considered.

A comprehensive IAEA study[33] shows both direct and indirect emissions for different generation sources. This concluded that even the "high" end of the range of emissions for nuclear energy is still almost a factor of twenty lower than the best fossil fuelled plant (latest gas-fired technology) and a factor of over 60 lower than older, coal-fired technology. The "low" end of the nuclear range (representative of more modern technology) shows a further improvement by more than a factor of two on even this performance. This assessment takes account of the emissions associated with all aspects of the nuclear cycle—including the construction, operation and decommissioning of nuclear power stations, as well as the uranium mining and enrichment, and the manufacture and spent fuel treatment of nuclear fuel.

[32] *"The State of Security in the Civil Nuclear Industry and the Effectiveness of Security Regulation: April 2004 to March 2005"*; OCNS; July 2005.

[33] IAEA Bulletin 42 (2) 2000.



A significant contribution to the emissions from nuclear power generation is in the carbon content of the energy used in the different processes of the fuel cycle. This is one reason why emissions vary from site to site. For example, the enrichment process is energy intensive. In the US electricity from coal-fired stations is used to power the enrichment plant, whereas in France the electricity used comes from nuclear power plants. Consequently, the lifecycle emissions of nuclear power plants using uranium enriched in France are lower than those from plants using fuel enriched in the US.

The results of this study and two others into the lifecycle emissions of different forms of generation are summarised below. These results show that emissions for nuclear, wind and hydropower are much lower than those of fossil fuels.

		Lifecycle Emissions gCO_2/kWh			
	Nuclear	*Wind*	*Hydro*	*Gas*	*Coal*
IAEA[34]	9–21	10–48	4–236	439–688	866–1,306
International Journal of Risk Assessment & Management[35]	8.9	15	16	Fossil fuels: 500–1,200	
Vattenfall[36]	3	10	5	409	696

The Vattenfall study includes a typical breakdown of emissions for the different stages of the nuclear fuel cycle, shown below.

Stage of Nuclear Fuel Cycle	*Emissions gCO_2/kWh*
Extraction/leaching (mining)	1.1
Conversion	0.2
Enrichment	0.1
Fuel Fabrication	0.2
Operation of Nuclear Power Plant (NPP)	0.2
Building & Decommissioning of NPP	0.6
Waste Facility Operation	0.4
Build/Decommissioning of Waste Plant	0.1

Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste as recommended in 2000 by RCEP?

As mentioned earlier, the answer to this point is a clear "No". This is because so much has changed internationally since the RCEP report. The UK's legacy is a result of historic choices of system and an extensive prototypic programme pursued 40–50 years ago. Wastes from potential new build are nothing like as challenging or problematic. Safe disposal is being routinely demonstrated in other countries. However BNES and INucE recognise the very important challenges ahead in gaining political and public

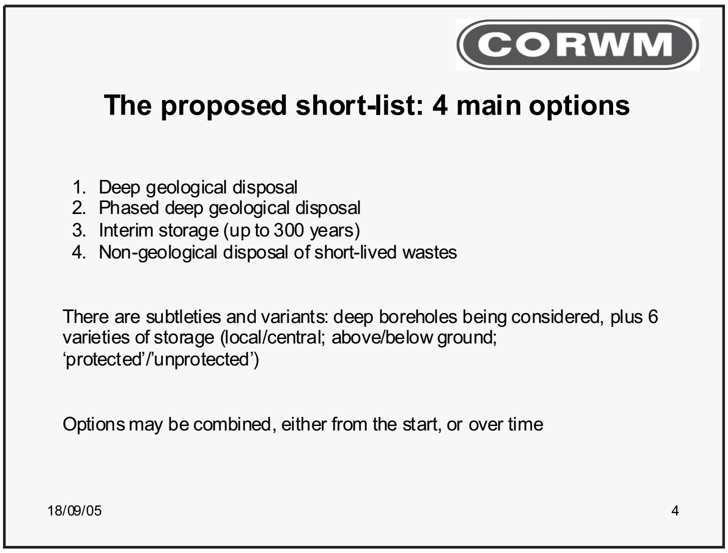
[34] IAEA Bulletin 42 (2) 2000.

[35] Joop F van de Vate, *International Journal of Risk Assessment and Management* 2002—Vol 3, No 1 pp 59–74.

[36] Life-Cycle Assessment Vattenfall's Electricity In Sweden, Eng 30966_Lca_Divk, 2005.

acceptability. Early implementation of the outcome of CoRWM's study and conclusions will be essential as will be good progress towards satisfactorily treating and packaging the legacy wastes in readiness for final disposal.

CoRWM's interim conclusions were published recently, indicating the direction in which their thinking is going:



3. Conclusions

The BNES and INucE strongly support the inclusion of nuclear power in a balanced future portfolio of energy generating options for the UK. In summary:

- **The Generation Gap** resulting partly from the closure of older nuclear stations will open up significantly over the next ten years, even if new build were to be started now. In order to secure a reliable and balanced mix in the medium term, decisions to progress new nuclear build must be made soon.
- **Financial Costs and Investment Decisions** associated with nuclear power have been analysed with rigour over the last few years by respected financial experts and it is firmly believed that the market would be prepared to invest under the right framework. The main issue remains risk, in particular those risks outside the investors' control to manage.
- **Strategic Benefits** associated with nuclear power are significant and include:
  - Provision of vast quantities of electricity with virtually no associated carbon emissions;
  - A substantial contribution to diversity and supply security in the generation portfolio;
  - Valuable price stability in the generation mix, at a time of highly volatile and uncertain fossil fuel prices;
  - A major impact on UK balance of payments as a result of the reduced dependence on imported gas;
  - Valuable, highly skilled long-term jobs in a crucial sector of the UK skillbase, and in communities which often have few comparable employment opportunities.
- **Other Issues** affecting the timescales for decision making in respect of nuclear need urgent action. Specifically:
  - Work on pre-licensing of established international designs should begin as soon as possible. This will help to maintain key skills and will cut the lead time for delivery of any new nuclear plant, without in any way implying a commitment to build.
  - The current lack of a formal waste policy should not be seen as an obstacle to taking steps immediately to encourage nuclear build. There is a process in place to deliver such a policy and the solution will be the same irrespective of whether or not new build takes place.

The BNES and INucE are grateful for the opportunity to contribute to the Environmental Audit Committee's enquiry and strongly recommend that measures are taken urgently by Government to allow nuclear power to contribute within a balanced energy mix (including fossil and renewable technologies) that ensures future security of supply for the UK and contributes to a significant reduction in carbon emissions for the benefit of future generations.

26 September 2005

Memorandum submitted by the British Retail Consortium

The British Retail Consortium

1. The British Retail Consortium (BRC) is the lead trade association of UK retailing and exists to defend and enhance where possible, the economic, political and social climate in which its members operate. BRC members sell a wide selection of products through centre of town, out of town, rural and virtual stores. Reflecting the diversity of modern retailing, BRC members include the large multiples and department stores, charity shops and small and medium sized independent retailers. In 2004 retail sales totalled £246 billion representing 35% of total consumer spending, channelled through 184,700 VAT registered retail businesses. The retail industry employs nearly three million people and accounts for one in nine (11%) of the total UK workforce.

Introduction

2. Climate Change is now recognised as a key driver of energy policy internationally, and the UK government has signalled that renewable energy technologies should be central in the future development of the UK electricity supply industry. The Government has set a target to generate 10% of the UK's electricity supply from renewable energy sources by 2010. At present, less than 3% of the UK's electricity supply comes from renewable sources. In order to meet the 10% target the UK will need to install approximately 10,000 MWe of renewable capacity by 2010, an annual build rate of over 1,250 MWe.

3. To promote business take-up of renewable technology, the Government has taken a number of positive steps, including:

- Climate change levy exemption for electricity generated from renewable energy sources;
- Reduction of VAT to 5% on renewable energy systems that are purchased from and installed by the same company;
- Business Rates exemption for "Good Quality" Combined Heat and Power (CHP) plant and machinery.

4. It is clearly anomalous for the Government to exempt CHP (which still emits carbon) from valuation but to rate entirely carbon free forms of renewable plant such as wind turbines and solar photovoltaics (PV). This paper argues that this anomaly in the rating system is leading the Government to perversely tax business investment in micro-renewable systems.

Valuation of Renewable Energy Plant and Machinery

5. For valuation purposed the Valuation Office Agency (VOA) does not make a distinction between small-scale renewable energy plant and traditional fossil fuel burning power generators. Accordingly an incongruous situation has emerged where retailers who look to reduce their carbon emissions by investing in renewables are penalised with increased liability. It is clearly anomalous for the Government to exempt CHP (which still emits carbon) from valuation but to continue to rate entirely carbon free forms of renewable plant such as wind turbines and solar photovoltaics (PV).

6. The rating of small-scale renewable plant is perverse in so far as retailers who look to reduce their carbon emissions by investing renewables are penalised with increased rating liability and retailers have voiced the opinion that this practice is a deterrent from taking up these important technologies. To remove this anomaly and bring rating practice in line with the Government's renewable energy plant and machinery should in our view be exempt from valuation.

7. Clearly VOA policy has not kept up with the pace of wider Government thinking on renewable energy and climate change. When CHP was exempted from valuation in 2001, retail interest in renewable technology was limited. However in recent years there has been a real growth in the renewable energy sector and now on-site renewable systems are an option for increasing number of retailers. It is clearly anomalous for the Government to exempt CHP (which still emits carbon) from valuation but to continue to rate entirely carbon free forms of renewable plant such as wind turbines and solar photovoltaics (PV).

Enablers and Barriers to Developing Renewable Technologies in the Retail Sector

8. Ernst & Young's global renewable energy market report ranks the UK as one of the two most attractive countries in the world for investment in renewable technologies. However, in the most recent edition of the report, the UK's position is downgraded for the first time because of the Government's business rates regime.

9. The retail sector has the potential to go some way in helping the Government meet its ambitious target of generating 10% of the UK's electricity from renewable energy by 2010. However at the present time it is still more cost effective for retailers to source their energy needs from the national grid. For the retail sector,

and indeed other business sectors operating these systems, micro-renewables are not a cost saving device. The rating of micro-renewables further re-enforces this situation. Retail investment in renewable energy systems must be encouraged by consistent policy support from Government, and a flexible style of policy capable of responding to technological developments.

28 September 2005

Memorandum submitted by Centrica

Introduction

Centrica was formed in 1997 when the former British Gas plc was demerged to form BG Group and Centrica. In the UK, it trades under its brand names, British Gas, Scottish Gas and Nwy Prydain. It is the UK's largest energy supplier, supplying gas and electricity to around 11 million gas and 5 million electricity customers in the domestic sector and around 900,000 in the Industrial and Commercial sector.

To support its supply businesses, Centrica owns both gas and electricity production assets. In recent years, as North Sea reserves have declined, Centrica has invested over £12 billion in new international gas supplies, helping underpin two new pipeline projects, BBL and Langeled, and one new LNG facility at Milford Haven. Its two gas contracts with Statoil and Gasunie will deliver 10% of future UK gas.

British Gas is also market leader in delivering energy efficiency advice and products to customers. Since 2000, it has made nearly 3 million homes more energy efficient, equivalent to 1 in 10 households in the UK. Around £200 million has been invested over the last three years by British Gas in helping customers save energy through our energy efficiency programme (2002–05). We will be investing a further £500 million in helping customers to save energy over the next three years (2005–08).

As part of an increasing environmental focus, British Gas is also investing in microgeneration and micro renewables. The company is working with Windsave on a domestic wind turbine and trials are expected to begin in the new year. In partnership with Microgen, British Gas will also be offering a microchp boiler to domestic customers. British Gas has also signed a heads of agreement with Ceres Power to develop the UK's first solid oxide fuel cell boiler.

Centrica has a significant £750 million renewable investment programme. A 26MW onshore windfarm in the Glens of Foudland is already delivering power and is expected to supply around 17,000 homes annually in Scotland with green electricity. The company also has planning consents under Round I developments for two offshore windfarms in Lynn and Inner Dowsing which, when constructed, will be the largest windfarm in Europe.

Centrica is 50% owner of and 100% offtaker from Barrow Offshore Wind, which is a 90MW offshore windfarm currently being constructed in Morecambe Bay. First power is due to be delivered by the end of 2005. This windfarm will produce enough electricity to satisfy the needs of 75,000 customers.

Centrica is a major participant in the EU Emissions Trading Scheme. Since the introduction of the scheme, Centrica has traded 30 million tonnes of carbon dioxide, which represents over 20% of the volume traded in the market.

Centrica's Position on Nuclear Power

Centrica is a "technology neutral" company. Our objective is to obtain cost effective, secure sources of electricity for our customers, while playing our role in reducing total carbon emissions. The very nature of the UK electricity market means a mix of technologies is required to balance and satisfy all the regulatory, economic, security of supply and environmental demands placed on the electricity generation industry.

Consequently, Centrica has no fundamental issues with nuclear generation which for many years has delivered secure and carbon free electricity. However, nuclear build is not an easy option and does not come without serious problems. These include:

Public acceptance

For the public to support large scale new nuclear build, it will be necessary to solve the outstanding long-term nuclear waste disposal issue. It is for the government to ensure that companies who own and operate new nuclear, do so in a safe and effective manner.

Planning and build problems

Given the local and political issues that will surround new nuclear build, we can expect the planning process to be extremely complex, with no certainty that at the end of the process consent will be given. The commercial risk is compounded by the fact that a great deal of expense in building new nuclear power stations is in the early stages of the project life cycle, when the company involved in the development of the project faces a number of costs associated with design, build and planning but is not yet making a return on its investment. In the nuclear sector, this period can take up to 10–15 years, compared to around 3–5 years for bringing online a new CCGT.

Waste and decommissioning

There is still no solution as to what to do with the nuclear waste and we will have to wait until the newly formed NDA delivers its proposed solution in 2006. Waste has significant problems associated with it in terms of public opinion and long-term safety.

Commercial

The time span involved to plan, build and make a return on investment for new nuclear build is longer than other forms of power and can take up to 50 years in total, (against the total product life cycle of a CCGT of 25–30 years). Investors would be wary of making such a long-term investment in any sector let alone the UK energy market, which has been subject to numerous policy changes over the last two decades.

To reduce the risk associated with new build, the government would have to provide either upfront subsidy or introduce a policy mechanism which forced retail suppliers to source a proportion of their electricity supply from nuclear stations. Both of these options would have a significant impact on the current liberalised market. Combined with the Government's desire to increase the Renewable Obligation to 20%, adding some form of nuclear obligation on suppliers would mean that almost one half of the energy supplied by private companies would be dictated by Government policy.

This would act to reduce the ability of suppliers to compete with each other, thereby impacting the price consumers pay, as well as reducing the potential of suppliers to source the most efficient sources of fuel for power generation needs.

The impact of the EU emissions trading on the development of less carbon intensive power production should not be ignored. By rewarding electricity generators that produce less CO_2 for every unit of electricity produced, the EU ETS builds the price of carbon into the power price and thereby favours nuclear generation.

It is Centrica's view that in addition to a decision on new nuclear build being made, real effort should be made to ensure the success of the EU ETS which, if allowed to work correctly, will deliver environmental savings at the lowest cost to the consumer.

Inquiry Issues

A. The Extent of the "Generation Gap"

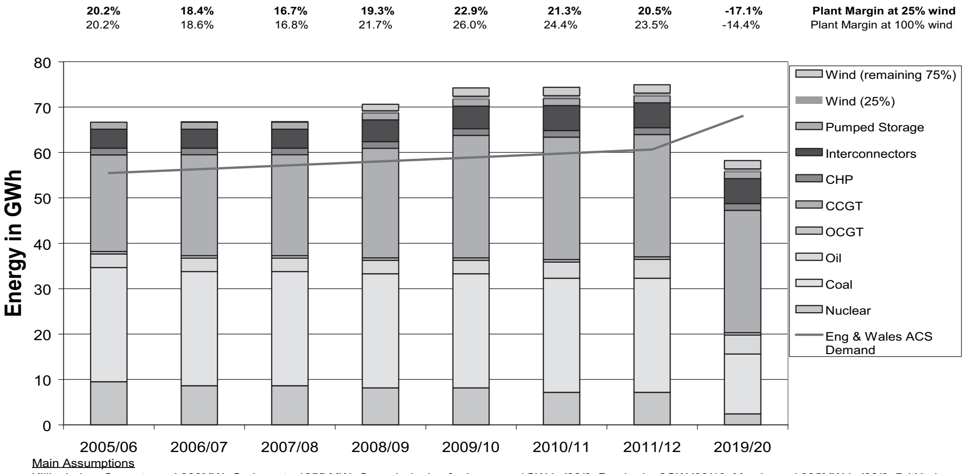
1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

1.1 Existing nuclear power stations in the UK currently meet around 19% of electricity demand. However, there has not been new build of nuclear power stations in Britain for over 10 years and as most reactors close over the next 20 years, this will leave only Sizewell B running until 2035.

1.2 Against this backdrop of declining nuclear power, many coal stations will be closing as a result of the Large Combustion Plant Directive (LCPD). With the implementation of the Directive in 2008, coal stations that have opted out will be allowed to generate for only a further 20,000 hours between 2008 and 2015, resulting in the closure of these plants by 2020.

1.3 Currently 40% of electricity generated comes from gas. This could increase over time as some of the new gas infrastructure comes on stream. Already the market is responding to higher price signals and delivering new capacity. Two new CCGTs have been granted planning consent for construction and more are expected to follow.

1.4 The graph below shows Centrica's analysis of the margin of power generation capacity over maximum demand. Whilst margin is tight in the short term, it increases from 2008–12 as new gas infrastructure comes on stream and as renewables make a greater contribution. However, assuming no new build, margin begins to fall off by 2019–20 as the result of the closure of the nuclear power stations and the effects of the LCPD.



Main Assumptions
Killingholme One returned 900MW, Grain up to 1355 MW. Commissioning for Langage 1GW in '08/9, Pembroke 2GW '09/10, Marchwood 935MW in '08/9, BritNed interconntr '08/9. Grain 590 MW in Oct 2010 and further 590MW in 2011.
Staythorpe 1.78GW and Immingham Stage 2 560MW will not happen.
Coal stations without FGD and 4.5 GW of nuclear closed by 2020
Dungeness B extended to 2018

1.5 Centrica believes the market will deliver the necessary capacity when needed. However, it is important that Government provides certainty in the regulatory framework going forward. Investment decisions need to be taken over the longer term but this is difficult in the current policy climate when the future energy picture looks so unclear. We would therefore urge the Government to give early clarification where possible on Phase II of the EUETS and EEC3.

1.6 Energy efficiency will also need to play an increasing role. However to date, the Government's record on energy efficiency has been disappointing. The Energy White Paper states that energy efficiency is the lowest cost carbon abatement tool. Yet despite the fact that 25% of carbon emissions come from the domestic sector, the Government has failed to introduce incentives to encourage people to invest in energy efficiency. Consideration should be given to how fiscal incentives—such as stamp duty and council tax rebates in the domestic sector—and capital allowances for the upgrading of existing commercial premises, can be introduced to encourage the take up of energy efficiency products.

1.7 British Gas and a number of Local Authorities have been trialling a green council tax rebate. Under the incentive, householders who install £175 of cavity wall insulation receive up to £100 reduction off their annual council tax bill. The "green home package" also provides a Home Energy Audit as well as energy efficient light bulbs to the value of £20. Initial response has been very encouraging, demonstrating an appetite for energy efficiency home improvements that are linked to council tax payments.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

2.1 Gas-fired combined cycle gas turbine (CCGT) has been the technology of choice for new build generation for the last 15 years and continues to be the most cost-effective form of new generation. For a company like Centrica looking to invest in new CCGT, a number of factors have to be considered based on an assessment of growth in demand and supply side issues and the difference between the market price of electricity and its cost of production.

2.2 Another consideration is the treatment of new entrants under Phase II of the EU Emissions Trading Scheme. The EU ETS has the potential to be a very effective carbon abatement tool. However, new entrants will be penalised if allowances are not allocated on the same basis as incumbents.

2.3 In March this year, Centrica commenced an invitation to tender process in order to evaluate the full costs of developing a 1,000MW combined cycle gas turbine power station, Langage located in Plymouth, Devon. The Invitation to Tender is currently under way and we expect the evaluation of the bid to be completed by the end of the year. However, a key factor in determining whether Centrica proceeds with construction will be an assurance from Government that new entrants will receive allowances on the same basis as incumbents. This is essential to preserve competition and to secure the commercial viability of the project. We estimate that the effect of not receiving allowances for Langage would mean we would have to go out into the market every year to buy at least £30 million worth of allowances, thereby putting us at a significant disadvantage to our competitors who would of course get the majority of their allowances free.

2.4 Where available, the generating costs, availability, reliability and efficiency of coal, nuclear, Gas CCGT, offshore and onshore wind and wave and tidal can be found below. The data shown are estimates only, and the performance of individual sites may vary outside to the indicated data, but it is representative of each industry, according to Centrica's analysis.

	Coal	Nuclear	Gas CCGT	*Offshore wind*	*Onshore wind*	*Wave and marine*
Cost of Generating p/kWh	2.10–3.33	2.25–3.37	1.94–2.58	5.52–7.00	3.10–3.68	6.00–7.00
Availability	92%	90%	95%	100%	100%	
Reliability	84%	71%	90%	96%	97%	
Efficiency	36%	30%	45%	38%	30%	
Estimated construction costs (£/kW)		1,100	400	1,300	850	
Estimated ongoing operating costs (£/kW)—excluding fuel costs		60	20	45	15	
Estimated fuel cost (£/MWh)		3	27	0	0	
Estimated planning period		5–7 years	1–3 years	2–3 years	2–3 years	
Estimated construction time		5–10 years	2–3 years	1 year	1 year	

Cost of Generation—The Royal Academy of Engineering—March 2004, University of Chicago—The Economic Future of Nuclear Power—August 2004, British Energy media statements.
Availability—Planned availability—Centrica estimate.
Reliability—Planned and unplanned availability—Centrica estimate.
Efficiency—Centrica estimate.

3. *With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience?*

3.1 In the past, nuclear programmes in the UK and elsewhere have significantly underestimated both the construction and lifetime costs. In many cases, indirect costs such as insurance and underwriting the back-end and fuel disposal liabilities have not been fully accounted for. Prior to any reassessment of the nuclear option, a comprehensive review of the true costs needs to be carried out.

4. *What are the hidden costs (eg waste, insurance, security) associated with nuclear?*

4.1 Costs need to be explicit to ensure that the economics of all generation technologies can be compared on a like for like basis. This includes waste, full liability cover (and any government caps must be transparent), training a new generation of technical staff for large build program, licensing and approvals, design selection (ie sunk costs), and a reflection of all capital costs (ie charge of interest during construction).

5. *How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?*

5.1 There are a number of international models that have tried to ensure funding has been set aside to ensure the back end liabilities are dealt with. These need to be evaluated, and ensure they are compatible to a liberalised market and deliver on all obligations. The model would have to ensure the funding is ring fenced and reflect the full lifetime costs and costs associated with decommissioning and waste disposal.

6. *Is there the technical and physical capacity for renewables to deliver the scale of generation required?*

6.1 Physical capacity is limited to sites being able to obtain grid connection/capacity and planning permission. Windfarms are considered to be the leading renewable technology. However sites that are suitable for onshore windfarms are near saturation. This has forced developers offshore which although has increased costs will give access to better wind resource and allow construction on a larger scale.

6.2 There are currently some limitations in the supply chain with different countries competing for the same supply capacity. It is therefore important that these suppliers have longer term confidence in the demand for renewables in order to make the necessary investment.

6.3 Technical capacity is limited by the intermittent nature of wind. However as forecasting technology becomes more sophisticated and the number of windfarms across the country grow (creating a portfolio effect), power generated will become more certain. It must be noted the amount of renewable generation capacity necessary to displace the equivalent firm nuclear generation capacity to the network, is substantially more and therefore considered an inefficient substitute for nuclear generation.

6.4 Renewable generation also has difficulty following on demand load requirements because of its intermittent nature and inability to deliver large scale capacity.

7. *If there is the capacity, are any policy changes required to enable it to do so?*

7.1 Any policy supporting renewables must provide an expeditious and predictable planning process for renewable technology. This ensures we can forecast and rely upon any capacity promised for delivery.

7.2 Given the development times required for new technology to become competitive, the Government must provide a stable environment for economic support, with a focus on ensuring that any new techonogy with potential is focused upon and developed as quickly as possible. The Government must also ensure that such technologies can become cost effective as quickly as possible.

7.3 Future capacity may be affected by a shortfall in funding for Round II projects. It was the expectation of Government and Industry that the costs of Round 2 offshore wind would fall to £1 million/MW. This has not materialised for a number of reasons including global rises in steel prices and problems with early offshore farms under Round 1 which have made contractors nervous. As a result, prices for subsequent developments have risen, making companies reconsider their investments. Round II projects are key to delivering the Government's renewable energy targets and it is unlikely that the 10% by 2010 target can be met without these projects going ahead.

8. *What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?*

8.1 Micro-CHP and micro-wind now offer real potential with recent developments in technology. Microgeneration also has the advantage that power can be generated locally thus reducing loss in transmission. British Gas is already working with Windsave on a domestic wind turbine with trials beginning later this year. It is also working with Microgen on a microchip unit which is expected to be available for sale from British Gas in 2007.

8.2 However, the key test will be the transition to mass market which will be essential in terms of reducing costs. To make this transition happen, a number of barriers need to be addressed, including:

8.2.1 *Cost constraints*—the lack of demand for microgeneration technologies has restricted the extent to which the industry has been able to exploit scale economies and learning effects in their production. Combined with the infancy of the industry, and the significant expenditure on R&D associated with product development, this means that the costs of these products are currently very high and act as an economic barrier to their uptake.

8.2.2 *Information constraints*—inadequate promotion and provision of information on microgeneration and the lack of a widely understood accreditation system for products and installers, reduces the incentive for consumers to purchase microgeneration products due to insufficient signals regarding the quality and characteristics of these products.

8.2.3 *Technical constraints*—the lack of metering arrangements that meet the needs associated with the management of electricity distribution and the needs of the consumer, and the lack of a comprehensive approach to dealing with the issues surrounding the connection of microgenerators to the distribution network, constitute barriers of a technical nature that could be preventing take-up of microgeneration technologies.

8.2.4 *Planning constraints*—are currently unclear as to what planning requirements are needed for installation of domestic wind and solar power.

9. *What is the attitude of financial institutions to investment in different forms of generation?*

9.1 Financing new nuclear is linked to the ability to insulate construction/technology and decommission liability risks. If the Government creates a clear stable operating framework, the market will look at innovative financing solutions.

9.2 CCGT can be financed and constructed without government intervention. As windfarms are a new industry, regulation is needed to ensure financing is available for the industry. This is used primarily to stimulate technological and manufacturing innovation. Wind is expected to fall in cost over the long-term and be able to compete with conventional technology, particularly as the EU ETS successfully builds the price of carbon into power prices.

10. *How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

10.1 If a stable policy framework is put in place by the Government and certainty in forward power prices could be given, then it is possible that nuclear could be economic. However, price certainties on the timescales for new nuclear seem incompatible with a competitive energy market. If the solution to this problem was to move away from competitive market principles, Centrica would not be in favour of this.

10.2 The long pay-back periods typical of new nuclear plants may make it difficult to attract private sector investment.

11. *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

11.1 The likely time at which first power would be delivered from a nuclear programme is 10–15 years meaning that new nuclear would simply be replacing current nuclear build which is coming to the end of its life. This would not displace the need for renewables which will continue to play an important part in the fuel mix.

11.2 However it is important that the Renewables Obligation remains in place and any nuclear program or policy development is independent of the Renewables Obligation.

C. Strategic Benefits

12. *If nuclear new build requires government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

12.1 Although nuclear is a zero carbon emitting technology, when evaluating nuclear's contribution to the issue of carbon, the mining and processing of fuel must also be considered. It is a very industrial process.

13. *To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?*

13.1 New nuclear build is one alternative in ensuring security of supply, particularly given its compatibility with a low carbon economy. However, the dynamics of energy procurement are changing and with the decline of North Sea gas, the UK is becoming more dependent on international sources of energy. As such, the emphasis is gradually shifting from having a diversity of fuel types to having diversity of supply of fuel.

13.2 This is especially so with gas. As North Sea reserves decline we are looking further afield for our gas, from countries such as Nigeria, Algeria and Russia as well as Norway and the Netherlands where sources are plentiful. Global LNG provides important diversity for Europe.

13.3 New infrastructure is being built to bring gas to the UK, including two new pipelines—BBL and Langeled. Capacity in the interconnector UK has been trebled and three new LNG import terminals are being built.

13.4 Yet capacity does not guarantee supply. As the UK becomes more dependent on transporting its gas though mainland Europe it is increasingly important that European energy markets are liberalised so that the UK can get access to pipelines. Centrica continues to lobby both the UK Government and the EU Commission to put pressure on National Government's to implement the Energy Markets Directive (2003) and liberalise their markets.

14. *In respect of these issues how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

14.1 There are clearly issues around waste management and decommissioning which are exclusive to nuclear and complex planning process can create delay in construction. However, successful new build that does not over-run on costs, as all previous nuclear construction programmes have, will add to diversity and security of supply and deliver low carbon power generation.

14.2 It is important though that any decision on nuclear new build does not overshadow or minimise the contribution that can be made from renewables, microgeneration and energy efficiency which have a major role to play in meeting energy policy goals. It is widely acknowledged that energy efficiency is the lowest cost option in delivering the Government's low carbon policy and, together with renewables and microgeneration, should remain a core part of Government's energy policy.

D. Other Issues

15. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

This has been addressed under earlier points.

16. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

16.1 Centrica is not an expert in this area and does not have detailed figures on carbon intensity of construction, operation and uranium mining. We agree that nuclear power should not be declared carbon free without a detailed analysis of the carbon emissions from construction, operation and mining. However this should be a level playing field. The emissions should be examined by comparison to those involved in coal and gas-fired generation.

3 October 2005

Memorandum submitted by the Chemical Industries Association

The Chemical Industries Association welcomes the Committee's decision to launch the above inquiry. We believe that the security of supply aspect of the energy debate in the UK, as highlighted by the phrase "Keeping the lights on" in the title of your inquiry, should not be lost in the arguments over climate change.

We leave it to better qualified specialists to provide responses to the detailed technical and economic questions you pose, but have some general comments from the perspective of our industry as consumers both of energy and of hydrocarbon resources as feedstocks. The latter are used in the manufacture of petrochemical intermediates which are themselves used to make products as diverse as dyestuffs, plastics, adhesives, paints, pharmaceuticals, detergents, cosmetics and toiletries.

1. Although the formal notice of the Committee's inquiry makes no reference to gas, other than indirectly by mentioning "CCGT" as one of several large scale generation technologies, we believe that the role of gas is critical to any assessment of future generation options. In order to avoid having to contemplate the replacement of nuclear capacity, the Energy White Paper proposes such a heavy dependence on gas for our future energy needs that it carries enormous risks for our fuel security, quite apart from limiting scope for reducing CO_2 emissions. High and volatile UK gas prices are already putting UK industry at a huge competitive disadvantage. We are projected to become ever more reliant on imports, either via long pipelines from which others will be seeking to draw supplies, or by using expensive specialised ships and unloading terminals for transporting liquefied natural gas over considerable distances. The liquefaction process is itself energy intensive. Moreover, to use such a flexible and versatile resource for such a large proportion (already 40%) of our electricity generation, when alternatives are available, seems wasteful in the extreme. We believe that hydrocarbons should preferentially first be used to make products, which after being recycled as many times as possible, can ultimately be incinerated for energy recovery. The same is true of biomass: growing, harvesting and immediate burning of such materials (other than waste) is an extremely inefficient means of converting solar energy, while denying first use of renewable sources of molecules for products.

2. Most renewable energy sources, whether wind, wave, tide or solar, provide irregular supplies. The last three have known cyclical variations within a day, month or year, and can to some extent be balanced. Wind, however, has no predictable behaviour. Although variability can be minimised by networking very large numbers of geographically dispersed installations, this means higher grid costs and even then the amount of power which can be guaranteed available at any given time (at least from within the UK) is but a tiny fraction of nominal aggregate capacity. The grid needs to be able to call upon dependable generation capacity immediately when required, in order to assure system integrity and certainty of supply. We believe that the Committee should investigate the feasibility and cost of providing complementary means of storage or other back-up capacity for such inherently variable renewable sources. A combination of wind and associated hydrogen generation and fuel cells might work, but it seems inevitable that other forms of standby capacity will also be required.

3. Our industry's raw materials are mainly commodities bought at global prices, while its primary products are similarly sold into global markets. The cost of the conversion process depends principally on the cost of energy, since the technology which determines the efficiency of large scale chemical

production processes is generally available to all the main competitors. The competitive position of companies is therefore closely tied to relative energy costs. At later processing stages where products become more specialised there is some ability to protect margins through differentiation, but the viability of the UK's producers of primary products remains an essential foundation. We ask, therefore, that the Committee keeps the need to ensure competitively priced energy for UK industrial users as a prime consideration throughout its deliberations.

5 September 2005

Memorandum submitted by the Confederation of UK Coal Producers

The Confederation of UK Coal Producers (CoalPro) represents member companies who produce over 90% of UK coal output. CoalPro is not opposed to the development of any form of energy. CoalPro is pro-coal.

CoalPro welcomes the opportunity of providing views on this inquiry. We do not pretend to be experts on the costs of nuclear and renewable electricity generation but would like to make some comments on the inquiry issues set out in the press release. Before doing so, we would like to preface these specific responses with some general remarks.

The recent public debate appears to have focussed on whether new and/or replacement electricity generating capacity should be nuclear or renewables. This debate has created a great deal more heat than light. It is thoroughly misplaced and completely fails to address the most basic issues.

Most, if not all, of the UK's nuclear generating capacity will close over the next 20 years. A programme of nuclear new-build will be very expensive and will have to overcome severe difficulties associated with planning and the treatment/disposal of waste. It will do no more than replace this capacity and there will be no reduction in carbon emissions from the electricity generating sector.

Electricity consumption is increasing by 1 to 1.5% each year. The Government has an aspiration to achieve a contribution from renewables of 20% by 2020. This, too, will be very expensive (a cumulative cost to the electricity consumer of £6 billion by 2010 has been estimated) and will also require a major effort in terms of planning and technology development. A contribution of 20% by 2020, even if it can be achieved , will do no more than offset the increase in electricity consumption and again there will be no reduction in carbon emissions from the electricity generating sector.

It is clear from the above that the entire nuclear/renewables debate is merely playing around the edges of the problem. A programme of nuclear new-build and a 20% contribution from renewables will both require enormous expense and Herculean efforts in other respects. Even if both are achieved, it will do absolutely nothing to address the problem. The net effect on overall carbon emissions will be zero. Fossil fuel consumption will remain at its present level.

CoalPro does not oppose either strategy but is convinced that much more need to be done if any significant reduction in carbon emissions is to be achieved let alone the deep cuts called for by the White Paper. Carbon emissions from fossil fuels will have to be addressed.

The nuclear and/or renewables strategies therefore need to be supplemented by a programme of new-build higher efficiency coal plant and by carbon capture and storage from both coal and gas plant. This is the only way that significant net reductions in carbon emissions can be achieved. Not only that, in cost terms, such an approach may well be significantly cheaper per tonne of carbon reduced/avoided than either the nuclear or renewables strategies.

I now turn to the individual issues referred to in the press release.

A1. The Extent of the "Generation Gap"

50% of the UK's present generating capacity is either coal or nuclear. Some 10GW of nuclear capacity is likely to close over the next 20 years (all except Sizewell B). The extent of coal plant closure will depend upon final decisions on whether plant will be opted-in or opted-out of the LCPD, but a range of 10-15GW of coal plant is likely to close by 2015. Some of it may close earlier.

If this is not replaced, the lights will go out under any conceivable demand forecast. Even the most monumental effort on renewables will have a minimal, if any, impact on closing the gap. A hugely expensive and extremely difficult programme of nuclear new-build will do nothing to address the gap caused by the closure of coal plant.

Energy efficiency policies may have an impact but show no signs of doing so at present. They cannot close the gap on their own and to rely on them doing so would be thoroughly irresponsible.

The danger is that the gap will be plugged by new gas plant because of its low initial capital costs which, in an uncertain world, exacerbated by regulatory uncertainty, minimise risk. This will occur by default, will have enormous security of supply implications and will lead to very high prices for both gas and electricity.

B2. Financial Costs and Investment Considerations

CoalPro is not competent to comment in detail on the cost and timescales of different technologies but welcomes the Committee's intention to examine both capital and ongoing operating costs of all technologies, including low-carbon coal. CoalPro would suggest that these costs are measured in terms not only of the costs of generation but also of the cost of carbon emissions reduced/avoided.

With respect to ongoing fossil fuel costs, the Committee will be aware that there is now a significant price differential between coal and gas which has lead to increasing coal burn. Indeed, coal burn has increased by nearly 2 million tonnes in the first half of 2005 compared with 2004, despite the introduction of the Emissions Trading Scheme and carbon prices of over €20 per tonne.

Some will argue that the gas price will fall as new infrastructure for importing gas is commissioned over the next few years. However, this runs the real risk of exchanging a UK/European gas price for a world gas price. With the United States now short of indigenous gas, gas imports to that country are rising steeply and US gas prices are higher even than UK average gas prices.

B3. *What is the attitude of financial institutuions to investment in different forms of generation?*

Financial institutions require certainty in order to invest. The renewables obligation and other measures provide certainty for renewables. Some form of Government guarantee would be required for investment in nuclear as has been given for the new nuclear plant in Finland.

CoalPro is convinced that neither closure of the generation gap, nor deep cuts in carbon emissions can be achieved without investment in replacement low-carbon coal technology if unacceptable price and security of supply risks are to be avoided. A pre-requisite is regulatory certainty in the form of long-term carbon allowances under the Emissions Trading Scheme going well beyond Phase II for a total period of at least 15 years. This will then need to be supplemented by a policy framework and economic instruments, perhaps including a competitive bidding element.

It may be that a major nuclear investment programme will impact on investment in renewables and energy efficiency, and may also impact on investment in other low-carbon technologies. But the question is misplaced. It is clear that neither on their own, nor both together will come anywhere near getting the job done. It is not a question of either/or. Large scale investment across the board in multiple technologies will be required. The issue cannot be avoided.

C4. Strategic Benefits

Nuclear new-build will not reduce carbon emissions. It will merely avoid an increase that would otherwise occur. Nuclear new-build would contribute to security of base load supply but it should be noted that electricity demand varies significantly both diurnally and seasonally. Nuclear generation is inflexible and cannot contribute to security of supply for higher loads.

C5. Comparability is not the issue. Investment in all options (not only nuclear and renewables) will be required. All options are compatible with each other and with the White Paper strategy. Indeed, without investment in all options, the multiple objectives of the White Paper cannot be achieved.

D. Other Issues

6. No form of electricity generating technology is carbon-free. Many of the considerations related to carbon emissions associated with the construction and operation of nuclear power stations, and the mining and processing of uranium, also apply to the various forms of renewables.

7. CoalPro believes that the nuclear waste issue should be resolved before committing to new-build. This is not an anti-nuclear point. It is a statement requiring political will.

22 September 2005

Memorandum submitted by Robert Corran

With regards to the generation of electricity nuclear power stations provide a clean source of power generation, at Sellafield the 4 no Magnox Reactors which were used to provide power for Calder Hall have been shut down and are currently subject to being decommissioned.

I believe that when the decommissioning is complete the government have at their disposal an ideal location where a new Nuclear Power Station can be built, with no direct impact on the environment as it would be inside the confines of the existing Sellafield complex.

On top of this it would provide new much sort after jobs for people in Cumbria, which at present is in a depressed state due to government cut backs in both the nuclear and defence industries.

26 July 2005

Memorandum submitted by the Country Land and Business Association (CLA)

Introduction

The Country Land and Business Association (CLA) represents approximately 40,000 members who between them own and manage more than half the rural land in England and Wales. We have long held concerns on the effect of climate change on our members property and businesses, and published a ground breaking report in 2002 "Climate Change and the Rural Economy", available from our website at www.cla.org.uk/climatechange

More recently we have undertaken our own review of current renewable energy policy, a copy of which (together with a copy of the executive summary) we are pleased to enclose by way of the substantive element of our response to the EAC enquiry [not printed].

Inquiry Issues

1. The Extent of the Generation Gap

Whilst we were unable to quantify the real extent of the generation gap in our report, we recognised that current policy is unlikely to deliver secure and sustainable energy supplies in order to keep the lights on in 2020.

We have laid out a range of policy recommendations, set out in the paper, which we consider are likely to deliver sufficient carbon neutral electricity generation, at the same time as delivering significant carbon savings in other forms of energy supply, notably in renewable heat and transport fuels.

Clearly, maintaining a secure and stable electricity generation capacity is a key target. Our members, like other business and domestic consumers rely on electricity. However, we have pointed out that, even in renewables, carbon savings can be achieved at lower costs in the heat sector which has so far been ignored in policy terms. We find this astonishing, given that more than a third of UK emissions are created in space and process heating.

It is for this reason we fully support the proposed "Renewable Heat Obligation" set out in Mr Mark Lazorowicz MP's private members "Climate Change and Sustainable Energy Bill" which we urge the EAC to support at its second reading on 11 November 2005.

2. Financial Costs and Investment Considerations

Our report "Renewable Energy: More than Wind" deals with the relative costs and benefits of alternative technologies. We have not sought to cost nuclear generation, it being outside our area of expertise, but have brought together information on relative carbon savings from different policy options.

Our analysis leads us to the conclusion that addressing the requirement to reduce greenhouse gas (GHG) emissions will add costs, but that in order to secure a thriving economy, energy efficiency alone cannot be relied on.

We have factored in a wide range of external costs and benefits which we see flowing from different forms of renewable energy, and have flagged up the very large contribution that the countryside can make to the mix.

We would urge the EAC to recognise the importance of renewable delivery outside of the electricity sector. Whilst this is important, it can only ever address the current GHG produced in that sector: some 25% of the UK total. Renewables have a place in addressing the remaining 75%.

Our policy recommendations are designed to ensure that the countryside, and rural business, can make the maximum contribution possible to delivery of secure and sustainable energy supplies.

We are confident that the capacity exists to deliver were our recommendations adopted.

3. What is the Attitude of Financial Institutions to Investment in Different Forms of Generation?

The design of the Renewables Obligation, in a "one size fits all" policy, together with the New Electricity Trading Arrangements, has ensured that wind power has secured very nearly all the capital investment available.

We see real dangers in this policy in terms of long term security of supply. Our analysis shows that costs rise significantly when wind power provides more than 10% of supply (owing to its intermittency) and that even this level required significant investment in the network which is not costed to the generators.

We see a real opportunity for a more widely dispersed and sustainable local generation policy, in which system risks are minimised by a large number of smaller scale local generators, backed up by stable load generation and the National Grid.

This implies that nuclear has a future, but we doubt that current policies will deliver the required investment, nor will the private sector alone be able to deliver the necessary waste management solution.

4. Strategic Benefits

Our report, cited above, shows that very large public benefits can be delivered in building capacity other than nuclear generation. In particular, we would point to the huge benefit to the range of public goods and services provided in the countryside through improved management of woodlands, new planting, and reduction of waste disposal.

That said, we are concerned that the strategic importance of security of supply, in particular in relation to intermittent wind generation, has not been recognised in renewable policy to date.

It is for this reason we argue that less should be paid to intermittent generators, and more to secure and stable generators, under a banded Renewable Obligation (RO).

We doubt that the RO is suitable or capable for securing replacement nuclear generation capacity.

We regard the replacement, and perhaps enhancement, of existing nuclear generation on the same sites as at present, as important alongside new renewable energy development. We agree it is necessary for replacement to take place to keep the lights on, and whilst there are undoubted risks in respect of security and terrorism, we do not regard these as fatal. Indeed, the current policy option of increased imports of compressed natural gas by ship presents more numerous and rather harder to defend targets to terrorism activity. Our report quotes the RUSI analysis that details security concerns on increasing exposure to risk as the UK becomes a net energy importer.

5. Nuclear v Renewables: Compatibility

We see little conflict between a new nuclear replacement policy and a wider and more sustainable renewable energy policy taking in heat and transport fuels.

The necessary precursor is that Nuclear should have its own support mechanism, separate from renewables more generally, and that steps should be taken to resolve the question of nuclear waste.

We regard a wide mix of renewables in all sectors, including microgeneration, SME based CHP or heat units, and regional renewables installations as being as important as nuclear. We do not suggest that there is one magic bullet.

Even if all electricity generation was nuclear, UK would still face a huge challenge in energy efficiency in order to meet the RCEP 2050 target for GHG reductions. We do not see such efficiencies arising without an overall reduction in economic activity and consequently our standard of living, and therefore regard it as essential we seek renewable energy in the heat and transport sectors.

6. How Carbon Free is Nuclear?

Please see our report [not printed].

7. Should New Nuclear be Conditional on Waste Solutions

Yes, subject to a reasonable risk assessment. We do not see that an absolute guarantee is feasible in this area.

23 September 2005

Memorandum submitted by Karen Cousins

Abstract

The United Kingdom's recent Energy White Paper establishes the goal of reducing carbon dioxide emissions by 60% of 1990 levels by 2050. A limited number of realistic options exist to reduce carbon emissions from the electricity sector, including efficiency improvements, increased use of renewable energy sources, carbon sequestration plants, and nuclear power. This paper investigates how UK's economic and energy growth projections can be reconciled with the government's plans for carbon abatement, given that renewable energy has practicable limitations and feasible electricity efficiency improvements are constrained below 2%/year. Under the relatively plausible assumptions, it is found that the UK will be unable to meet electricity demand in 2050 without a large scale program of nuclear energy or carbon sequestration.

The Author

Karen Cousins is a graduate student at the University of Oxford. Her thesis involved an in-depth analysis of energy policy and the energy market in the United Kingdom, and focused on reconciling the Government's carbon abatement ambitions with the country's energy needs. Particular attention was given to the potential and costs of nuclear power.

1. Introduction

1. Electricity generation from fossil fuel energy sources is a major contributor to global emissions of carbon dioxide, a greenhouse gas that contributes significantly to climate change (Ansolabehere *et al,* 2003). Fossil fuel energy sources have formed the basis of the world's economy since industrialisation (IPCC, 2001a) and reducing carbon emissions from electricity generation is a significant challenge. A limited number of realistic options exist to reduce carbon emissions from the electricity sector, including:

- improved efficiency in electricity generation and use;
- increased proliferation of renewable energy sources such as wind, solar, biomass, and geothermal;
- carbon capture and sequestration at fossil-fuelled (especially coal) electricity generating plants; and
- increased use of nuclear power (Ansolabehere *et al,* 2003).

2. The threat of climate change is recognised by the United Kingdom's recent Energy White Paper, "Our Energy Future—Creating a Low Carbon Economy", (DTI, 2003a), which establishes four key goals for energy policy, one of which is to "place the UK on a path to reduce carbon dioxide emissions by 60% of 1990 levels by about 2050". The aspiration of achieving a 60% reduction in carbon dioxide emissions is an ambitious one, particularly given that at present over 70% of the UK's electricity is generated from fossil fuels.

3. Moreover, electricity consumption in the UK is steadily increasing. Although the switch from coal to gas has prevented significant growth in carbon dioxide emissions, from 2010 onward, as nuclear power stations begin to close, dependence on fossil fuel sources of electricity is projected to increase and carbon dioxide emissions are forecast to climb (DETR, 2001).

4. Meeting the carbon dioxide emission reduction target will require significant cuts in carbon emissions from electricity generation. Electricity generation is responsible for 38.1% of emissions in the UK, as shown in figure 1.3. Emission cuts from electricity generation are likely to require both energy efficiency improvements and a significant shift to carbon-free sources of electricity.

Figure 1.3: UK 2003 emission generation, by sector (%)

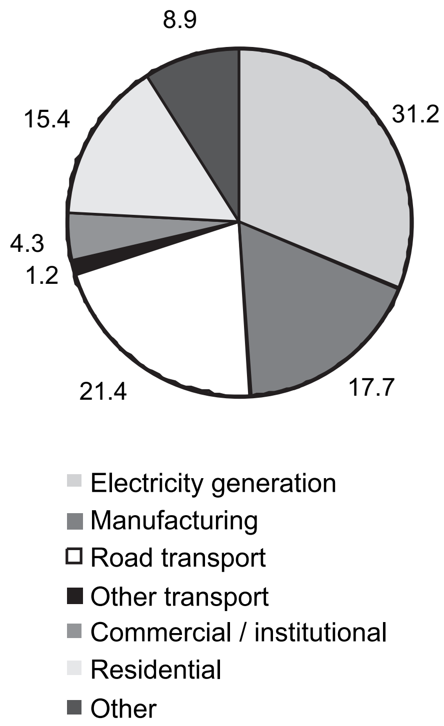
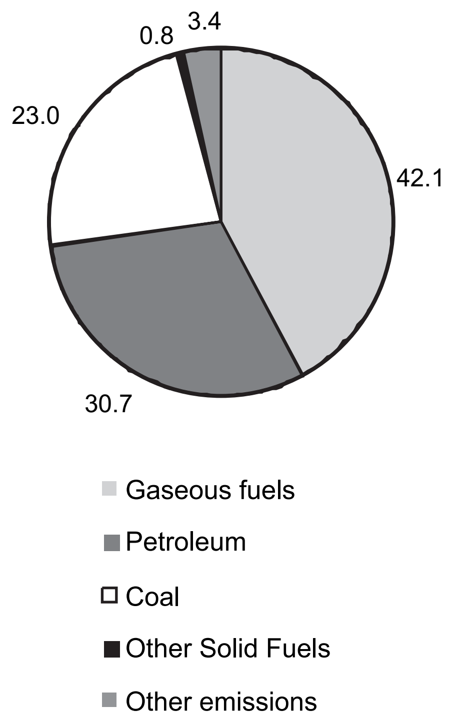


Figure 1.4: UK 2003 emission generation, by fuel type (%)



Source: DEFRA, historic data (Estimated emissions of carbon dioxide (CO_2) by UNECE source category, type of fuel and end user: 1970–2003[37]).

5. In spite of this, the Energy White Paper does not set targets for different generating capacities. Rather it sets out a range of policy measures intended to create a market framework that will deliver the stated energy policy goals most effectively. However, under current plans, a gap exists between expected electricity demand and supply if the 2050 carbon abatement target is to be achieved.

6. Indeed, the 2020 renewable energy target is insufficient to put the UK on target to meet its 2050 carbon abatement goal (Oxera, 2005a). Furthermore, the Renewables Obligation is underperforming and it is unlikely that the 2020 renewable energy target will be met (Mitchell and Connor, 2004). Additionally, over the same time period, nuclear capacity is forecast to decline from providing 23% of the nation's electricity requirements, to providing just 7%. As a result, the benefits of investment in renewable sources of energy will be offset, in carbon abatement terms, by the decline in nuclear capacity. Hence, in order to meet the 2050 carbon abatement target, an additional program of renewable energy, carbon sequestration, energy efficiency or nuclear build will be necessary (Oxera, 2005a).

7. The Energy White Paper considers nuclear power an important source of carbon-free electricity and keeps the nuclear option open. However, it suggests that nuclear power is an unattractive option for new, carbon-free generating capacity due to the current economics and unresolved issues of waste disposal.

8. In liberalised electricity markets nuclear power is not presently cost competitive with gas or coal as private investors are deterred by the high capital requirements and the long lead times of nuclear generation. However carbon emission credits give nuclear power a cost advantage over coal and gas under reasonable assumptions of reductions in capital costs, operation and maintenance costs, and construction time (Ansolabehere *et al,* 2003).

9. This paper investigates how UK's economic and energy growth projections can be reconciled with the government's plans for carbon abatement. The 60% target was a key feature of the Energy White Paper of 2003, and although it applies to more than just the electricity sector, the electricity sector might be expected to contribute pro rata.[38] More specifically this paper investigates whether an adherence to both the aspiration of reducing carbon dioxide emissions by 60% by 2050, and to the promotion of competitive energy markets, will force an increasing reliance on nuclear power.

10. In addition to investigating the electricity mix to meet the UK's electricity requirements in 2050 in the most cost-effective manner, this paper investigates how inter-generational equity concerns would alter the electricity mix. Hence, in considering the costs associated with nuclear power, both a time-constant and a time-declining discounting treatment will be applied.

[37] http://www.defra.gov.uk/environment/statistics/globatmos/gaemunece.htm. Accessed 6 August 2005.

[38] This paper assumes a 60% reduction in carbon emissions will be required from the electricity sector.

11. Before considering the research questions, Section 2 outlines the methodology and presents the scenarios used in the research. Results are presented in Section 4. Section 5 provides a discussion on these results. Section 6 concludes by analysing the implications of the results for energy policy in the UK and presents recommendations for achieving the 2050 carbon abatement target at least cost.

2. Methodology

12. Results in this paper are derived using a relatively simple model which calculates the expected profitability or subsidy requirements of different electricity mix scenarios. To achieve this, the model first determines the electricity demand and the carbon emissions limit from electricity generation in 2050. A number of sensible electricity mix scenarios, that meet both the electricity demand and the carbon emission targets, are then constructed. The model then determines the present value, in 2005, of each scenario.

2.1 *Key assumptions*

13. The electricity price forecast model, which is at the core of this paper, required a number of assumptions regarding available technology and associated costs. The analysis assumes that in future, six different types of electricity generating technology will be constructed. These are Combined Cycle Gas Turbines (CCGTs), Integrated Gasification Combined Cycle (IGCC) coal power plants, nuclear power plants, offshore wind power plants and CCGT and IGCC coal power plants with carbon capture capabilities.

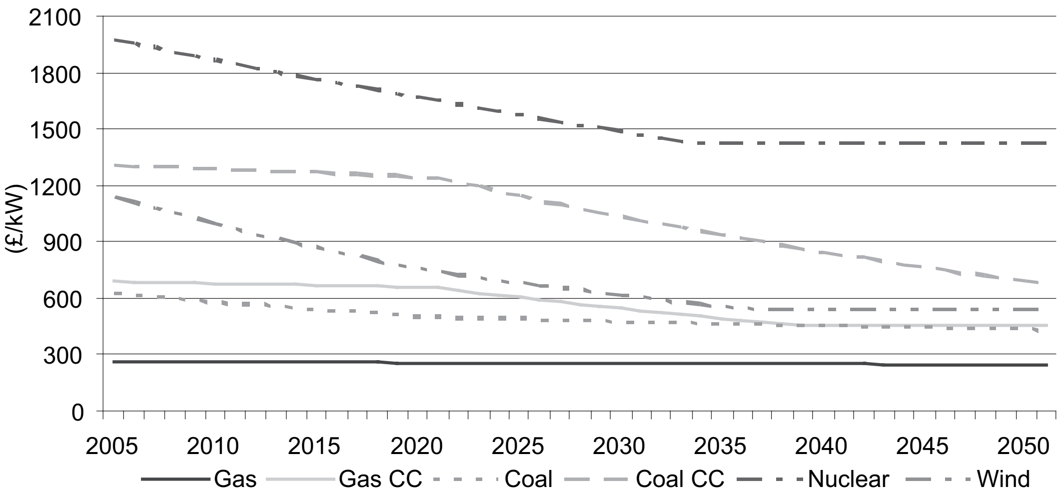
14. This selection reflects the expectation that new coal and gas power plants will use the latest available technology in order to maximise the electricity output/emissions ratio, as well as to achieve economic sustainability. Offshore wind is the only form of renewable energy included in the model as offshore wind it is expected to make the most significant contribution to electricity generation from renewable sources in the UK in the medium to long-term (Gross, 2004).

15. The cost structure of all power plants is assumed to consist of the following four cost elements: capital expenditure, operation and maintenance ("O&M"), fuel (except for wind) and the cost of carbon (except for wind and nuclear). For nuclear power plants, there is also a cost for decommissioning after the plant is closed down.

16. Capital expenditure, which includes all start-up costs, largely planning and construction, is expected to show the most variation. Variation in capital expenditure with time is shown in figure 2.1:

Figure 2.1

CAPITAL EXPENDITURE, 2004–2050 (£/kW)



17. Nuclear capital expenditure is significantly above the capital costs of all other technologies modelled. Capital costs for nuclear energy are based on estimates by Oxera (2005b). Thus, capital expenditure for the construction of the first nuclear plant is estimated at £1,600/kW, decreasing to £1,200kW from the third plant onward. Additional costs are included as follows: £100 million each for FOAK[39] and public enquiry costs, and an allowance of 10% for over-run costs. Thus, capital expenditure for nuclear energy is estimated at £1,980/kW initially, decreasing to £1,430/kW in the long-term.

[39] Only applicable to the first nuclear power plant built.

18. These cost estimates are conservative. The current nuclear reactor in Finland is being built on fixed-price contract of £1,140/kW. Further, the PIU Energy Review (2001) indicates that capital expenditure for current nuclear technology is in the region of £1,400–£1,700/kW and that capital expenditure may decrease to £690/kW in the long-run.

19. For offshore wind turbines, the 2004 capital expenditure is set at £1,140/kW. This number is based on Dale *et al* (2000) and includes £1,000/kW for the plant itself and £140/kW for necessary transmission and distribution ("T&D") investments. Dale forecast the costs of wind turbines to fall to £600/kW by 2020 and to £400/kW in the long-run, with the cost of T&D remaining constant.

20. CCGT gas plants are a relatively mature technology, and no major cost savings are expected. The PIU (2001) indicates current capital expenditure is £270/kW. Capital expenditure is expected to decrease to £250/kW in the long-run (PIU, 2001).

21. Capital costs for CCGT plants with carbon capture capabilities are assumed to be £690/kW (Tzimas and Peteves, 2005). The assumptions made for the model are that, due to limited technological learning, initial cost savings are of the order of 5% between 2004 and 2020. Post 2020, once the technology is established, it is assumed significant cost savings are possible, and that the costs of the capture plant (but not of the power generating plant) will decline by 50%. Thus the lower limit for CCGT with capture is £460/kW.

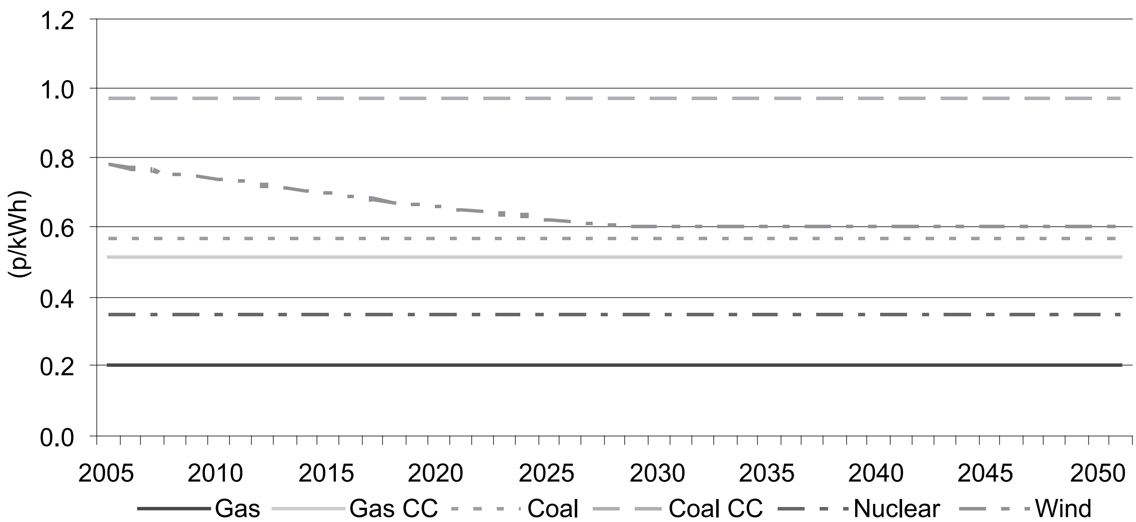
22. Marsh (2003) estimates current capital expenditure for IGCC coal power plants as £625/kW. The DTI (2001) has indicated that a 20% reduction in capital expenditure by 2020 is feasible. No cost reduction forecasts are available after 2020, but the model assumes a 50% reduction over the 2004 level in the long-term. This is conservative considering the higher expected reduction for other new technologies, ie offshore wind and nuclear.

23. For IGCC plants with carbon capture capabilities, Tzimas and Peteves (2005) estimate capital expenditure as £1,310/kW. No forecasts are available, but based on the same assumptions used for gas carbon capture plants, a reduction to £655/kW is considered feasible in the long-run.

24. As shown in figure 2.2, the O&M costs are less variable than capital expenditure.

Figure 2.2

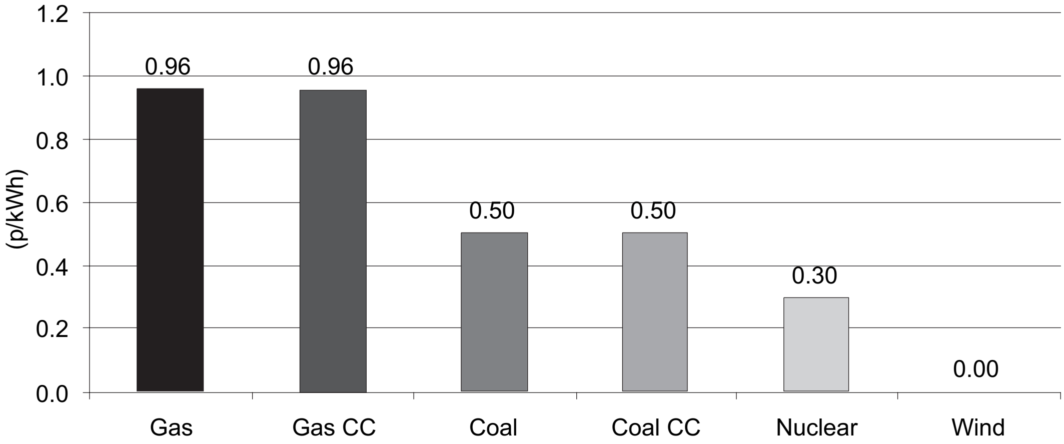
OPERATION AND MAINTENANCE COSTS, 2004–2050 (p/kWh)



25. The only O&M costs expected to decrease are those of wind farms (Dale *et al,* 2004). The anticipated decrease is based on the expectation of larger wind farms and thus higher operating efficiency. All other O&M costs are based on reports by Marsh (2003) for the DTI, and Oxera (2005, for nuclear), reflect the complexity of the plant in question and are not expected to change significantly.

26. Fuel costs are assumed to remain constant over time. Fuel prices are affected by many uncertainties and an attempt to quantify these uncertainties is beyond the scope of this paper. The current levels are summarised in figure 2.3:

Figure 2.3



FUEL COSTS, 2004–2050 (p/kWh)

Source: DTI, historic data (Average prices of fuels purchased by the major UK power producers and of gas at UK delivery points[40]); Oxera, 2005b.

27. The cost of carbon is a cost factor of increasing relevance for coal and gas powered plants. Forecasts from The Carbon Trust (2004) for the market price of carbon traded under the EU ETS are included when analysis uses market discount rates. This forecast sees the price increase from a current level of €5/tonne of carbon dioxide to €25/tonne of carbon dioxide in 2013. The price is forecast to remain flat post-2013. When analysis is based on the social rate of time preference, Clarkson and Deyes' (2002) estimate of the social cost of carbon is incorporated. Thus a value of £74/tonne of carbon is included to represent the social cost of carbon in 2005. This value is inflated by £1/tC per year.

28. As nuclear power plants need decommissioning at the end of their operating life, this cost item has been included in the model. Oxera (2005b) estimates the net present value of decommissioning costs in the final operating year of a nuclear plant as £500/kW. This value has been used for the model.

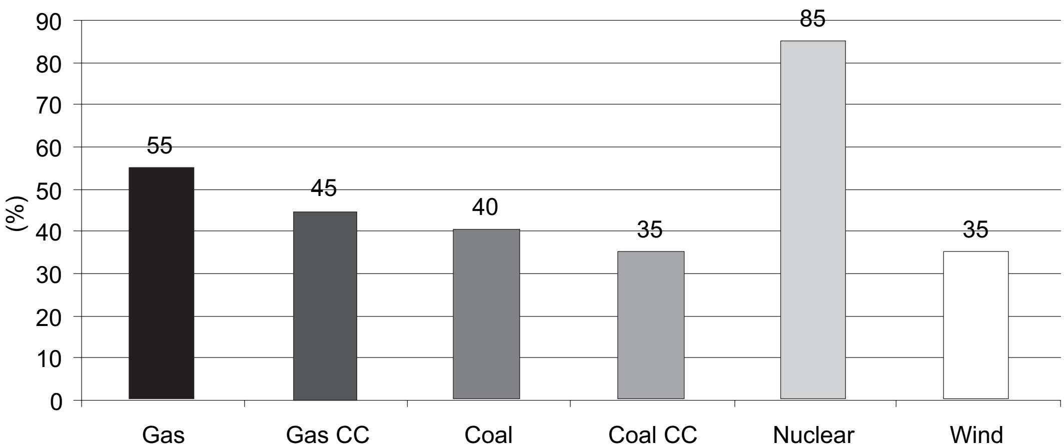
2.2 *Other assumptions*

29. The economics of the different technologies modelled are influenced by capacity utilisation and carbon emissions, as well as costs.

30. Capacity utilisation varies significantly by technology reflecting technical aspects and resource availability. See figure 2.4.

Figure 2.4

CAPACITY FACTORS, BY TECHNOLOGY (%)



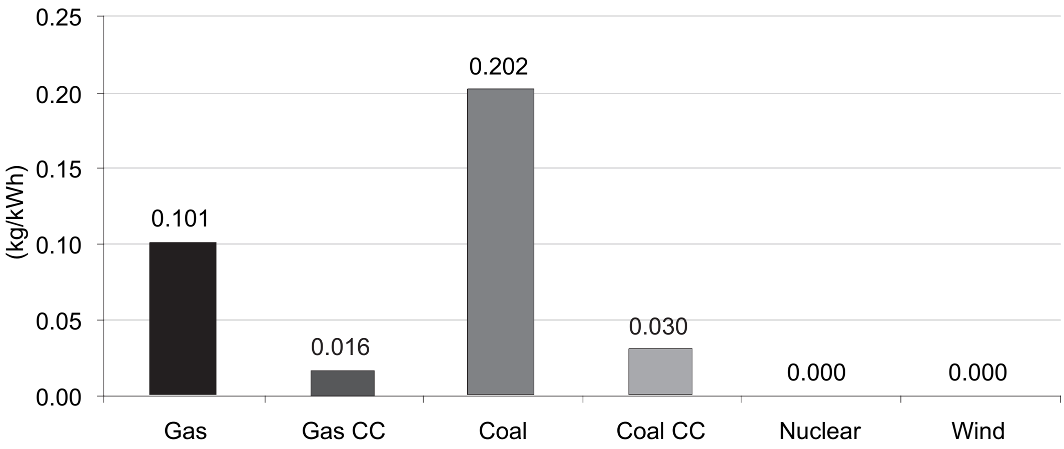
Source: Dale *et al*, 2004; DTI, 2002; Marsh, 2003; MIT, 2003.

31. Carbon emissions relative to electrical output vary considerably by technology with nuclear and wind power at an obvious advantage in this regard (see figure 2.5).

[40] Available online at: http://www.dti.gov.uk/energy/inform/energy_prices/qepupdate.shtml. Accessed: 6 August 2005.

Figure 2.5

CARBON EMISSIONS, BY TECHNOLOGY (kg/kWh)



Source: Marsh, 2003.

2.3 *Scenario Construction*

32. The model considers eight different scenarios grouped into two sets of four. The first group considers an electricity demand base case in which the same efficiency improvement rates that have been achieved over the past decade are forecast to continue. The second group considers a lower electricity demand situation that is as a result of electricity efficiency improvements. The four scenarios in each demand group differ in the way that wind, nuclear and carbon sequestration are used to meet the 2050 supply target without violating the carbon emissions limit.

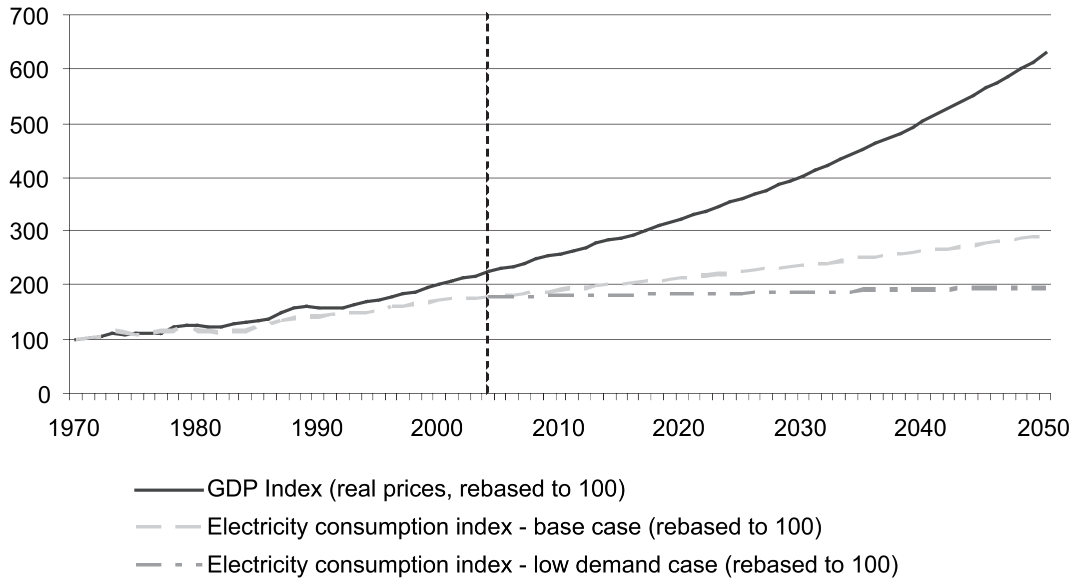
2.3.1 Electricity demand

33. Electricity demand in 2050 is forecast as a function of GDP and electricity intensity. Assumptions relating to GDP growth are in line with forecasts by HM Treasury (2003). Thus it is assumed that GDP will grow at 2.5% for the next five years, before levelling out at a long-term growth rate of 2.25%. These assumptions result in a doubling of GDP over the next 35 years. Economic output is linked to electricity consumption via the Electricity Intensity Ratio[41] (EIR), which has decreased steadily over the past decade, reflecting continuous improvements in electricity efficiency. The average increase in efficiency over the past decade is 1.16% and is used to forecast the base case electricity demand in 2050 of 563TWh in 2050. More optimistic electricity efficiency savings of 2% per year, which are considered achievable but optimistic (Blok, 2004), result in demand of 377TWh in 2050. See figure 2.6:

[41] The ratio of electricity consumption and GDP.

Figure 2.6

GDP AND ELECTRICITY DEMAND FORECAST (REBASED TO 100)



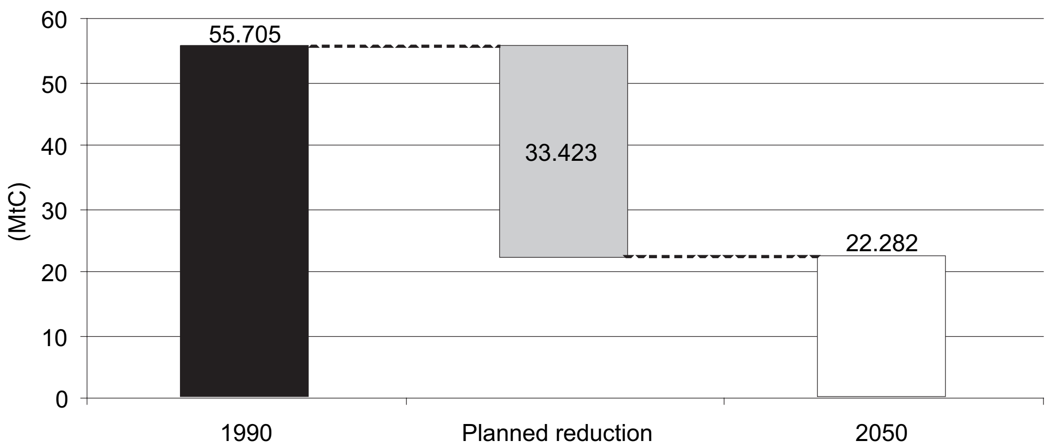
Source: Office of Statistics, historic data (Primary energy consumption, gross domestic product, the energy ratio[42]).

2.3.2 The emissions limit

34. It has been assumed that the 60% target will be applied to the economy and its sub-sectors, the electricity sector included, in equal proportion. As such, the 2050 emissions limit for the electricity sector is determined as 22.3MtC/yr as is shown in figure 2.7. All scenarios modelled further assume that coal and gas generate the maximum amount of electricity possible without violating the 2050 emissions limit for the electricity sector.

Figure 2.7

PLANNED REDUCTION IN CARBON EMISSIONS BY ELECTRICITY SECTOR (MtC)



Source: DEFRA, historic data (Estimated emissions of carbon dioxide by UNECE source category, type of fuel and end user: 1970–2003).

35. *Gas and coal generation.* In all scenarios gas and coal are assumed to be employed in a 2:1 ratio. This assumption reflects the superior attractiveness of gas, but also the important role of coal generation in diversifying the electricity mix (DTI, 2003a). Given this ratio, and the relative emissions to output ratios shown in figure 2.5, the maximum output from gas and coal generating plants, in the absence of carbon capture, can be determined as follows:

[42] Available online at: http://www.dti.gov.uk/energy/inform/energy_stats/total_energy/index.shtml. Accessed 6 August 2005.

Needed values:

S_g = Gas supply

S_c = Coal supply

Given values:

EL = Emissions limit = 22.3MtC, as shown in figure 2.7

$S_g/S_c = 2{:}1$

e_g = emissions to output ratio for gas = 0.101kg/kWh

$_ec$ = emissions to output ratio for coal = 0.202kg/kWh

$$EL = e_g S_g = e_c S_c \qquad (1)$$

$$\frac{S_g}{S_c} = \text{thus } S_g = 2S_c \qquad (2)$$

Substituting (2) into (1):

$$S_c = \frac{EL}{2e_g + e_c} \qquad (3)$$

36. Inserting the known values into (3) it follows that coal can supply up to 55TWh in 2050, and given e_c, this will result in 11.1Mt of carbon emissions. It follows from (2) that gas can supply up to 110TWh, which, given eg, also generates 11.1Mt of carbon emissions.

37. Thus, in the absence of carbon capture, gas and coal can supply 166TWh of electricity in 2050, whilst jointly generating 22.3MtC, which is the 2050 carbon emissions limit. Under the base case scenario, this is equivalent to 29.4% of electricity demand in 2050, 563TWh, and 43.9% of electricity demand, 377TWh, in the lower demand case.

38. Under both the base case and the lower electricity demand scenarios, gas and coal alone are unable to meet the 60% target and simultaneously satisfy electricity demand. Substantial scope remains for other technologies.

2.3.3 Construction schedules

39. To facilitate the analysis, it is assumed that the capacity required in 2050 will be built in four 10-year intervals starting in 2010, with a quarter of the capacity needed in 2050 built in each construction phase. The construction mix in each period reflects the final electricity mix in 2050. An underlying assumption has been made that, for a technology to be reliable on a large scale in 2050, investment in the technology is required for a significant period of time.

40. The construction schedules ignore the phasing out of current generating capacity. Precise matching of new capacity requirements with the phasing out of existing power plants goes beyond the scope of this paper. However, it is assumed that an even distribution of new capacity over a 40 year period approximates the requirements of both new demand and phasing out of existing capacity. It is further assumed that all current power plants will be out of service by 2050. The model does not include the cost of replacing any capacity post-2050, but given the long discounting period it is unlikely that such costs would impact in a significant fashion on present investment decisions.

41. The model does however include the costs of replacing new capacity that phases out before 2050. This is the case for all plants built in 2010, with the exception of nuclear which does not require replacement before 2057, as well as for wind farms built in 2020. The phasing out of newly built capacity is summarised in table 2.1:

Table 2.1

PHASING OUT OF NEWLY BUILT CAPACITY

	Construction year				
Technology	*2010*	*2020*	*2030*	*2040*	*Comments*
CCGT	2042	2052	2062	2072	replace first generation in 2040
CCGT (CC)	2042	2052	2062	2072	replace first generation in 2040
IGCC	2046	2056	2066	2076	replace first generation in 2040
IGCC (CC)	2046	2056	2066	2076	replace first generation in 2040
Nuclear	2057	2067	2077	2087	no replacement needed before 2057
Wind	2031	2041	2051	2061	replace first generation in 2030, second in 2040

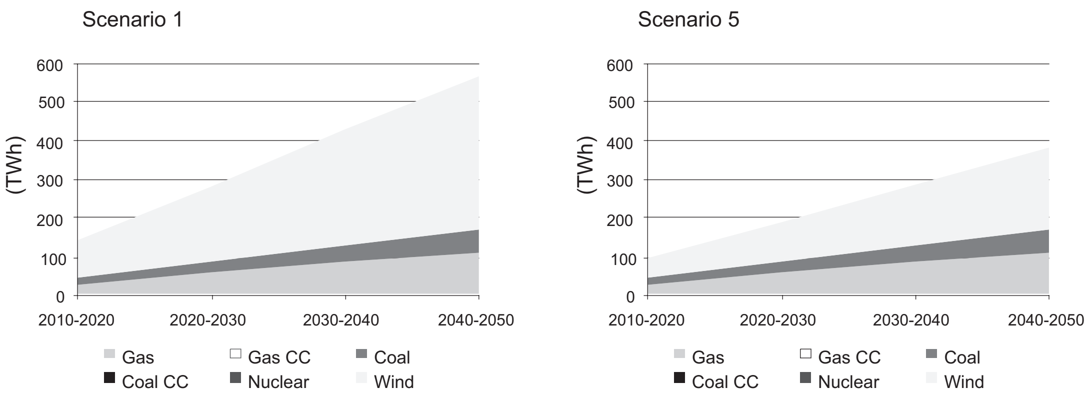
2.4 Scenario Overview

42. The scenarios used in the model illustrate how the gap between electricity demand, and supply by traditional fossil fuel generating technologies, can be filled by carbon-free generating capacity.

43. Scenarios 1 and 5. Scenarios 1 and 5 assume that the entire supply shortfall can be covered by wind. The two scenarios differ only in the overall demand, and therefore in the amount of electricity supplied by wind, as shown in figure 2.8:

Figure 2.8

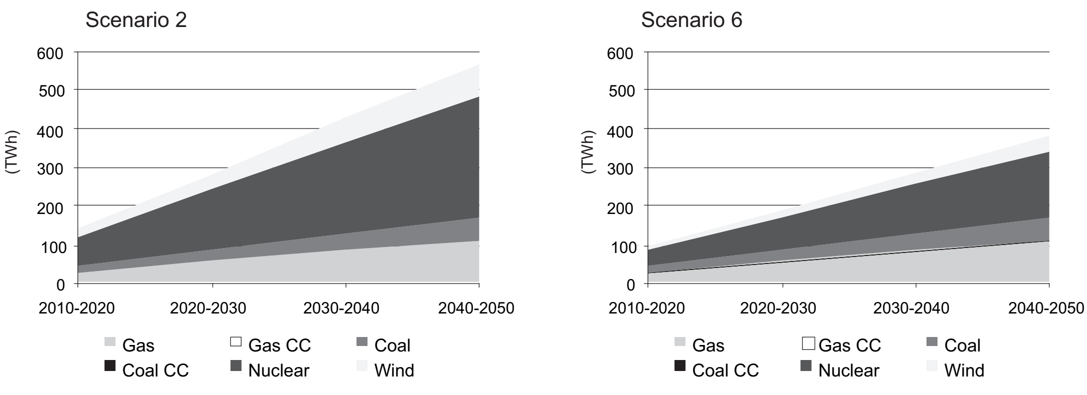
CUMULATIVE NEW ELECTRICITY SUPPLY, 2010–50 (TWh), 1/5



44. Scenarios 2 and 6. Scenarios 2 and 6 consider significant investment in nuclear power. As wind energy is expected to contribute to the electricity mix regardless of investment in nuclear power, nuclear only covers 80% of the supply shortfall in these two scenarios. The scenarios vary only in the overall electricity demand in 2050, as can be seen in figure 2.9:

Figure 2.9

CUMULATIVE NEW ELECTRICITY SUPPLY, 2010–50 (TWh), 2/6

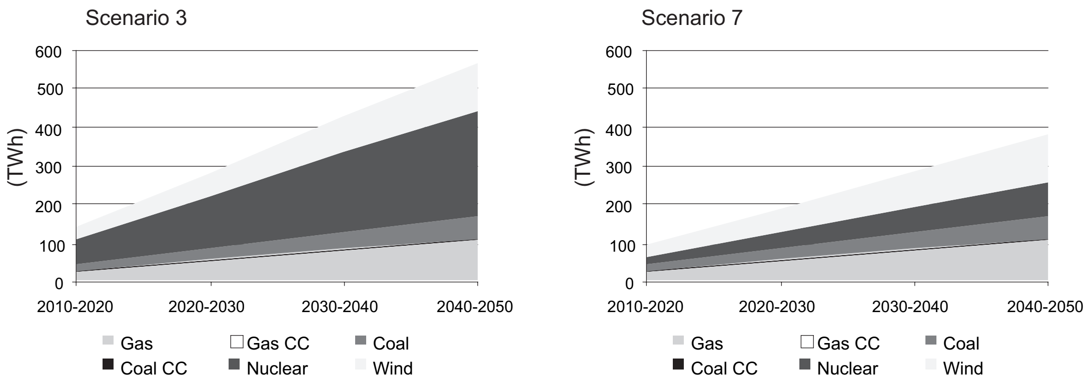


45. Scenarios 3 and 7. These two scenarios model more realistic wind scenarios than was represented by scenarios 1 and 5. The practicable potential for offshore wind power generation in the UK in 2025 has been estimated at 100TWh annually (Gross, 2004). No equivalent estimate exists for 2050, but a generous 25% improvement assumption[43] yields an annual limit of 125TWh/yr. Scenarios 3 and 7 assume wind power supplies this upper limit in 2050, and that nuclear power supplies any shortfall. As a consequence of these assumptions, scenario 3 does not differ substantially from scenario 2. However, the impact of the assumptions is more starkly illustrated by the differences between scenarios 6 and 7, as shown in figure 2.10:

[43] Practicable potential is also influenced by space availability, efficiency and uptake; hence the 25% improvement assumes significant improvement in one of these areas.

Figure 2.10

CUMULATIVE NEW ELECTRICITY SUPPLY, 2010–50 (TWh), 3/7



46. Scenarios 4 and 8. In the final two scenarios, wind is again modelled to supply up to a realistic limit of 125TWh/yr, however scenarios 4 and 8 assume significant investment in carbon sequestration technologies rather than in nuclear power. The assumption of a gas to coal ratio of 2:1 is maintained, and the percentage share of electricity supplied by plants with carbon sequestration capabilities necessary in order to meet both the electricity demand and the carbon emissions target is computed determined. This procedure is illustrated in table 2.2:

Table 2.2

CALCULATION OF SUPPLY SHARES IN CARBON CAPTURE SCENARIOS

	Scenario 4	*Scenario 8*
2050 demand (TWh)	563	377
Less: wind supply (TWh)	125	125
Needed from coal and gas (TWh)	438	252
Gas to coal ratio	2:1	2:1
Gas supply (TWh)	292	168
Coal supply (TWh)	146	84
Share of carbon capture in coal and gas	73.6%	40.7%
Gas supply—traditional (TWh)	77	100
Gas supply—with carbon capture (TWh)	215	69
Coal supply—traditional (TWh)	39	50
Coal supply—with carbon capture (TWh)	108	34
Gas emissions—traditional (MtC)	7.77	10.07
Gas emissions—with carbon capture (MtC)	3.52	1.12
Coal emissions—traditional (MtC)	7.77	10.07
Coal emissions—with carbon capture (MtC)	3.22	1.03
Total emissions (MtC)	22.3	22.3

47. The critical element in the above analysis is the share of carbon capture in coal and gas output. This is calculated in the following manner:
Given values:

EL = Emissions limit
S_c = total supplied by coal
S_g = total supplied by gas
e_{ct} = emissions to output ratio, traditional coal
e_{ccc} = emissions to output ratio, coal with carbon capture
e_{gt} = emissions to output ratio, traditional gas
e_{gcc} = emissions to output ratio, gas with carbon capture

Needed value:
s_{cc} = share of carbon capture in overall coal and gas supply

The total emissions output can be set equal to EL and is the sum of all the emissions generated by the four different technologies:

$$EL = e_{ct}S_c(1 - s_{cc}) + e_{ccc}S_c s_{cc} + e_{gt}S_g(1 - s_{cc}) + e_{gcc}S_g s_{cc} \qquad (4)$$

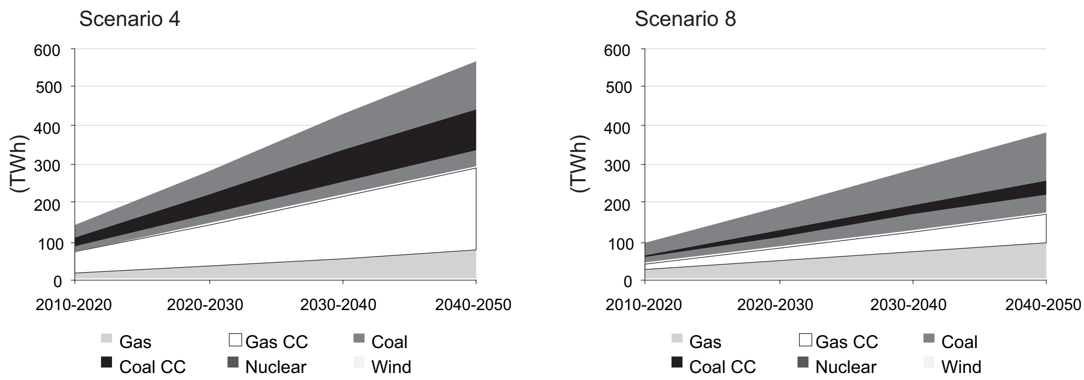
(4) can be simplified and solved for s_{cc}:

$$s_{cc} = \frac{(e_{gt}S_g + e_{c}tS_c) - EL}{(e_{gt} - e_{gcc})S_g + (e_{ct} - e_{ccc})S_c} \qquad (5)$$

48. Substituting all known values into (5) yields the share of carbon capture in overall coal and gas supply: 73.6% for scenario 4 and 40.7% for scenario 8. Consequently, the two scenarios differ in the way that carbon sequestration is used and also in the impact of wind supply, as shown in figure 2.11:

Figure 2.11

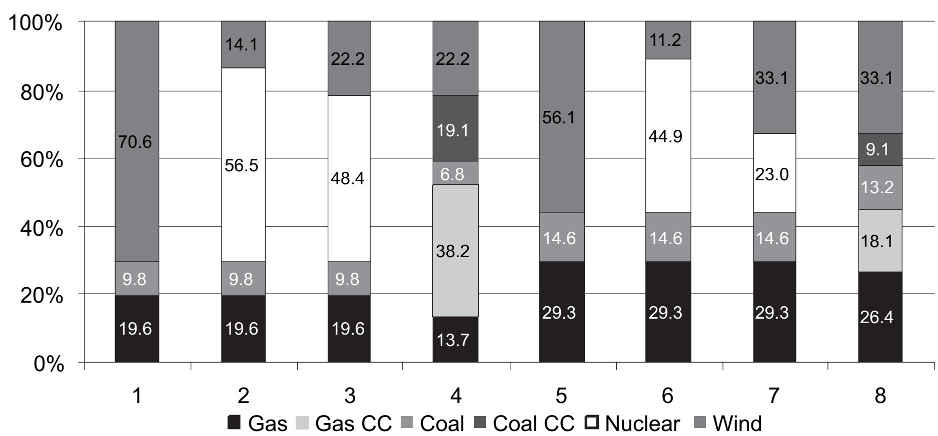
CUMULATIVE NEW ELECTRICITY SUPPLY, 2010–50 (TWh), 4/8



49. Scenario summary. To summarise, the eight scenarios are compared in figure 2.12, which illustrates the relative shares of the different generating technologies by scenario. Most interesting for the analysis in subsequent sections are scenarios 3 and 7, in which coal, gas and wind supply electricity up to their maximum. It is thus apparent that these three technologies alone are insufficient to meet future electricity demand—indeed, even in the lower demand case, in the absence of additional generating capacity, a supply gap of almost 30% exists which is filled by nuclear generation.

Figure 2.12

2005 SUPPLY SHARES, BY SCENARIO (%)



2.5 *Discounting*

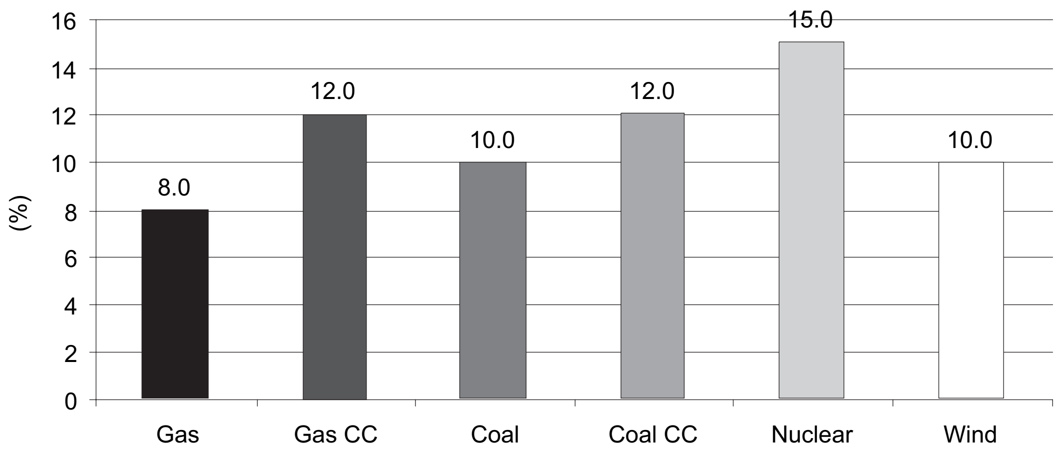
50. While conventional approaches to discounting value a gain or loss in the future at less than the same gain or loss today, ethical controversies rage over the applicability of fixed-rate discounting approach to social issues (Heinzerling, 2000; Ackerman and Heinzerling, 2002). These controversies have particular applicability to nuclear build as nuclear energy has both positive and negative environmental attributes that are important in the long-term. While nuclear power can provide large amounts of carbon-free energy in the face of worsening climate change, negative environmental effects are associated with the decommissioning of nuclear power plants, the storage of nuclear waste and the potential for catastrophic nuclear accidents in the future.

51. As nuclear investment decisions will be made by the market, a fixed discount rate will be used to evaluate the investment potential, and social concerns will play no role in the decision making process. Consequentially, risks to future generations will be valued to a lesser extent than risks to the present generation. However, recent advances in discounting theory suggest that the correct social discount rate is not a single number, but a value that declines with time (Pearce et al, 2003). Official guidance to Ministries notes the power of time-varying discount rates when evaluating investments and policies with costs and benefits that accrue over more than thirty years hence (HM Treasury, 2003). Consequentially, this paper investigates the costs of energy investments using both a constant market discount rate, and the declining social discount rate scheme advocated by HM Treasury in the Green Book.

52. *Fixed rate discounting.* Private investors use a fixed discount rate, which reflects the risk of an investment, in evaluating investment potential. Oxera (2005b) quote the average expected return for a utility company as 8–12% annually. This is reflected in the discount rates used in the model. Gas, as the safest of the six technologies, is discounted at the lower end of the range, while nuclear is discounted at 15%, reflecting the extra-ordinary risks involved. This is in line with an Oxera (2005a) study that argues that nuclear investors expect a return of between 14% and 16%. Figure 2.13 shows the discount rates used for the different technologies, and reflects their expected risk:

Figure 2.13

FIXED RATE METHOD DISCOUNT RATES, BY TECHNOLOGY (%)



53. These discount rates are used to discount all cash flows relating to a project from the day of its initiation, ie the first day of planning, to the last day of operation. Once the net present value of a project at initiation is determined, this value is discounted back to 2005 at a discount rate of 10%. This is the average return of a utility company and as such is deemed applicable to any money not yet committed to any specific project.

54. *Green Book Method.* The declining social discount rate scheme advocated by HM Treasury in the Green Book recommends a discount rate of 3.5% for the first 30 years of a project, and 3% for the next 45 years. Afterwards, it declines further, but is no longer relevant for this analysis. This discounting treatment requires risk to be dealt with before discounting takes place. As such, conservative assumptions of costs and benefits are appropriate for use with this discounting scheme.

55. The use of a declining discount rate scheme has two important consequences for the analysis of the future electricity mix.

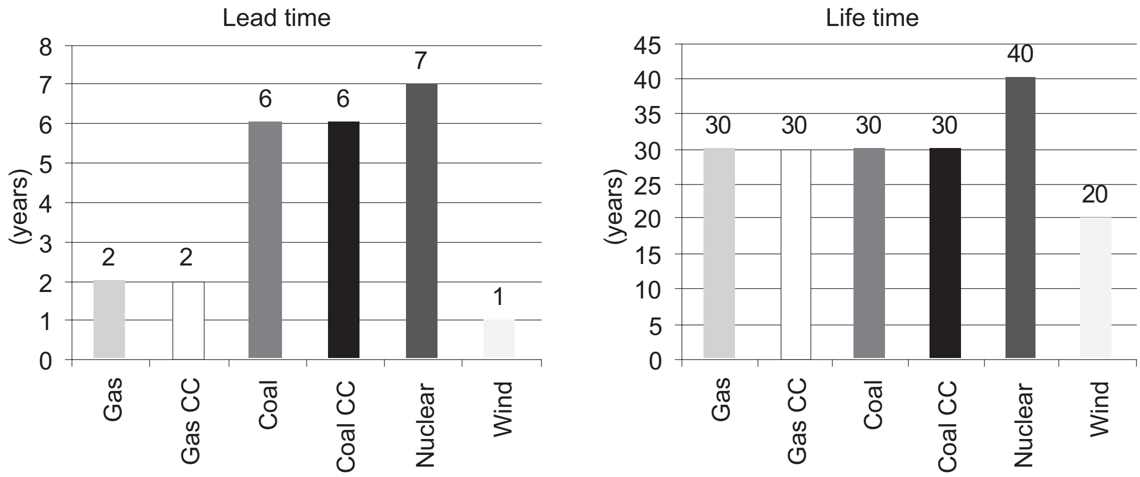
56. First, a unified rate is used for all technologies. Thus nuclear energy is no longer penalised by a high discount rate. The investment risk of nuclear generation is accounted for by the use of conservative assumptions and an allowance for cost over-runs.

57. Second, declining interest rates increase the impact of future cash flows. As most negative cash flows involved in power generation occur during the planning and construction phases and profits are generated in later periods, an effect of declining discount rates is increased profitability. Hence, the longer the lead-time, the later a technology reaches its profitable phase, and the more likely its profitability will improve as a result of lower discount rates. Similarly, projects with long lifetimes are likely to benefit from low discount rates due to distant positive cash flows, which become more significant using a declining-rate scheme.

58. Figure 2.14 shows that, relative to other generating technologies, nuclear power plants have the longest lead- and life-times. Wind has the shortest. Consequently, nuclear benefits to a greater degree than wind from low and declining discount rates.

Figure 2.14

LEAD AND LIFE TIME, BY TECHNOLOGY (YEARS)



Source: Dale *et al*, 2004; MacKerron, 2004, Whittington and Bellhouse, 2000.

2.6 *Profitability*

59. In order to compare the profitability of the various technologies and scenarios modelled, a wholesale electricity price of 3p/kWh is assumed. This price is used in analysis by Oxera (2005b) as a long-term average wholesale electricity price and is consistent with a gas price of 28p/therm. The expected profits or losses from different generating technologies calculated are then discounted to 2005 for comparison.

60. In the absence of government subsidies it can be expected that investors will only pursue those projects that, based on traditional discounting methodology, offer positive net present values ("NPV"). To the extent that a scenario generates a negative NPV, it can be argued that this reflects the size of the government subsidy, either in form of direct subsidies or in form of risk guarantees, required to make it attractive.

3. Results

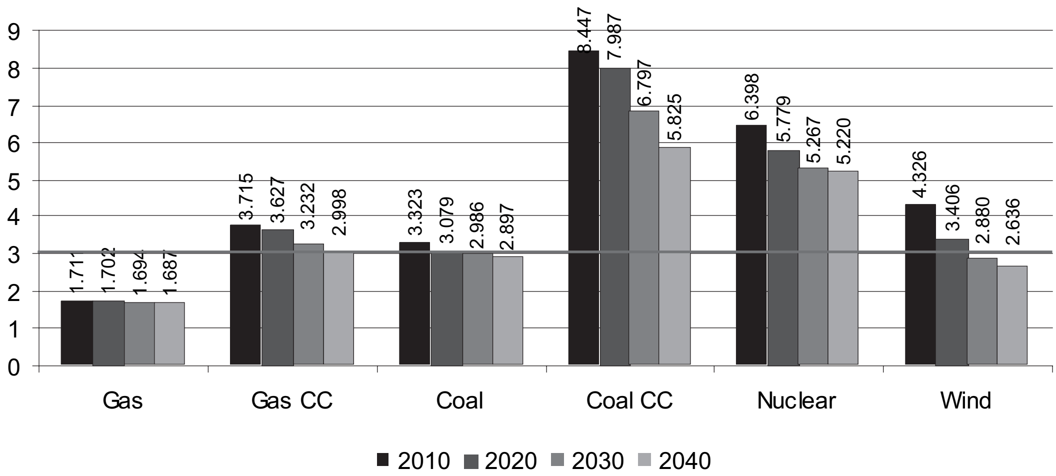
61. This section presents the results of the discounting exercise carried out by the model described in the previous section. The costs of the different technologies are compared before the costs of the scenarios are examined.

3.1 *Technology Comparison*

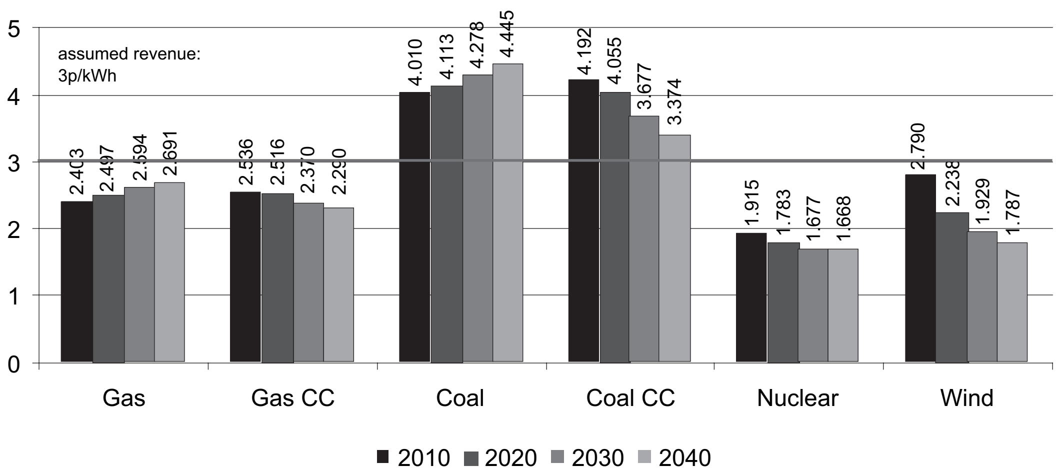
Figure 3.1

COST, BY TECHNOLOGY (p/kWh)

Fixed rate method



Green Book method



Note: Cost defined as the price in pence per kWh that yields a NPV of zero.

62. The costs of the six different technologies evaluated are summarised in figure 3.1 in terms of pence per kilowatt hour. The figure shows the electricity price that is required to generate a net present value of zero for each technology. Thus, it reflects not only the costs of capital expenditure, O&M, fuel and carbon, but also the risk associated with each technology.

63. Costs for plants initiated in 2010, 2020, 2030 and 2040 are shown. As discussed in the previous section, capital expenditure costs in particular, are expected to decrease with technological learning. Consequentially, plants of all technologies built benefit from lower costs with time under the market method.

64. As becomes apparent from figure 3.1, under the market method, only CCGT power plants are able to generate electricity in 2010 at costs that are below the assumed price level. Despite significant cost savings, this does not change in 2020. Further analysis reveals that due to continuous cost savings, wind turbines built in 2030 will be able to generate electricity profitably, at costs of 2.88p/kWh. Similarly, in 2050 IGCC plants will generate electricity profitably, at costs of 2.90p/kWh. However, neither nuclear plants nor plants with carbon capture ability are expected to become profitable technologies if the wholesale electricity price remains at 3p/kWh.

65. Of the technologies that are likely to be needed to fill the supply gap left by traditional fossil fuel generating capacity and wind, gas plants with carbon capture technology are the cheapest option, followed by nuclear and coal plants with carbon capture technology.

66. The outcome changes significantly when the declining discount rate scheme recommended by HM Treasury, and the social cost of carbon recommended by DEFRA, are used. Under this treatment, all

technologies except traditional gas and coal, which increase due to the application of the social cost of carbon, become considerably cheaper. Further, technologies discounted at higher discount rates under the market method benefit the most.

67. Consequentially, nuclear is the biggest beneficiary under the social cost method, in which low, declining discount rates are used and the social cost of carbon is included. Indeed, nuclear is not only profitable but becomes the cheapest technology.[44] All technologies except traditional coal and coal with carbon capture technology are profitable when Green Book discounting is used.

68. These results should be interpreted with caution. The rationale for using declining discount rates is to give more weight to the costs and benefits experienced by future generations. However, potential environmental costs are difficult to quantify. In particular, the costs of climate change and externalities associated with nuclear power pose a challenge. While the model includes the social cost of carbon, climate change has the potential to cause irreversible damage to ecosystems that is impossible to quantify in monetary terms. In respect of nuclear energy, the inestimable societal costs nuclear energy has the potential to impose[45] remain external to the model. Thus, the results of the analysis based on the Green Book discount rates have the potential to mislead as some, but not all, social costs have been included.

3.2 *Scenario Comparison*

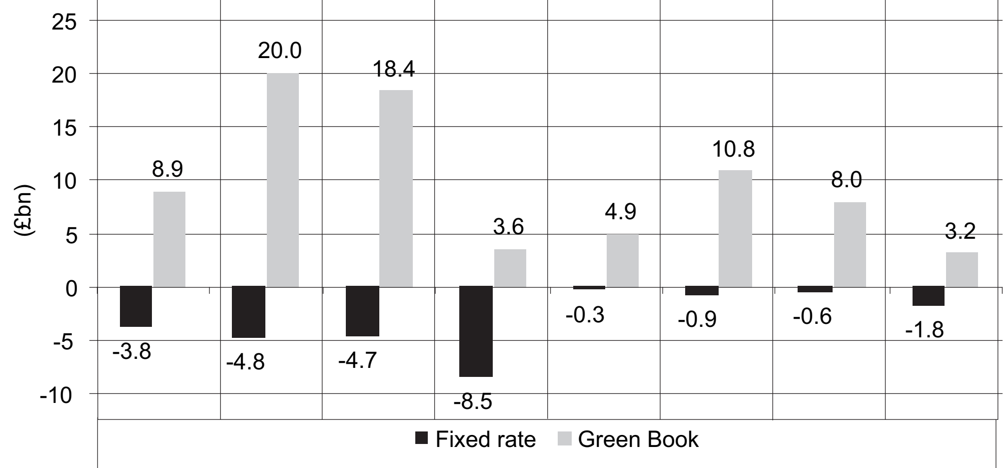
69. The technology prices discussed above determine the profitability of the different scenarios analysed. The net present values of the various scenarios are summarised in table 3.1. For ease of comparison, key demand and supply parameters are given as well.

Table 3.1

2005 NPV, BY SCENARIO (£bn)

	Scenarios							
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Energy demand (TWh, 2050)	Base case 563				Lower demand case 377			

2005 NPV (£bn)



2050 supply (%)	1	2	3	4	5	6	7	8
Gas	19.6	19.6	19.6	13.7	29.3	29.3	29.3	26.4
Gas CC				38.2				18.1
Coal	9.8	9.8	9.8	6.8	14.6	14.6	14.6	13.2
Coal CC				19.1				9.1
Nuclear		56.5	48.4			44.9	23.0	
Wind	70.6	14.1	22.2	22.2	56.1	11.2	33.1	33.1

[44] This is the case even if the social cost of carbon is omitted.

[45] That is, the effect of nuclear catastrophe on human health and society, and on the environment.

70. The first key insight is that none of the eight scenarios generate a positive net present value when using the fixed discount rate method. From this it can be deduced that either the assumed wholesale price of 3p/kWh is too low, or that government intervention will be necessary to achieve the emissions reduction target in 2050.

71. The need for government support is minimised in scenarios 1 and 5, which rely on wind energy to a degree that is improbable.[46] Further analysis reveals that those scenarios that rely heavily on nuclear power require less government support than the carbon capture scenarios.

72. This seems counter-intuitive as nuclear is not the cheapest option on a per kWh basis. The apparently contradictory result is caused by a peculiarity of discounting. Indeed, while the high discount rate of nuclear drives up the price at which a nuclear power plant can break even, it also discounts any losses generated by a nuclear plant at a higher rate.

73. Under the declining discount rate scheme, all eight scenarios are NPV positive, and therefore economically feasible. The two scenarios relying most heavily on nuclear are the most economically attractive. This is a consequence of the low price per kilowatt-hour for nuclear under the Green Book discount rate scheme.

74. It is however highly unlikely that the discount rates recommended by HM Treasury would be utilised in assessing privately financed electricity investment without government support to reduce the risks to investors. This could be achieved by a government offer to finance packages at the discount rates set out in the Treasury Green Book, and would result in the taxpayer carrying the risk in excess of discount rates recommended by the Treasury, should costs exceed expectations or benefits disappoint.

4. Discussion

75. The results of the model indicate that the British government has some difficult choices to make if it is to meet the 2050 carbon emissions target. The limits imposed on coal and gas generation by the 2050 target, together with the limit imposed on renewable energy generation by its practicable potential, necessitate massive energy efficiency savings if the 2050 target is to be met without a large-scale nuclear energy or carbon sequestration program. Indeed, in order to achieve this, demand must be contracted to 1995 levels.[47]

76. The energy efficiency scenario used assumed efficiency savings of 2% per year. Blok (2005) suggests year-on-year efficiency savings of this level are possible but rarely achieved. Hence, the efficiency improvements assumed are considered optimistic and it is improbable that sustained efficiency improvements beyond this level will be achieved.[48]

77. The prospects for renewable energy sources are limited by what is practicable. DTI (2000) estimates for 2025 indicate that the practicable limit to generation by wind (both off-shore and on-shore) is 108TWh/yr, whereas all current renewable energy technologies have a practicable limit of 230TWh/yr (Gross, 2004).

78. If the UK could achieve electricity efficiency savings of 2% per year until 2050 and realise the practicable potential suggested by the DTI (2000) in wind (both offshore and onshore), biomass, BIPV, wave, tidal and small hydro,[49] notwithstanding uneconomic generating costs and ignoring any extra generation requirements due to intermittency, the electricity demand in 2050 could be met.

79. At present, this scenario seems impossibly optimistic.

— The Renewables Obligation is underperforming and is unlikely to achieve its objectives (Mitchell and Connor, 2004).

— The goals of the Renewables Obligation are insufficient to put the UK on track to reduce carbon emissions by 60% by 2050, especially in the face of declining nuclear contribution to the electricity mix and growth in electricity demand (Oxera, 2005b).

— The costs of wind generation, considered the most promising renewable energy technology, increases significantly as wind penetration approaches 30% (Dale *et al*, 2004)—this cost increase is difficult to model and not included in the analysis in this paper.

80. As a consequence of practicable limitations on electricity efficiency improvements and renewable energy penetration, either a large scale carbon sequestration or a nuclear energy program will be necessary to meet both future energy requirements and the 2050 carbon abatement target.[50]

[46] Both these scenarios require more generation from wind than is practicable, ie more than 125TWh of wind generation.

[47] Assuming a 2:1 ratio of gas:coal, gas can provide a maximum of 110TWh/yr, coal can provide a maximum of 55TWh/yr and wind is limited by a practicable potential of 125TWh/yr. This amounts to 290TWh/yr, which is equivalent to the electricity demand in 1995.

[48] To contract demand to 1995 levels, a yearly electricity efficiency improvement of 2.5% is needed—significantly above both the 1.7% achieved in the last decade and the 2.0% Blok (2005) considers possible but unlikely.

[49] The costs of renewable technologies other than offshore wind have not been assessed. In the case of onshore wind, due to limited practicable potential of 8TWh/yr—the majority of the growth in wind to 2050 is expected to be offshore. In the case of all other renewable energy technologies this is due to prohibitive costs.

[50] This paper has assumed that the UK government will either support a large scale program of nuclear energy or a large-scale program of carbon sequestration, but not a combination of the two, as cost reductions are dependent on economies of scale.

81. The economic analysis completed indicates that scenarios that rely on nuclear power to meet the shortfall from traditional fossil fuel generation and wind energy require less government support than scenarios that rely on carbon capture.

82. The argument for nuclear is advanced as a carbon sequestration strategy increases the nation's dependence on imported fossil fuels, while a strategy of nuclear energy goes some way to meeting the UK government's stated requirement for energy diversity (DTI, 2003). The value of this cannot be quantified in an economic sense however it is undoubtedly a factor that weighs in favour of nuclear energy.

83. Carbon sequestration is similar to nuclear energy in that a large-scale project involving considerable investment is necessary for implementation. Unlike nuclear energy however, carbon sequestration is an unknown quantity. Only one carbon sequestration project operates worldwide (Tzimas and Peteves, 2005). Widespread deployment of carbon capture, transport and injection infrastructure carries unknown economic risks and significant scientific and technological challenges.

84. For the reasons discussed above, all else being equal, nuclear power is an attractive option in the transition to a low carbon economy. However two important constraints exist.

— The risk premium required by the private sector for nuclear investment results in unprofitable generation at a wholesale electricity price of 3p/kWh—a nuclear plant built in 2020 would generate electricity at a cost of 5.8p/kWh.

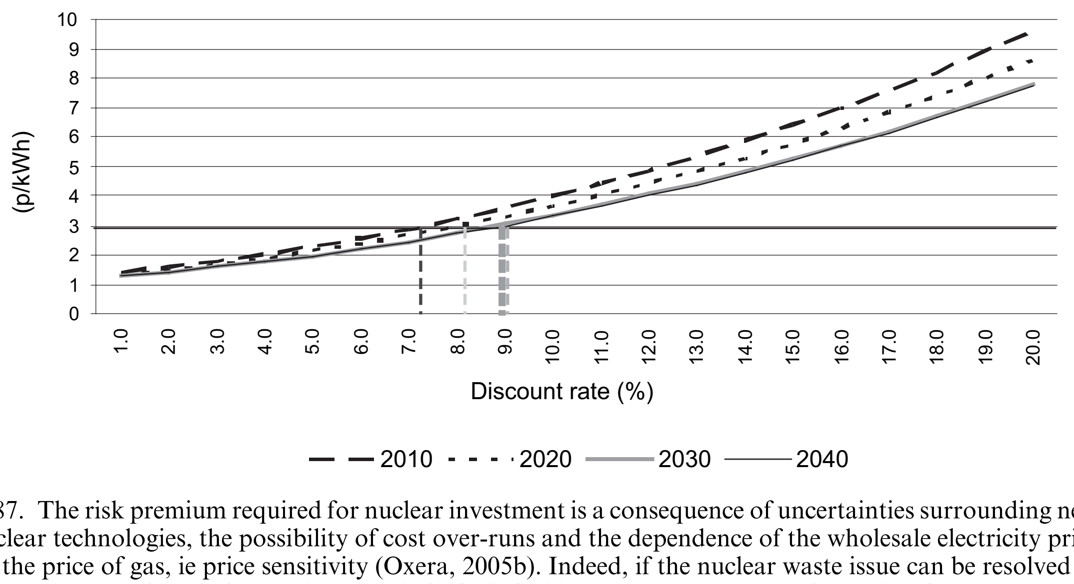
— The issue of nuclear waste is unresolved.

85. Risk has a dramatic effect on the cost of nuclear generation. This is well illustrated by the example of the new Finnish reactor, which is being built on a fixed-priced contract by the French company, Areva. Areva is partially owned by the French government, and as such, French tax-payers bear the risk of cost over-runs. This arrangement has enabled the private consortium, TVO,[51] which financed the Finnish reactor to use a low, 5% discount rate to do so.

86. The effect of the discount rate on profitability is shown in figure 4.1, which illustrates that nuclear power stations built in the UK in 2020 could be financed profitably at a discount rate of 8%.

Figure 4.1

NUCLEAR COST, BY CONSTRUCTION YEAR AND DISCOUNT RATE (p/kWh)



87. The risk premium required for nuclear investment is a consequence of uncertainties surrounding new nuclear technologies, the possibility of cost over-runs and the dependence of the wholesale electricity price on the price of gas, ie price sensitivity (Oxera, 2005b). Indeed, if the nuclear waste issue can be resolved to the extent that privately financed nuclear build is desirable, government support for nuclear investment must address these uncertainties.

88. Uncertain new technologies. While new nuclear technologies are predicted, by the nuclear industry, to be able to supply electricity very cheaply, these designs have yet to be built anywhere in the world (PIU, 2001). The private sector, which considers the risk of investment in nuclear relative to investment in gas, requires a high return on investment to bear this technology-related risk.

89. The government on the other hand must consider the social cost of carbon and the imperative to reduce carbon dioxide emissions. As such, it is required to choose between two uncertain technologies if it is to meet its own emission reduction target while supplying sufficient electricity for economic growth.

[51] One of TVO's six shareholders is the government-owned utility company, Fortum.

Hence, the risk profile faced by the government is markedly different from that faced by private investors and government intervention in favour of either nuclear energy or carbon sequestration is necessary for the 2050 target to be met.

90. Cost over-runs. A second generation of nuclear reactors could be expected to suffer less from cost over-runs. However, cost over-runs have been a feature of nuclear power in the UK and elsewhere to date. Consequently, this paper has been conservative in the assumptions made regarding the costs of nuclear energy—upper estimates of costs have consistently been used. Further, a 10% allowance for cost over-runs has been made.

91. Uncertainties over costs continue to affect potential nuclear investment regardless of cautious estimates. If the UK government decides nuclear energy is to be part of a solution to carbon abatement, this risk must be addressed by government. This can be done either through a cost guarantee or by a government-owned company building the plants on a fixed-priced bid.

92. Cost over-runs are not restricted to nuclear investment and could be expected to afflict a large-scale carbon sequestration project. As such, similar measures would be needed to reduce the risk of investment in a carbon sequestration project and encourage private sector involvement.

93. Price sensitivity. As a consequence of the low cost of gas generation in the liberalised market, the price of electricity is dependent on the price of gas. Part of the risk associated with nuclear investment is concerned with gas prices, and thus electricity prices, falling. The realised price of electricity is of particular risk to nuclear investors due to the long lead- and lifetimes of the nuclear power plants, although this risk is also present in a large-scale carbon sequestration project.

94. Private investors will require assurances that investment in a nuclear power plant will not result in an unprofitable source of generation several years hence due to a fall in gas prices. In this regard, government could prevent gas prices falling below a price floor by using either a carbon tax, or a "smart" import tariff that is dependent on the price of gas.[53]

95. However, a government decision to support nuclear new build will consider more than just economics. Ultimately, government may decide that supporting nuclear investment carries too much political risk, in which case commitment to carbon abatement will suffer, and the 2050 target will almost certainly fall by the wayside.

5. Conclusion

96. Uncertainty is inherent in any study which attempts to predict the future. This paper required assumptions regarding, among other factors, energy efficiency improvement rates and the practicable potential of renewable energy sources. In either case, significant deviation from the numbers used, would affect the results of the model in a relevant manner. However, the best case scenario (ie high energy efficiency savings and high penetration of wind energy) results in a 23% short-fall in supply in the absence of a nuclear energy or carbon sequestration program. Thus, significant changes to either or both of these numbers (in the same direction) would be required to alter the conclusion that either nuclear energy or carbon sequestration will be required to achieve the 2050 target.

97. Further study regarding the practicable potentials of renewable energy technologies past 2025 is necessary. Decisions regarding the generating mix are long-term decisions, and full information in this regard is essential.

98. It must be noted, that an economic analysis of the sort undertaken for this paper has limitations in accounting for social costs. Indeed, it is impossible for the social cost of carbon included in the analysis to account for the worst consequences of climate change, such as irreversible damage to the climate system and ecosystems. Similarly, certain societal costs nuclear energy has the potential to impose[54] remain external to the model.

99. These limitations notwithstanding, the analysis suggests that reconciling the UK's economic growth projections with the government's plans for carbon abatement will not be easy.

— The carbon abatement target imposes restrictions on fossil-fuelled electricity generation.

— Renewable energy has practicable limitations.

— Feasible electricity efficiency improvements are constrained below 2%/yr.

100. As such, the UK will be unable to meet electricity demand in 2050 without a large scale program of nuclear energy or carbon sequestration. There are compelling arguments for investment in new nuclear generating capacity:

— Nuclear energy is more cost effective than a carbon sequestration program (involving both gas and coal sequestration), although both would require government subsidy.

— A large-scale nuclear power program supports the government's desire for energy diversity, while a carbon sequestration program requires increased dependence on imported fossil fuels.

[53] That is, an import tariff that acts to ensure a minimum price but is absent at gas prices above this minimum level.

[54] That is, the effect of nuclear catastrophe on human health and society, and on the environment.

— Nuclear energy has benefited from much technological learning. Carbon sequestration, by contrast, is untried on the scale necessary to meet the predicted shortfall.

101. However, management of nuclear waste is a major weakness in the case for nuclear. Consequentially, whether the UK's national emission reduction targets will force an increasing reliance on nuclear power depends on satisfactory resolution of the nuclear waste issue.

102. The analysis presented in this paper suggests that an environmental toll will be paid for electricity usage in the UK over the next fifty years. Whether that toll will be in carbon emissions or nuclear waste is a decision for the country's politicians.

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4 September 2005

Memorandum submitted by CPRE

1. CPRE welcomes the opportunity to comment on the above inquiry, which is both wideıranging and timely given the discussions over the future security of supply. We exist to promote the beauty, tranquillity and diversity of rural England by encouraging the sustainable use of land and other natural resources in town and country. It is from this standpoint that we wish to comment on a number of the questions raised by the Committee.

2. There is a lively debate over how future energy needs should be met, and the place of nuclear within any future energy supply mix. We believe that it is important that this debate is informed by the implications of any decision on the countryside. CPRE recognises that climate change is already occurring, that the rate of change is a consequence of human activity, and that it has the potential to damage irreversibly the character of the countryside and coastline. This should be a central consideration in guiding Government policy, and we believe this warrants re-examining the objectives that underpin the Energy White Paper.

THE EMPHASIS OF THE ENERGY WHITE PAPER NEEDS TO BE REVIEWED

3. When publishing the Energy White Paper, Ministers referred to the importance of tackling four issues simultaneously. These were increasing competitiveness in energy markets (through lower prices), tackling fuel poverty, reducing carbon emissions, and ensuring security of supply. Few would dispute the desirability of achieving these objectives. Yet, it is important that the inter-action between these is considered. In particular, we question the extent to which lower prices for gas and electricity (as a policy objective) are consistent with achieving energy efficiency and a low carbon economy. The minutes of the Government's Sustainable Energy Policy Advisory Board (SEPA) meeting of 8.6.05 illustrate this dilemma stating that "Although high energy prices undoubtedly posed challenges for UK commerce and industry they also offered additional stimulus for energy efficiency measures and opportunities for CO_2 reduction" (DTI website).

4. A related issue is the importance of tackling what DEFRA called in its consultation paper on the Climate Change Programme, the "comfort or rebound" effect. Specifically, it said "Policies that enhance energy efficiency make it cheaper to heat our homes or to travel and past experience is that people respond by heating homes or travelling more. Such comfort or rebound effects tend to offset the initial gain from policies designed to reduce overall energy demand and carbon dioxide emissions" (*Review of the UK Climate Change Programme,* paragraph 3.21). Such rebound effects were estimated to be between 10–30% for example, as a consequence of improved fuel efficiency.

5. CPRE believes the Energy White Paper needs to address the potential conflict of falling prices for energy and improving its efficient use, and moving beyond energy efficiency to actually reducing consumption and overall carbon emissions. This should be at the heart of any new energy policy. The leaked briefing by a senior DTI official to incoming Ministers following the 2005 General Election includes the comment, "continuing high or rising consumer prices will make it harder to achieve fuel poverty objectives". CPRE believes this demands a more intensive targeted approach to tackling those in need, rather than a strategy that tries to reduce costs across the board. Given the growing data which exists on climate change, and evidence that the Government is unlikely to meet its domestic targets for reduction of CO_2, the need for a review is urgent.

6. We are encouraged that the new Secretary of State for Trade and Industry, Alan Johnson MP, in his speech to the Labour Party Conference said, "We have put energy conservation and the development of renewables at the heart of our approach". He went on to say "the challenge now is to consider what we can do to reduce still further CO_2 emissions while ensuring our energy remains both secure and affordable". This further highlights the tensions between the Government's policy objectives and we urge the Committee to examine the compatibility of these aims.

Reducing Energy Demand Must Take Priority

7. The Terms of Reference for the Inquiry consider the extent of the "generation gap" (question 1). CPRE believes this places an emphasis on how the energy mix can meet growing demands for electricity and fuel. If we are to deliver significant savings in carbon emissions, we believe it is essential that the debate moves on from how energy supply (eg gas or electricity) can be provided, to how energy services (eg heat or light) can be provided in ways which reduce carbon emissions. We welcome, in this respect, the discussion within Government of a renewable heat obligation but believe much more needs to be done if we are to secure significant improvements in energy efficiency.

8. A commitment to reduce energy consumption needs to be shared across Government if a coherent programme for reducing emissions is to be delivered. CPRE is concerned that other departments, such as the DfT, ODPM and HMT have not embraced this agenda sufficiently. The minutes of the SEPA meeting (quoted above) say "it was noted that revenue-neutral congestion charging (the subject of a recent announcement) might actually have the effect of increasing emissions, by making rural driving cheaper". Meanwhile the ODPM and Treasury's plans for a significant increase in market housing provision will have considerable implications for energy consumption.

9. The effect on energy use of tackling problems of low housing demand are also significant. Yet, calculations on the net energy balance from demolishing existing properties in northern communities have generally failed to incorporate the embedded energy contained within the house. And as the Sustainable Development Commission note in their submission to the Government's review of its climate change programme, "Refurbishments pay 17.5% VAT, whereas new build is VAT free. This is distorting the economics of developments in favour of demolition and replacement rather than refurbishment. This is causing unnecessary destruction of communities, and destruction of older buildings which could be refurbished to immensely higher standards of efficiency". In addition, the very act of demolition releases CO_2, as well of course as the emissions released through the construction programme.

10. Recent Government statements illustrate the absence of a coherent approach to energy conservation. The response by the Chancellor of the Exchequer to the events following Hurricane Katrina included a call for increased production (ie extraction of fossil fuels and processing). This illustrates well the dependence we have allowed to occur on fossil fuels. Reducing this dependency will assist in reducing emissions, and improve security of supply. It is an uncomfortable truth that frequently the hard decisions over reducing consumption come in times of acute shortage. A good example of this is the way in which motorway speed limits were reduced during the oil crisis in the 1970s. We believe that the Government should focus on using the opportunity of high fuel prices to address how overall energy consumption can be reduced, rather than look to ways of increasing supply.

11. The Director-General of the DTI's Energy Group, Jan MacNaughton, in her (widely leaked) memo advised "we need to push DEFRA and other Government departments hard on the scope for more vigorous energy efficiency measures, including on transport, buildings and the domestic sector'. Areas where we believe action by Government is needed include:

- working towards ensuring all sectors are covered by fiscal instruments which aim to reduce the consumption of carbon;
- requiring all new housing development in the Government's Growth Areas to be "excellent" in terms of the Eco-Homes Standard;
- developing an "energy conscious" approach to securing sustainable communities;
- strengthening guidance to OFGEM so it has a clear objective of reducing energy consumption rather than just improving energy efficiency;
- turning the proposed report on the implementation of the Air Transport White Paper into a full scale review which has demand management at its centre;
- ensuring proposals for road pricing contribute to emissions reduction;
- reviewing the Government's Targeted Programme of [Road] Improvements in the light of the need to reduce CO_2 emissions; and
- taking the necessary measures to ensure the cost of public transport falls, and the cost of motoring increases.

12. Government has a key responsibility in creating the right framework for businesses and members of the public to reduce their patterns of consumption. It has an important role too in encouraging the development of new technologies through research and development. CPRE is concerned, however, that the need for behavioural change in order to address the challenging targets for climate change has not been sufficiently appreciated within Government. There appears to be a reliance on technological fixes to address climate change. In CPRE's view this will be insufficient on its own for the task.

13. This emphasis on technology is underlined by an on-line question and answer session that the Prime Minister had during the Labour Party Conference. During this, he was asked about climate change. He remarked, "my honest view about this is one that no government is going to sacrifice economic growth for the environment. Short term economic growth for the long term problems of the environment, and therefore you have to find the ways both in energy efficiency and in science and technology and renewables and all

the rest of it, of managing to grow sustainably without damage to the environment". CPRE believes this sits uncomfortably alongside the Government's Sustainable Development Strategy, Securing the Future, with its emphasis on recognising environmental limits, and seeking to influence behaviour. Indeed we believe the science amply demonstrates that climate change cannot be viewed as a long term environmental problem. The effects are already being felt, and need an urgent response. This was underlined during the Climate Change conference in Exeter earlier this year which was organised by the UK as part of its Presidenicy of the EU. We are deeply concerned that this urgency is not being reflected in the decisions being made by Government. The danger of catastrophic climate change as feedback loops reinforce the effects from human induced emissions reinforces the need for a precautionary approach. We urge the Committee to address this issue of urgency during the course of its inquiry.

The Supply of Energy

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

14. CPRE supports the development of a broad range of renewable technologies in contributing to meeting our energy needs. It is important to recognise, however, that all forms of producing electricity have some environmental impact. We have been concerned that the Government's approach, to date, has focused heavily on the use of onshore wind farms to deliver the Government's 2010 target. Onshore wind is assumed by the DTI to contribute between 7–8% of the target for 10% of electricity generation to be by renewables by 2010. While this is a consequence of the maturity and relative investment that has gone into different technologies, we believe this approach is posing a considerable threat to the character of the countryside. We attach particular importance to the question of whether there is sufficient physical (as opposed to technical) capacity for renewables to deliver the generation required.

15. To answer this question requires agreement on the relative contribution of renewables to meeting society's needs. This needs to be informed by an assessment of how energy consumption will be reduced. It should also be informed by a proper understanding of the consequences of policy decisions on the landscape of the countryside. We do not believe the adequate answers have yet been provided to either question.

16. To our knowledge no Strategic Environmental Assessment (SEA) was undertaken of the Energy White Paper, its renewable energy targets, or other proposals. Unlike offshore wind, where a national SEA was undertaken by the DTI, responsibility for undertaking any appraisal has been left with regional planning bodies. Furthermore, there seems little opportunity for the results of any assessment to feed back into national policy. Indeed, the Energy Minister, Malcolm Wicks MP, has stated to the House of Commons (21.7.05) that regional and local planning bodies should consider the targets for renewable energy as "floors" and should not restrict further development even if targets are exceeded. Given that SEA should be about considering the potential impact of development on the environment, one is left wondering what the purpose of the SEA may actually be, or how a regional planning body is to use the findings of the SEA in coming to decisions over what is an appropriate level of development.

17. The failure to appreciate properly the impact of onshore wind on the landscape has contributed towards the heated debates that now exist over the topic. Nobody benefits from the current situation. To some degree, this conflict is an inevitable consequence of blaming the land use planning process as an obstacle to progress with renewables. The wording in the Energy White Paper, new Planning Policy Statement 22: *Renewable Energy,* a subsequent statement by Energy Minister Malcolm Wicks MP (see above), and the fact that DTI have charged officials with overcoming "barriers" including planning, all weaken the planning process.

18. In fact, the land use planning process is the principal mechanism by which proposals can be considered in the context of the land, its environmental and cultural qualities, and other competing uses for it. Normal planning arrangements allow for this to be done in an open way, enabling members of the public to have a proper say, with decisions made by democratically elected local authority members. This is in contrast to how projects with a theoretical capacity of 50 mega-watts or more are considered. Here, the decision is taken outside of the control of the local planning authority and handed directly to the DTI. Although local authorities can trigger the need for a public inquiry, the ultimate decision rests with the Government department that holds primary responsibility for meeting the target for renewable energy. This highly questionable arrangement arises from Section 36 of the *Electricity Act* 1989 and adds to the criticism of the way in which renewables are planned in this country. CPRE believes amendments should be made to this legislation to ensure more projects are considered under normal planning procedures.

19. One of the criticisms levelled at some renewable energy technologies is its intermittency. While there appears little consensus over the degree to which this is a problem, it seems apparent that to reduce intermittency would be a positive step forward. We would urge that serious consideration be given to how to develop less intermittent renewable technologies (like wave/ tidal) so that these may contribute towards the achievement of Government targets. Sensitively planned offshore wind projects too, have a very important role to play.

What contribution can micro-generation make?

20. CPRE warmly welcomes the growing interest in the contribution of micro-renewables to energy provision, that is micro wind, PV, solar thermal panels, micro CHP and ground heat pumps. We believe these are a more benign way of ensuring we are able to meet society's needs. Important aspects of what makes them valuable is their ability to be retro-fitted to existing developments, the potential which exists in urban areas, and for the areas of electricity generation and consumption to be located very close together. It also places greater responsibility upon individuals in relation to understanding their own patterns of energy consumption.

21. We believe there is an urgent need for the Low Carbon Buildings Programme to be implemented. This needs to be carefully integrated with proposals for housing growth (such as in the Thames Gateway) as part of implementing the Communities Plan. We believe that Government needs to move towards a goal where all new build is, as far as possible, carbon neutral. But even if all new housing development were carbon neutral, its proportion compared to the whole building stock would be small. It is critical, therefore, to address what can be done to improve performance in existing buildings through micro-generation and energy efficiency measures. In order that micro-generation plays a bigger role in future, CPRE also recommends that:

— a review should be undertaken of the current regime of Permitted Development Orders to see if micro-generation can be further supported (particularly outside Conservation Areas) while ensuring existing policy objectives concerning design, conservation, the historic built environment and other environmental issues are effectively addressed; and

— the Government should support a series of locally organised road shows for local authority planners and councillors to provide information on micro-generation technologies.

Nuclear Power

22. CPRE has a long history of involvement in relation to scrutinising proposals for specific new nuclear plant. We neither advocate, nor object to nuclear power on principle. Our starting point is the impact which it, alongside other alternative measures, may have on the countryside. Because of the sensitivity of these particular developments, they are often proposed in rural landscapes, especially remote coastal ones. We objected to a number of proposals for nuclear power plants and waste disposal facilities in the 1980s on the grounds of insufficient justification of their need, their significant impact on the landscape, and the unresolved problem of nuclear waste. This included proposals for drilling boreholes in the Northumberland National Park.

23. In considering the place of nuclear power plants in the overall energy mix we believe it is important to consider the different timeframes involved. Over the short term, the approval of new nuclear power plants would not be able to address the "generation gap" identified by the inquiry. The Performance and Innovation Unit report, *The Energy Review* 2002 estimated that new nuclear plant would require 10 years to build. Crucially, this estimate was made "on the assumption that the projects concerned do not face major planning obstacles". Given the sensitivity of the public to nuclear, particularly in the absence of an agreed way of addressing nuclear waste, this would seem to be an optimistic assumption. Therefore, new nuclear power will not "keep the lights on" in the short term. The contribution of existing plant, however, could become more important.

24. Looking to the longer term, the Government faces a crucial decision concerning how energy is both generated and supplied in this country. We have an established energy distribution network which is predicated on a relatively small number of generators of electricity. There is, however, a recognition that if we are to move towards a scenario where renewables, and in particular micro-generation, are to play a bigger role, then a more localised distribution system would be required. The development of a more localised model would also reduce leakage caused by the long distance distribution of electricity—leakage that benefits nobody. We urge the Committee to look, therefore, not just at the impact of a decision to invest in new nuclear build on energy and renewable energy, but also on the distribution network and any changes which might be needed in future.

25. CPRE is concerned by references to planning and new nuclear plant in the leaked memo by Jan MacNaughton (Director-General of the Energy Group at DTI) to incoming Ministers. Specifically, she asks the Minister, "if we wanted to encourage new build, what steps might we take eg on planning issues regarding sites and pre-licensing of reactor technologies?". We urge the Committee to explore what may lie behind this statement.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

26. It is CPRE's judgement that investment in new nuclear build would have important influences on investment in renewables and energy efficiency. To some extent renewable energy as a whole may be cushioned from the effects of investment in nuclear more than it has in the past because of the commitments made in the Renewables Obligation. However, even with an extension of the Obligation it is likely that

investing in nuclear would deter investment in less mature renewable technologies, such as wave power. This is likely to mean a continuing domination by wind in renewable energy generation. The impact of investing in nuclear is likely to be more severe in terms of its impact in undermining efforts to promote energy efficiency and energy conservation.

27. The initial cost of new nuclear build is substantial. It is important to consider the effect of providing electricity from a new programme of nuclear reactors on energy efficiency. But it is also necessary to consider the opportunity costs associated with putting that money towards major new generating plant, compared with boosting substantially measures to help consumers reduce their energy demands.

How carbon-free is nuclear energy?

28. Although we do not possess the expertise to answer this question specifically, we believe that it is a very important question to pose. If we are to tackle climate change, then it is important that our sources of energy are as low carbon as possible. We endorse the need to consider this in the form of a life-cycle analysis, and we believe this should be applied to all forms of supply, and not just nuclear.

Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the Royal Commission on Environmental Pollution?

29. CPRE has supported the recommendation of the RCEP, and believes it would be irresponsible to build new nuclear plant until a solution had been found to how to deal with radioactive waste in the long term. The scale of waste generation may indeed be less through advances in technology; if so, CPRE welcomes this. It does not, however, address the problem that the overall legacy has still not been addressed. The Committee on Radioactive Waste Management (CoRWM) will report on nuclear waste containment solutions in June 2006, and its chair, Professor McKerron, has warned that preparing for a new generation of nuclear stations will hamper attempts to find a solution to the nuclear waste problem.

30. The latest estimate by the Nuclear Decommissioning Agency of £56 billion highlights the huge opportunity costs associated with this technology. CPRE is also concerned by speculation that rather than re-converting decommissioned plants to greenfields (as previously planned), areas may come under "indefinite institutional control" (ENDS August 2005). In effect this could mean land being blighted for many many years to come, tightly controlled and without public access. This would reduce the financial costs associated with decommissioning. The Government has established a process for considering the issue of tackling nuclear waste. We believe that this needs to be able to run its course.

CONCLUSION

31. CPRE believes that the threat of climate change means that concerted action is needed to move towards a low carbon economy. While the Energy White Paper has focused principally on the generation and consumption of electricity and fossil fuels, we believe a vital contribution to tackling overall emissions can come from action taken in other sectors. These include in particular the aviation, surface transport, and housing sectors. The Government should take a stronger lead in setting a suitable framework which will not only seek to improve energy efficiency, but actually deliver reductions in energy consumption and carbon emissions. This must be the first priority for Government if it is to promote a sustainable energy policy.

5 October 2005

Memorandum submitted by Ian Critchley

GENERAL VIEWS

1. The nuclear industry is presently in the process of being dismantled, and whilst it will be some time before the more recently constructed plants become due for decommissioning, it is only a matter of time before its contribution to the net national demand for electricity becomes marginal.

The industry is not attractive to young people and recruiting quality staff has almost become impossible, as young people see no future in nuclear power. Nuclear dismantling is a new business, and it is very different from nuclear power plant operation.

The only way that operational capability can be retained is to attract young people who see nuclear plant operation as a potential career, and this can only happen if there is a commitment to retaining nuclear power for the long term. If this does not happen, a return to nuclear in the future will be very much more difficult simply as there will not be the right mix of skills of knowledge to support an industry on any meaningful scale.

The industry has done itself no favours over the last generation. The public remains suspicious and ignorant due to the misleading "facts" peddled by self-appointed nuclear "experts" and the so-called green lobby who also have to resort to lying and distorting the truth to make their case against nuclear power.

The culture within the industry has however changed markedly over the last 10 years, and safety has become paramount alongside conservative decision making over production and environmental protection. Whilst there is some way to go before British plants are operated on a level with the world's best in terms of operational excellence, the movement is in the right direction and continues.

If we were able to go back to the early days of the industry knowing what is known now with the values that we now have, nuclear power would be perceived very differently and we could have a very safe means of generating electricity with almost no discharges to the environment, relatively small quantities of waste and a safety record that would be the envy of every other industry. The industry didn't live up to its promises for a variety of reasons that we are now able to learn from.

There is an opportunity to create a new nuclear industry that benefits from the learning of the last 50 years and could become such an ideal, but only if the opportunity is taken before the window closes and capability is lost forever. The knowledge needed to make the ideal a reality resides in the experience of people who in a few years will be gone without being replaced.

This would point to making a commitment to nuclear power generation now so that a career in nuclear returns to the minds of our next generation of engineers and scientists. The alternative is to lose the capability.

2. The reality of this of course is that it will be an expensive investment over the lifetime of several governments that the country cannot back out of once it has started. The political will and courage to make such a long-sighted investment will always be a challenge for politicians.

A nuclear industry can never be completely detached from government control for a number of good reasons—financial, waste disposal and security to mention but a few of the most obvious. Private industry and competition can do a lot to make the industry financially self-sustaining, but it cannot be allowed to become a monster that is controlled by profit. Government control must therefore be retained, but there is already a model in existence in the Nuclear Decommissioning Authority that could easily be extended.

This would point to committing to nuclear power generation that remains under government control with a similar model to the NDA.

3. The alternatives to nuclear power for large-scale generation without CO_2 emissions do not provide the means to avoid nuclear power. Wind, tidal and solar power all have their own technical and reliability problems, but the main one is simply one of scale. They do of course have their place in a healthy diversity of generation options. The New Electricity Trading Arrangements (NETA) do not provide for a sensible electricity supply strategy, as it does not recognise the obvious difference between base load and non-base load. They favour plants that can be switched on and off with no notice, which is simply not how nuclear plants can be operated.

This points to the need for a healthy diversity in a national electricity generating strategy that recognises the unique aspects of nuclear power plants. Such a strategy must treat base load differently from non-base load in trading arrangements, and accept that safe and reliable nuclear generation comes at a cost in return for the benefits of pollution avoidance and security of supply.

4. Nuclear waste management requires a pragmatic single national approach instead of the dithering that besets it at present. There are not many options, it is high time one was chosen. Deferring a decision on a national repository for our grandchildren to see through is nonsense. Reprocessing spent fuel should remain an option only if there is a very clear benefit in sustaining future fuel supplies, which at present it does not. Reprocessing has hitherto created additional waste and cost for no benefit. This however does not preclude the option of long-term safe storage of spent fuel that retains the option to retrieve it in the future for reuse should future generations wish to do so, but requires that appropriate storage is invested in and its ongoing costs accepted.

Other solid waste should be minimised through design and good practice, and as far as possible should by recycled within the industry. This needs to be the subject of a unified industry that is geared up to recycle its own waste. Where solid waste has to be disposed of, a consistent industry-wide approach should provide for it. This essentially means either a single nuclear waste storage facility, or local on-site facilities at each location. In either case, the waste should be conditioned and made ready for permanent passive disposal prior to storage. As with spent fuel, the waste should be retrievable in case it becomes necessary to maintain its passive storage condition.

This points to the need to set a new industry up with a collective solid waste management strategy and disposal regime that opts for immediate final disposal with retrievability. Spent fuel should be retrievable to retain the option to reuse it in the future.

Consultation Paper Questions:

A. *Generation gap*

1. I defer to the knowledge of others who have studied the subject for the assessed size of the gap. It is important to note however that there is a gap, and to some extent its size is of little relevance in deciding whether or not commit to new nuclear build. There is a risk that the existing plants will have to be taken out of service sooner that planned for technical reasons to do with graphite erosion that cannot be repaired. This will have the effect of creating the gap sooner in a climate of increasing electricity demand and a growing requirement for supply reliability to support a computerised society.

B. *Financial costs and investment*

2. I refer to my comments above. The country needs a secure base load generating capability that comes with reliability and minimal environmental impact, over which government should retain strategic control. This is worth paying a premium for, and should be topped off with a range of responsive plant operated by private industry that includes a significant proportion of renewables operating in a competitive environment.

Government should own the provision of base load, and private industry should be free to supply non-base load. This puts the relatively small (compared with nuclear investment) investment decisions and risks associated with renewables with the private sector.

The costs of new nuclear build and operation if allowed to stand alone from the existing industry should be reasonably accurate. Past experience shows us that the cost of waste management and decommissioning is very difficult to assess, as are the unforeseen costs that arise from uncertainties. New plants are designed for decommissioning and the technical aspects of their disposal are more predictable. The legacy we have at present is the product of a different era and no planning for plant lifecycles. Decommissioning of any new facilities should be addressed in a national radioactive waste strategy that must come with a new-build programme. This would bring far more predictability into the costs of new build over its lifecycle.

Hidden costs are invariably associated with waste management, which again if planned in as part of the investment should be reasonably predictable. The cost of security is higher than at any time in the past but is not a significant factor as plants can be designed for security, and a security force is necessary for any industrial site.

Other hidden costs have historically arisen from regulatory demand for safety enhancements that increase an already generous safety margin and come at grossly disproportionate cost for the negligible or no benefit delivered. The industry and regulators understand this better now and work together more effectively to avoid such instances.

I do not believe that renewables can deliver reliable large-scale generation. Common sense tells us that such units are subject to the unpredictability of the weather, climate change and extreme operating conditions, which render their operating capability a hostage to fortune. The units cannot be built on a large scale other than number with the obvious visual impact that nobody enjoys. The maintenance burden and poor load factor simply makes renewables a non-runner for a reliable supply.

Micro-generation should be encouraged on the obvious basis that every little helps. Where energy can be recovered without excessive cost, it should be encouraged as this puts the cost with the immediate user with minimal additional environmental impact in terms of fuel and waste. Solar water heating should also be considered as a contributor as it avoids electricity and other fossil fuel usage, and collectively would reduce electricity consumption by a significant amount if householders and business users could afford to install it.

Micro-generation at isolated locations should be supported as self-sufficiency avoids the need to provide grid and mains connections at disproportionate cost, with minimal environmental and visual impact. Apart from solar panels and heat recovery systems, micro-generation in communities does not make economic or environmental sense where installations are obtrusive. Eg Encouraging 100 householders in a village each to erect a windmill is not sensible whereas encouraging a farmer on a remote hillside to erect a windmill would be.

3. Financial institutions simply do not have the knowledge to make investment decisions on nuclear build as there are to many uncertainties at present. Any financial institution that takes risk in nuclear investment in the present climate cannot really understand what it is taking on. The recent fortunes of British Energy amply show this, and the government had to come to the rescue twice.

Whilst the provision of funding from private investors with the promise of reward should be sought, new nuclear build must remain the responsibility of the government and that is where the risk has to be taken. Most of the risk is driven by government through the waste strategy and regulation, and it is therefore within its own gift to manage such risk whereas the private sector cannot.

Investment in other technologies is always going to be more attractive simply because such as CCGT is well understood and very simple to predict in terms of cost and risk. Without the incentive to do otherwise, profit will force investment into the easiest options without regard for what is best for the country.

C. *Strategic benefits*

4. The main public good would be in the provision of a secure and reliable supply of electricity with minimal carbon emissions. If it were implemented properly, electricity would also be produced at a reasonable cost. Consideration of the benefits should also be weighed against the alternatives of not providing such an electricity supply and the costs incurred by unreliable supplies and ongoing avoidable air pollution. The short answer is that there is no real choice—it has to be provided.

The investment involved in creating a "new" nuclear industry would be considerable and would probably take more than a generation to pay for itself. It would however be there in perpetuity.

The affordability of this would largely be down to the level of investment that could be attracted and how quickly the plants could be in a position to start earning. A commitment to a "new industry" rather than bolting on new build to the back of the existing industry with its historic problems and uncertainties would make investment far more attractive, particularly if the government was to guarantee some reward without investors having to take a huge step of faith on risk from waste strategy and ever-changing regulatory impacts.

Carbon emission reduction would be significantly enhanced if nuclear plants were provided with the intention of underpinning base load, simply as they would displace carbon-generating base load plants. Whether these plants would be taken out of service before the end of their lives would be down to their ongoing profitability where they have to compete in a smaller (non-base load) market.

Nuclear facilities do not pose a threat from terrorism. They are difficult targets, they are guarded and their construction does not lend themselves to being damaged easily. New nuclear build would be at far less risk than the old facilities which are much more vulnerable, particularly at Sellafield. If a terrorist organisation wanted to further its cause through a serious nuclear incident it would need to resort to a large missile attack or possibly an attack with a very large aircraft packed with explosives, and the certainty of success would be higher at other targets than new power stations.

There seems to be little to suggest that terrorist groups would choose to target a nuclear site mainly as the resources needed to have any real effect are difficult to obtain, the sites are in remote locations and contaminating a country that has a cross-section of people from their own belief system is rather self defeating. Terrorists go for the outrage factor of causing mayhem and suffering on easy targets, and they do not appear to be capable of mounting a numerically large-scale attack. An outrage on that scale would not draw support from within their own cultures.

5. I refer to my views above. Renewables, micro-generation and energy efficiency need to sit alongside a new nuclear industry as part of a diverse electricity generation system, but should be funded by private industry in their own (non base load) market. The Energy White Paper lacks this vision—new nuclear build has to be more than building new nuclear power stations, it has to be the launch of a new industry that is largely separate from the old one.

D. *Other issues*

6. In considering carbon freedom, the construction of a nuclear power station is not vastly different to building any other power generating plant of the same capacity. The operation of a nuclear power station is a different matter depending on the design of the plant. The AP1000 reactors are water cooled and do not discharge CO_2 coolant like the magnox and AGR reactors in service at present. The amounts of carbon emissions should be readily available from existing knowledge of the plants.

The mining of uranium is no more or less carbon generating than the extraction of other fuels, but the energy yield for the volumes extracted are far beyond the calorific values of other fuels. I maintain my point that whilst renewable energy is desirable from a carbon freedom aspect, the practicality of constructing, maintaining and operating such plant to generate the equivalent amount of power is unachievable without disproportionate effects on society and the environment.

7. I have made my position on radioactive waste in the views expressed above. A waste management strategy in essential and must be intrinsic to any new build.

11 September 2005

Memorandum submitted by Neil Crumpton

Apologies for the late response to this consultation. Developments in low-carbon technologies are moving quickly and the emerging possibilities outlined in the response below are, I believe, worthy of some consideration.

The Role of "Carbon-negative" Electricity Generation Technologies in Filling the UK's "Generating Gap", and for Demonstrating Such Technologies Worldwide

Even with increased and determined support for renewable energy generation, new energy efficiency programmes and possibly mandatory policies for the take-up of CHP schemes and devices at all scales, there could still be a sizable electricity generation "gap" to fill over the next twenty years or so. The gap would be created as much of the existing nuclear and coal power station capacity is closed down in the period to 2020. This proposal rejects the call for a new nuclear programme to contribute to the filling of any gap and puts forward how a significant capacity of carbon-neutral and, more importantly, carbon-negative generating capacity could contribute instead.

Avoiding a new nuclear programme means that, after demand reduction, any gap left after serious progression of energy efficiency, low-carbon and renewables programmes would likely have to be filled with a combination of new and or existing centralised fossil fuel stations. There are several types of generating technologies which could do this: next-generation gas-fired capacity (CCGT), new coal/biomass fired capacity (IGCC gasification/AD 700), and modified existing coal station capacity. The selection of such technologies would be much dependent on the emission reductions achievable, capital cost of new or modified plant, biomass availability, output cost and public support. A consideration of a fuel's pre-combustion emissions and security impacts could also feature significantly in informed public debate and decision-making.

Also, as part of an energy policy, emission levels from such technologies could be reduced significantly by the use of carbon capture and storage (CCS) if and as the various technical and regulatory issues are addressed. CCS does have financial costs and an energy "penalty" which would have to be factored in. However, CCS costs would likely be reduced if used for "enhanced" oil and gas recovery (EOR) in the depleted North Sea oil and gas fields. There may be pre-combustion impacts and security considerations associated with the importing gas and oil from longer distances and or certain areas that may benefit North Sea EOR in that regard.

Yet, more significantly, carbon capture and storage opens up the possibility of developing a "carbon-negative" electricity generating technology, which could actually remove carbon-dioxide from the atmosphere during operation. This could potentially have significant benefits in reducing global warming emissions. It would be achieved by co-firing as much biomass as possible in either modified (retro-fitted) existing coal power stations, new coal gasification schemes (IGCC), and or new advanced super-critical coal plant, then capturing and storing the emissions. The use of CCS in combination with a significant take-up of biomass/energy crops could allow the UK to develop the world's first large scale carbon-negative generation system. The UK could take a lead world wide in developing and demonstrating such a system, with potential benefits in other countries, particularly China and India.

The benefits of using co-fired coal technologies and CCS in such a carbon-negative way would be:

- (i) enable significant reductions in UK power sector emissions to be achieved before 2020;
- (ii) demonstrate carbon-negative technologies to major coal using countries particularly India and China;
- (iii) enable more biomass to be used in power generation more quickly as part of the "renewables" portfolio;
- (iv) provide a large and viable biomass market and supply chain from which smaller biomass CHP schemes could emerge;
- (v) contribute significantly to UK energy security by the use of an indigenous energy resource (backed by strategic reserves of UK coal resources in an emergency); and
- (vi) contribute to the rural economy.

Carbon Capture and Storage (CCS) and Efficiency

Current estimates of the carbon dioxide capture efficiency range between 85–90% of the emissions in the flue stack. The process is energy intensive which produces additional emissions albeit mainly captured ones. Improvements in capture technology may raise the efficiency to 95%. The CCS process is estimated to require nearly 20% additional energy so the additional emissions would result in a slight loss of capture efficiency (eg down from 90% to 88% capture) per unit of output.

CCS as a concept has been successfully demonstrated. Currently CCS is carried out in the US for enhanced oil and gas recovery (EOR), in a Norwegian gas field (to reduce CO_2 content of gas which would other wise be vented to atmosphere) and in Algeria where BP are re-injecting CO_2 from extracted gas, again to avoid venting. The capacity of the UK North Sea gas and oil fields for EOR is significant and storage potential in other geological formations is huge.

THE CAPABILITY OF CARBON-NEGATIVE TECHNOLOGIES

The amount of biomass that could be co-fired in what are basically coal-firing technologies is key to their carbon-negative capabilities. There are basically three types of coal-fired technology which could use significant amounts of biomass, namely coal "retro-fit", IGCC gasification and new build AD700 plant. The percentage capture, the capital and or retro-fitting cost, the cost of CCS, and price of electricity may differ between the options. Some provisional figures are shown below but they show the potential.

(i) *Retro-fitted coal stations*

Existing coal stations (in UK, China, etc) can be modified by fitting advanced super-critical boilers and feedwater heaters which at least one leading power generation industry player (Mitsui Babcock) estimate would improve typical efficiencies by around forty percent (ie from 35% to 49% thermal efficiency). The super-critical boilers would also be capable of being co-fired with up to 20% (possibly 25%) biomass, rather than 6–7% in current boilers. Furthermore, the feedwater heating could use biomass boilers as an alternative to gas turbine/boiler plant. This would significantly increase the amount of biomass used overall in the scheme. According to industry sources (Mitsui Babcock) if the main boilers are co-fired with 20% biomass and the feed water heaters are also biomass-fired then the overall amount of biomass used per output of electricity is around 40%. Hence, around 40% of the emissions would be from biomass and hence carbon-neutral.

Assuming 40% carbon-neutral (biomass) emissions and an overall carbon capture efficiency of 88% then 35.2% of the emissions captured (40 x 0.88) would be carbon-neutral and hence "carbon-negative" when stored. Of the 12% of CO_2 that does get released to atmosphere 7.2% (12 x 60%) would be from coal and 4.8% (12 x 40%) would be from the carbon-neutral biomass. So, to account for the uncaptured emissions from the coal the overall carbon-negative emissions capture would reduce to around 28% (35.2–7.2) of the overall emissions. If CCS efficiency rose to 95% then overall carbon-negative capture capability would rise to around 34.6% (37.6–3).

An overall carbon-negative capture capability of around 28% possibly more is significant. It would mean, broadly speaking, that for every 10 power stations so fitted, then the emissions from an additional 2–3 coal power stations could also be neutralised (ie made carbon neutral).

(ii) *IGCC gasification*

Sill under development, the Integrated Gasification and Combined Cycle (IGCC) technology would allow around 10% co-firing with biomass according to one developer (Progressive Energy, who proposing an 800 MW IGCC with CCS on Teeside). This figure might be pushed upwards once the technology is proven. The benefits of IGCC is that the carbon dioxide is captured in pipe at a temperature and pressure that facilitates lower cost capture, possibly around $15 per tonne as opposed to $30–45 from supercritical boiler flue gases. Assuming a 90% CO_2 capture efficiency then with 10% biomass co-firing the technology would be essentially carbon-neutral. However, if the amount of biomass could successfully be increased to 15–20% then a modest carbon-negative capability would be achieved. A variation of IGCC, namely IGFC, which incorporates a robust solid oxide fuel cell as the first of a three stage process could raise the efficiency to over 50% which could result in cost reductions.

(iii) *AD700 coal technology*

The next generation of supercritical coal technology would improve efficiency to about 54% about 5% more than coal retro-fit schemes. The efficiency is improved by raising the super critical boiler temperature to 700 degree Celsius. The boilers would be capable of co-firing with up to 20% biomass. As this new-build technology has a useful efficiency improvement over coal retro-fit the price of electricity could be reduced while the potential carbon-negative capability would likely be of the same order.

PRICE OF ELECTRICITY AND CAPITAL COSTS

According to Mitsui Babcock, all three technologies have estimated price of electricity costs, including CCS, of around 3.2–3.6 pence/kWhr based on coal at £30.5 per tonne. This may rise slightly depending on the cost and amount of biomass fuel and may reduce depending on carbon (trading) price. For comparison, CCGT with CCS is estimated at 3.9 pence/kWhr based on gas at 30 pence/Therm, or 3.4 pence/kWhr at 25 pence/Therm. Electricity from new-build nuclear plant is estimated by the Cabinet Office (PIU 2003 report) at 3–4 pence/kWhr. Wind energy from onshore wind turbines is around 3.2 pence/kWhr currently. Offshore wind energy, currently around 5.5 pence/kWhr is estimated by the Cabinet Office to be around 3–4 pence/kWhr by 2020. So the cost is within the price range at which other benefits could be considered without economic concerns.

As regards capital costs, some of retro-fit technology is already operating and can be costed. It is likely that investors would have more confidence in retro-fitting their existing assets, rather than investing in next-generation IGCC or new build coal plant. Yet CCS costs may give IGCC an edge in the next decade albeit with much lower carbon-negative capability.

Biomass Land-use Requirement

A DTI/Carbon Trust recently carried out a study on the land area needed to grow a given biomass energy potential (www.defra.gov.uk/industrialcrops). The study estimated that "biomass might generate 6% of UK electricity by 2020 using 350,000 Ha". Assuming 2020 electricity demand is around 400 TWhrs/year (the current figure) then this would represent 24 TWhrs/year of electricity. If this is so, assuming 40% biomass use in coal retro-fit schemes then 24TWhrs/yr would result from 60 TWhrs/yr coal/biomass overall output. This order of output could be generated by 10 GWe of coal retro-fit stations operating at 70% load factor. To replace the "baseload" output of the existing UK nuclear stations (88 TWhrs/yr) would require 12 GWe of coal retro-fit capacity (at 80% load factor) and around 500,00 Ha of biomass. In the latter scenario there would be a significant carbon-negative capture benefit rather than an additional nuclear waste disposal problem.

Benefits of Using Biomass in Large Power Stations

It is currently generally considered that any biomass used in electricity production should be used in good quality CHP plant as the biomass would be used at the highest overall efficiency. Yet, very few such biomass schemes have come to fruition in the UK to date. Indeed, the potential resource according to studies by the Royal Commission on Environmental Pollution, the DTI and the Carbon Trust, would likely exceed the forseeable maximum usage likely in decentralised mini and micro CHP schemes. Furthermore, co-firing in super critical boilers may actually be nearly as an efficient way to get the most energy value from the resource as a good quality biomass CHP. Mitsui Babcock suggest this is arguably the most efficient use of the resource, though Grid transmission losses may not have been included in the overall analysis. The increased use of biomass would likely be, at some point, moderated by public attitude and biodiversity factors assuming the costs are reasonable. Biomass could be grown indigenously and or possibly imported.

Yet, by providing a large UK market for biomass, co-firing coal schemes may actually build a stable biomass market from which decentralised CHP schemes would benefit from. So current concerns may be overstated and in any event policy could incentivise the best use of the resource.

Energy Security

It could also be argued that using biomass, rather than gas imports, for electricity generation would reduce the amount of biomass available for the production of bio-fuels. Yet, in energy security terms, electricity production could probably be more easily disrupted than the supply and stocks of transport fuels and hence should be considered a priority in that regard. For example, long distance gas pipelines and LNG tankers and facilities are vulnerable to terrorist attack which could reduce supply capacity significantly and quickly. In contrast, coal and biomass can much more easily, cheaply and safely be stockpiled in the UK, and there are indigenous sources of both coal and biomass on which to rely or fall back on (a strategic reserve of opencast coal sites could be established). Furthermore, global gas resources are estimated to peak far sooner than coal by some margin (and obviously biomass is renewable). The estimated global resource is around 50 years for gas and 200 years for coal. So, price increases for gas are more likely as a finite and diminishing resource, and the availability less certain in comparison with coal. Coal would also be imported from more secure countries than gas (eg coal from South Africa, gas from Middle East, Russia).

Pre-Combustion Emissions

It is worth noting that in terms of combustion within a gas or coal electricity generating technology the best efficiencies and lowest emissions per kWhr to date have been obtained from North Sea gas-fired CHP then by CCGT with sub-critical coal lagging some way behind. However, when pre-combustion emissions associated with gas are considered, namely venting (extracted gas contains up to 20% CO_2). flaring, pumping over long distances, leaking pipes, or with LNG, liquefaction, transport and re-gasification, then the "life-cycle" emissions associated with gas and hence CCGT increase potentially significantly (see Wuppertal Institute LCA analysis).

In comparison, the pre-combustion emissions from coal can be relatively low, particularly for open cast coal. The pre-combustion emissions arising from coal are mainly transport and methane releases. Methane releases are by far associated with deep-mined coal (particularly if no methane capture technology is installed at the mine). Opencast coal contains little residual methane as the seams are not nearly as compressed by overburden as deep mine seams, so the methane has already mostly escaped.

If the pre-combustion emissions of coal and gas are included in a life-cycle emissions analysis then efficient super-critical coal plant narrows the emissions gap, co-firing with 20% biomass potentially closes the gap, and biomass feed water heaters could put coal/biomass schemes ahead of even next-generation CCGT (all without CCS). In summary, when pre-combustion emissions are included in the analysis then generating electricity by CCGT with CCS would not have any particular environmental advantage over coal / biomass with CCS.

A UK Carbon-Negative Power Generation Programme

It is estimated by Mitsui Babcock that around 2GW, possibly more, of current coal station capacity could be retro-fitted per year, each taking two years to complete. Hence a 12GW retro-fit programme (replacing the current nuclear output) would take around seven years. Fitting CCS would take three years per scheme, so a complete "retro-fit plus CCS" programme would take around eight years to complete. So, if it began in 2008 it would be completed in 2015. Most of the retro-fitted capacity would be operating before 2015 and so would likely preceed the earliest date that any new-build nuclear stations would possibly come on line (2015 ?). The availability of the required capacity of the biomass resource could compromise the amount of carbon captured as would the availability of viable CCS storage sites (probably EOR in the North Sea but also possibly in saline aquifer in the Irish Sea).

Such a 12GW retro-fit programme, generating around 85 TWhrs/yr would likely fill much of the emerging "generating gap" caused as existing nuclear and some existing coal and CCGT plant is retired. The gap may be around 100 TWhrs/yr in 2015, rising to around 150 TWhrs/yr in 2020 depending on a number of variables. Either way this would be a substantial capacity and importantly, with CCS, it would be a low carbon if not a significantly carbon-negative output. This could additionally neutralise the emissions from about 24 TWhrs/yr (85 x 28%) of output from efficient coal plant without CCS (eg the 4GW Drax if it were not retro-fitted as it is relatively more modern and efficiency anyway—it would produce 24 TWhrs at 70% load factor). In total, the carbon neutral output could be around 110 TWhts/yr (85 + 24) which would be a substantial part of the emerging generating gap.

Such a retro-fit programme would also answer concerns about energy security, as the coal and biomass would be sourced either indigenously and or imported from less volatile regions than an alternative programme based on CCGTs and gas imports. Neither would it give rise to nuclear proliferation concerns or present a radio-logical hazard in terms of terrorism and accident.

Perhaps most importantly in global terms such a programme could demonstrate to the world a carbon-negative generating technology based on modifying existing coal-fired plant and a renewable resource. As there is a very large number of such sub-critical coal power plants worldwide, especially in China and India, which are not due to be replaced for possibly decades such a demonstration could be extremely important as befits a country wishing to show global leadership on the issue of climate change. It may also be beneficial to UK plc in terms of technology transfer.

Summary

The UK has the potential to develop what would be at least a carbon-neutral if not a significantly carbon-negative electricity generating technology which could be copied world wide. The figures produced in this response are based on hard data and on-going industry studies, and look promising. Also, nearly all of the components of the overall technology are already operating in a number of power stations around the world or in oil/gas fields. As a carbon-negative capability is likely to some degree from such technologies and fuels, and the benefits of carbon-negative technologies potentially so useful, that more detailled studies should be undertaken by the DTI and others with best speed so as to inform the "energy review" in 2006.

If further investigation and debate does prove positive then political backing and policies should speedily be put in place to give carbon-negative energy generating technologies the support they might need to come to fruition.

7 October 2005

Memorandum submitted by The Dalton Nuclear Institute at The University of Manchester

The Dalton Nuclear Institute at The University of Manchester welcomes the opportunity to respond to the Environmental Audit Committee's Inquiry, Keeping the Lights on: Nuclear, Renewables, and Climate Change. The Institute is the focal point for the University's nuclear research and education programmes and is playing a leading role in UK academia in addressing the future skills shortages faced by the nuclear industry. The following memorandum highlights the Institute's concerns and opinions in the context of the inquiry.

1. Introduction

The Dalton Nuclear Institute at The University of Manchester believes that both nuclear and renewables have a role to play as part of a balanced, low carbon energy mix.

Whilst we will leave the detailed justification for a nuclear renaissance to others we believe nuclear power to be the only large scale carbon free generating alternative that will be financially competitive in the liberalised energy market. Advances in design and construction techniques have given confidence that plants can be delivered on time and to budget and waste related obstacles are political rather than technical with long term waste solutions being delivered in other countries.

However, the current policy of keeping the nuclear option open gives uncertainty for the future which concerns both industry and investors alike. This uncertainty is reflected in the decline in the UK's nuclear skills base, a skills base that would be called upon to select, license and operate a new fleet of nuclear power stations should the opportunity arise.

When considering options for investment in meeting future energy requirements it is essential that the associated skills base is considered, regardless of the technology. In the context of nuclear this means investing not only to maintain the skills to allow the nuclear option to be opened but also to undertake research to develop innovative waste management solutions and next generation reactors.

2. Current State of UK Nuclear Skills Base

The uncertain future for the nuclear industry has resulted in a reduction in investment in research and education. Using nuclear fission as an example, research funding has fallen from around £500 million in 1974 (at year 2000 monetary values) to close to zero today. This has resulted in key centres of national expertise in industry, government and academia being closed, which in turn has led to a declining number of research staff, new graduates and up-to-date facilities being available.

Industry projections, backed up by Government and independent reports, indicate that the skills base has reached such a low level that it threatens the UK's ability not only to re-open the nuclear option, but also to deliver on the legacy requirements for decommissioning and clean-up. For example the Council for Science and Technology, in a recent report, highlighted the need for new investment in the UK nuclear R&D and skills base in order to sustain the UK's nuclear industry ("An Electricity Supply Strategy for the UK", May 2005).

If the nuclear option is to be kept open investment in nuclear research and education must be increased from its existing levels to ensure we have the necessary skills, capability and infrastructure should we decide to deploy.

3. Requirements

The Dalton Nuclear Institute is taking steps to address the decline in the UK's nuclear skills base. The Institute pulls together Manchester University's well established nuclear research centres to pool resources and address broader research challenges. Additionally the University is self investing to establish new nuclear research centres to allow us to undertake research programmes across the broad spectrum of the nuclear field. However, the Institute alone cannot address the problem, it must be supported by Government and industry investment in research programmes to grow and sustain the skills base while re-establishing the UK's position as a major nuclear player. Unless this happens the skills base will continue to decline and the nuclear option will be closed.

The UK's nuclear industry and academia require a clear and positive direction on the role of nuclear power in the future energy portfolio. This should be supported by a research programme of sufficient size to attract the high calibre engineers and scientists in to the sector to secure and grow the skills base.

In July 2003 an independent nuclear task force were commissioned to undertake a study titled "An Essential Programme to Underpin Government Policy on Nuclear Power". The task force identified the research programme that would be required to secure the skills base to keep the nuclear option open. The report concluded that investment of £20 million per year in nuclear research is required to support existing operations, keep the nuclear option open, keep us abreast of new technologies and manage the nuclear waste legacy. Since the report was published there has been little or no increase in investment and consequently the UK skills base remains in a perilous condition.

4. Summary

The Dalton Nuclear Institute believes that nuclear power has a role to play as part of the UK's future low carbon energy mix. However, the Institute is concerned that the lack of investment to maintain the UK's nuclear skills base may close the nuclear option before an energy policy decision can be taken. To avoid this scenario the Institute recommends that increased investment in nuclear research should take place to maintain the skills base and allow the nuclear option to be re-opened in the future.

22 September 2005

Memorandum submitted by Drax Power Limited

Introduction

1. Drax Power Limited (Drax) is the owner of Drax Power Station, the largest, cleanest and most efficient coal-fired power station in the UK. The output capacity from the plant's six generators is 4,000MW and at current output levels it utilises around 10 million tonnes of fuel (principally coal) to supply some 7% of the UK's electricity needs. The plant has the capability to be operating at high load factors up to 2025 and beyond, particularly if market conditions enable it to invest in appropriate environmental upgrades.

Government Policy

2. There is a range of initiatives which could be taken in the energy sector to ensure that the key objectives of security of supply, competitive markets and fuel poverty initiatives are achieved simultaneously with environmental compliance. These include the potential use of new nuclear plant, the expansion of the renewable/biomass programme, increases in efficiency of coal-fired plant and the development of carbon abatement technologies. Each of these needs to be considered but the appropriate investments will only materialise if long-term certainty can be realised through a stable and consistent environmental and climate change policy.

3. It is important that much more clarity is developed in the Government's long-term planning to ensure that the Power Generation Sector can deliver the substantial investment programme needed. In particular, there needs to be much more consistency in policy formulation and implementation across Government, particularly between DEFRA and the DTI.

4. The energy sector operates on long timescales and investment in a new plant or retrofit abatement technology, with typical payback periods of 10–15 years, is unlikely to happen without a much higher degree of certainty relating to the extent of future regulatory change, especially in the overlap of energy and environmental policies. The potential for "stranded assets" is currently too high to enable significant investment.

Long-Term Projections of Energy Mix

5. By 2020, on current projections, 60–70% of the UK's electricity may be generated from gas, with 80% of that gas being imported. This is not a particularly robust policy since much of that gas will originate from areas of low political stability. In addition, the uncertain medium to long-term outlook is not promising because input fuel volatility means that there are no price signals to sustain an early new CCGT build programme. In the interests of security of supply at a competitive price, Drax firmly believes that there needs to be a move away from an over-dependence on gas in the future UK generation mix.

6. The uncertainty in the future gas market, combined with the uncertain future of nuclear and the slow and economically inefficient renewables programme, means the current coal-fired generating capacity needs to remain in service. According to Government projections, as given in the recent Updated Energy Projections, output from coal-fired generation in 2020 will be around 62TWh. This indicates that a substantial tranche of coal-fired plant will need to be fitted with both Flue Gas Desulphurisation (FGD) for SO_2 control and Selective Catalytic Reduction (SCR) for NO_x control by that time.

7. Many renewable energy sources are intermittent and cannot follow demand (or load). They, therefore, require both the back-up and independent load-following generating capacity which the coal plant can provide.

8. The world has abundant coal reserves—almost 200 years of proven reserves—and the Government needs to ensure a regulatory climate conducive to investment at existing coal-fired power stations which would enable them to supply electricity reliably for many years to come. It is now time for a serious re-consideration of the vital role that coal-fired generation can play in helping to provide Britain with a long-term secure energy supply at a competitive price, which, with assistance to promote low carbon technologies, can also be in line with the Government's environmental targets.

9. We recognise that environmental pressures are set to increase and that these will be the critical parameters affecting coal burn in the period up to 2020 and beyond. Indeed environmental legislation and regulations will, over the coming years, ensure that it is only the cleanest and most efficient coal-fired plant that survives. Hence the UK requires a much improved regulatory framework to facilitate investment in emissions abatement technology to enable these plant to meet current and future environmental pressures. In particular, the pressure is on the coal-fired generation industry to invest in technology to significantly reduce carbon dioxide emissions.

Technological Options for CO_2 Control at Coal-fired Plant

10. A great deal is happening in order to encourage the coal-fired plant to implement lower carbon technologies. The Renewables Obligation (RO) was amended for co-firing specifically to provide a mechanism for developing the energy crop market and the DTI has recently published a Carbon Abatement Technologies (CAT) strategy. Drax fully recognises that if significant reliance on fossil fuels continues beyond 2020, there is a need to research, develop, demonstrate and deploy a range of Carbon Abatement Technologies.

11. It is critically important for energy and environmental policy-making in the UK to recognise that the application of these technologies would enable boilers such as those at Drax to emit CO_2 in comparable amounts to CCGT plant. This would put coal and gas on a similar policy footing and would reduce, or even reverse, the view that coal-fired plant cannot operate within a carbon-constrained economy.

12. The scale of these CAT programmes demands that they receive Government support and this is fully justified given the potential carbon savings that come with world-wide application.

13. Drax foresees such a programme happening in three or more stages:

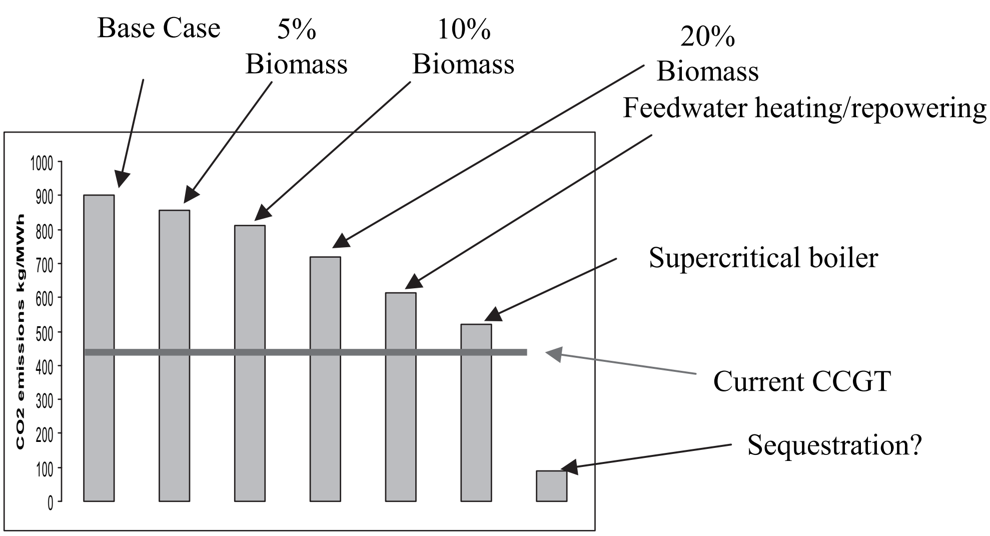
(a) Co-firing uses existing generating capability; it is an efficient, effective and relatively simple means of reducing overall CO_2 emissions. Costs are lower than alternative renewables generation technologies and there is no "new build" environmental impact, which is often associated with other renewables sources. Co-firing has emerged as a credible renewables technology and it is already making a difference through delivering significant savings in CO_2 emissions. But, more importantly, only minor capital investment is required in existing plant to enable a biomass throughput of up to 10%. Beyond that level, it is anticipated that increasing biomass throughput to 20% would require significant expenditure (for example, in burner and materials handling facilities) but this is still potentially commercially and environmentally attractive. If all the opted-in (under the LCPD) coal-fired plant were modified to burn 20% biomass (by heat output), the savings in CO_2 would be 10 million tonnes per year or nearly twice the total savings the Government is seeking to be made in CO_2 emissions by all power stations by 2010. Drax alone is capable of making savings of up to 4.4 million tonnes of CO_2 through co-firing, that is, some 80% of the Government's target for the sector.

(b) Investment in feedwater heating systems using either biomass or, more likely, gas could give rise to substantial further CO_2 reductions of up to 20%. This is achieved partly by the substitution of gas or biomass for coal, but also because better use is made of the waste heat from the gas turbine exhaust than would be the case in a more expensive, stand-alone CCGT plant. The additional fuel is utilised with a thermal efficiency equivalent to a Combined Heat and Power plant.

(c) The UK fleet of coal-fired power stations, with unit sizes in the range 500–660MW and efficiencies of 35–38% (LHV), is typical of the large, sub-critical boiler-turbine plant built in the 1960s to 1980s, with Drax the leader in terms of size and efficiency. However, more recent plant built overseas in Europe and Asia use supercritical boiler-turbine technology and achieve efficiencies in the range 42–46% (LHV), a technology that is now standard in China for large power stations. Replacement of Drax's existing boilers with supercritical units would require a 12–18 month outage but would improve the efficiency of the unit by 17–20%.

(d) In the long term, carbon sequestration deserves examination. Whilst not on the horizon just yet, we believe that further work is necessary to ascertain its economic and environmental implications and to that end we welcome the attention afforded Carbon Capture and Storage in the Government's CAT strategy.

14. Figure 1 illustrates the incremental savings that can be made in CO_2 emissions with each of the above technologies:



15. The following table compares the capital, generating and CO_2 abatement costs for onshore and offshore wind power (assuming a capacity factor of 25% and excluding the necessary back-up costs that would be required for wind power and any costs that might be required to strengthen the electricity grid) with a retrofitted 600MWe advanced supercritical (ASC) coal-fired boiler operating at a 60% load factor. The calculations assume a given level of CO_2 savings against existing coal-fired plant operating at 36% efficiency.

	600MWe Supercritical Retrofit	*234MWe Installed Wind Turbines Onshore*	*234MWe Installed Wind Turbines Offshore*
CO_2 savings (kte/yr)	471	475	475
Capital cost (£m)	116	175	216
Generation cost (p/kWh)	1.8[1]	3.75[2]	5.5[2]
Cost of CO_2 abated (£/te)	12	40	62

Notes:

[1] 15 year write off

[2] 20 year life

16. The table illustrates that wind power is significantly more expensive in terms of capital cost, between two (onshore) and three (offshore) times more expensive in terms of generating costs and at least three (onshore) and five (offshore) times more expensive per tonne of CO_2 abated.

Policy Requirements

17. We believe that with the right policy framework, that is one that supports and encourages the examples given above, coal-fired generators such as Drax would be able to provide continued secure and competitive supplies of electricity, whilst contributing to emissions reductions targets for many years to come. However there are several policy issues which need to be resolved before such a programme could be considered.

Biomass Policy Requirements

18. Through the RO and the CAT Strategy, co-firing could make a major contribution to realising the Government's commitment to reducing CO_2 emissions. However, the current regulations under the RO are putting this important contribution at risk. Instead of encouraging the growth of co-firing of biomass at Drax, the current regulations introduce a level of uncertainty that is both reducing Drax's confidence in both the short and long-term markets and delaying or even losing altogether, a real opportunity to reduce CO_2 emissions.

19. In our view the RO should be able provide the necessary incentive for Drax to develop both the equipment to co-fire biomass as an increasing component of the plant's long-term fuel procurement strategy and to ensure that the biomass supply chains are well founded. However, the willingness to invest in the necessary technologies and processing plant, and particularly in contracting for the relatively expensive energy crops which generally require Renewables Obligation Certificates (ROCs) support to make them commercially viable, is critically dependent on the perception of magnitude and stability of the future ROC price.

20. We recognise that in the long term the combination of an increase in the price of CO_2 under the EU Emissions Trading Scheme (EU ETS) and a more competitive biomass market may make co-firing biomass economically viable without ROC support. Whilst future expectations of high biomass throughputs at Drax are predicated on that assumption, that position is some way off and in the short to medium term we look to the RO as a vehicle through which Drax can "kick-start" a high volume biomass industry, including the production of quantities of energy crops.

21. We are, therefore, concerned that, from April 2006, the proportion of an electricity supplier's obligation under the RO allowed to come from co-firing reduces from 25% to 10%. This is likely to lead to an oversupply of co-fired ROCs, a collapse in their market price, a significant cut in the extent of co-firing at Drax and a consequent increase in CO_2 emissions. The risk of a lower, or even negative, return to Drax through co-firing post-2006 means that we are becoming much more risk-averse when contracting with farmers and biomass suppliers. In turn, farmers are expected to become even more reluctant to plant energy crops, which may take up to four years to mature, as they fear being left with un-saleable crops.

22. Drax Power has put forward to the DTI one option to tackle the short-term problem of a surplus of co-fired ROCs. Instead of having a cut-off for redeemable ROCs, there would be a reallocation of the total ROC value over all redeemed ROCs, ensuring that they all achieve the same average value. This would mean that, in the event of a cap being exceeded, there would be a smooth reduction in ROC prices rather than a situation

where their value collapses to zero. An electricity supplier, therefore, would continue to receive value from co-firing or banked ROCs in the event that the relevant cap is exceeded. The effect of the proposal is to share the risk of an excess number of co-firing ROCs, and this therefore removes the advantage that vertically integrated companies have through the potential to secure value at the expense of independent generators.

23. The Government has rejected this approach on the grounds that it is not looking to change the co-firing limits in the RO, that it would make the RO more complex and that it may require primary legislation. We are not, however, aware that any alternatives have been proposed either by the Government or other interested parties. It is our concern that if nothing is done, the opportunity for encouraging significant reductions in CO_2 emissions at zero net cost to the consumer will be lost. This would be unfortunate given the fact that climate change policy is high on the political and public agenda.

24. The prospect of such an event is already inhibiting independent generators, such as Drax, from securing a market for our eligible renewables generation and it could significantly affect the extent of CO_2 reduction that we can effect. In addition, and perhaps more importantly, it will considerably impair our plans for entering into long-term contracts with farmers, foresters and landowners for energy crops. We firmly believe that a collapse in the price of ROCs would be highly embarrassing and damaging, not only to confidence in the RO and the market but also to our ability to develop the technology necessary to co-fire energy crops into the future.

25. Without such a mechanism, the current ROC limits will certainly constrain total energy crop usage and will seriously impact total UK CO_2 reduction both in the short and long term. This would appear to fly in the face of the Government's recently announced CAT Strategy, which fully recognises the contribution that co-firing can make to reducing emissions of CO_2.

Plant Upgrading Policy Requirements

26. If 12GW of the UK's 28GW coal-fired fleet were retrofitted with advanced supercritical boilers and turbines, the saving in CO_2 would be almost 10 million tonnes of CO_2 each year or around 11.5% of the amount of the annual reduction that the Government is seeking by 2010 compared with 1990.

27. However, for a feedwater repowering, or an advanced supercritical boiler/turbine retrofit, considerable amounts of capital would be required and such investment would only be made if there was sufficient confidence in the long-term market conditions as well as a confidence in the technologies to be employed. The Government could make a significant contribution in both these areas, particularly by supporting a supercritical retrofit project to demonstrate the substantial efficiency improvements that can be made at existing power stations such as Drax; Government support of around £30 million is needed.

28. In respect of commercialisation, all forms of low-carbon energy will cost money, whether coal or gas with carbon capture, renewables or nuclear. The RO has encouraged some investment, particularly in wind farms, but at £1 billion per year by 2010, it is expensive. Mechanisms are required to encourage investment in clean coal technologies, with rewards closely linked to improved environmental performance. Such a mechanism needs to be in place quickly, in order to provide the incentives to modify coal plant within Phase 2 of the EU ETS.

Conclusions

29. There will continue to be a significant future reliance on fossil fuels for electricity generation. Hence, there is a need to research, develop, demonstrate and deploy a range of Carbon Abatement Technologies. Government support is critical to this process to ensure that the power generation sector delivers the substantial investment programme needed and, in turn, delivers the significant CO_2 savings that are possible.

30. Appropriate market-based mechanisms are required to encourage investment in clean coal technologies, with rewards closely linked to improved environmental performance.

31. As one of the most economic and efficient renewables technologies, the uptake of co-firing biomass under the RO should be maximised and not constrained by regulations. The Government needs to recognise the inherent flaws and introduce a mechanism into the RO to ensure continuity in support for co-firing in the short term, preferably along the lines already suggested by Drax.

21 September 2005

Memorandum submitted by the Energy Networks Association (ENA)

Introduction

1. ENA is the industry body of the licensed electricity and gas transmission and distribution companies in the UK. We welcome the opportunity to provide our views on this inquiry.

2. It is our view that changes in the fuel mix should not be contemplated without due consideration of the impacts on the transmission and distribution networks.

3. One of ENA's core values is minimising the environmental impact of networks, including environmental change.

Technical and Practical Considerations for Networks

4. Renewable generation sources such as wind will bring a range of changes to networks, including a need to address stability, intermittency, security and plant margins issues. At distribution level there will be an impact on how networks have to be designed and operated, potentially transforming them from largely "passively" managed to more "actively" managed systems. The ENA recognises that this is technically possible but the changes will require time to research, prove reliably in the field and then to build into the networks. There will also be a concomitant requirement for investment.

5. Development of nuclear power or new forms of large-scale centralised generation (including gas and coal) plant will have implications for the higher voltage transmission networks through the location and design of new power stations. There could be considerable demand for new or augmented network infrastructure.

6. There are also increasing pressures on the configuration of the transmission network arising from the EU internal market and the effect this will have on interconnection and cross-border requirements.

Regulatory Framework

7. The regulatory framework for the energy network companies will need to be adapted to accommodate the technological developments outlined above. The existing regime has been successful in removing inefficiencies, resulting in network charges to customers falling by 50% in real terms since 1990. Additional elements have been added to the simple RPI-X model to incentivise reductions in losses, improve quality of supply, and support for distributed generation and network innovation. However, it will be necessary to consider whether the current framework of incentives gives sufficient weight to long-term considerations of the environment and network development. If not, can it be adapted to accommodate them or do we need a different, more strategic approach to deliver the kind of networks which will be required in response to the long term needs of customers? It will be important for such a debate to begin now during the current transmission price review and ahead of the forthcoming gas and electricity distribution reviews.

Falling Assets and Skills Base

8. The bulk of the existing electricity transmission and distribution system was built in the 1960s to meet the needs of a very different electricity generation paradigm. Principal asset lives are typically 50 years.

9. A considerable deficit is developing in engineering skills, which may constrain the ability to build and operate the networks of the future.

Summary

10. Successful deployment of generation by whatever technology is tied inextricably to parallel developments in networks. We are concerned that energy policy and how this is reflected in the regulatory regime for networks does not adequately deal with the need to synchronise developments in generation and infrastructure.

28 September 2005

Memorandum submitted by the Environment Agency

SUMMARY

The Environment Agency is the Government's principal adviser on the environment. Our interest in climate change and energy is informed by our role as a modern regulator and as a champion for the environment.

In considering options for future investment in energy supply technologies we make the following key points:

— Climate change is the biggest threat to our environment. In order to play our part in avoiding dangerous climate change the UK must meet the goals of 20% CO_2 reductions by 2010 and putting ourselves on the path to the longer term cuts required.

— The UK is not currently on track to meet these goals. All sectors will need to contribute to further reductions in CO_2. New policies designed to achieve this ambition should be set out in the revised Climate Change Programme, due to be published this autumn.

— The primary focus of energy policy should be energy efficiency and further development of renewable energy sources. We support the goals set out in the Government's Energy White Paper.

— We must meet both energy security and environmental goals. There are synergies between the two and these links should be exploited.

1. INTRODUCTION

1.1 The Environment Agency has a central role in respect of climate change and energy.

— We regulate industries under the Pollution Prevention and Control (PPC) regime that are responsible for 40% of UK greenhouse gas emissions. These industries include major energy users and fossil fuel power stations.

— We act as the Competent Authority for the EU Emissions Trading Scheme (EU-ETS) in England and Wales. We are responsible for issuing permits to eligible installations and assessing compliance with the scheme's operational rules.

— Adaptation to climate change is critical to our operational functions, especially flood risk and water resource management. We are a lead partner in much of the regional adaptation work.

— We support adoption of renewables and low carbon technologies.

1.2 The composition of future UK energy supply will determine whether many of the environmental outcomes we seek are achieved. We will have an important role in regulating and supporting many of the future energy supply technologies.

2. CLIMATE CHANGE

2.1 Climate change is the biggest threat to our environment. Scientists agree it is happening and that human activity is increasing it. Over the past century, global temperatures have risen—with the last 10 years being the warmest 10 in the century.

2.2 The European Commission has set an indicative long-term global target of not more than 2°C above pre-industrial levels (before about 1750) as its interpretation of the UNFCCC objective to prevent dangerous anthropogenic interference with the climate system. Significant impacts are already built in to the climate system as a result of past and present emissions, and we have already experienced the unwelcome impacts of increased climate variability (drought, flooding) in our operational work.

2.3 We recently published our first national report on climate change, *The climate is changing—time to get ready*. The report gives a graphic demonstration of the kind of lifestyle and environment we could be living with in the future if we do not tackle the causes of climate change and build our resilience to it now.

2.4 Already, in the first years of this century, floods, storms and drought have shown how vulnerable the UK is to the weather. The floods in January in Carlisle, last summer's flash flooding in Boscastle, the catastrophic sewage overflow into the Thames and the record temperatures in August 2003 all serve to highlight the type of problems we have to face as climate change bites.

2.5 The science tells us that weather events like these will become more frequent and the extremes will get worse. We have to face up to escalating costs, the damage to our property, disruption to our way and quality of life and in some cases increased threat to health and even lives. For example, the DTI Foresight report, *Future Flooding,* concluded that we might face a rise in the annual flood repair bill from the current £1 billion to as much as £25 billion by 2080 if we do not take action now. Already, since 1998, the cost of repairing damage from extreme weather and floods has increased by 60%.

2.6 In light of these findings, the costs of climate change either need to be internalised now or the, probably higher, costs of the damage of climate change, such as flood damage will be inevitable.

3. The Review of the Climate Change Programme

3.1 We support the UK energy strategy that is set out in the 2003 Energy White Paper. This sets targets for reducing greenhouse gas emissions while ensuring continuity and security of energy supply and the affordability of energy services to all parts of society.

3.2 However, emissions projections and trends show that the UK is not currently on track to meet its targets of a 20% reduction by 2010 and a 60% reduction by 2050.

3.3 The Climate Change Programme Review should identify what more we need to do meet the 2010 target and longer term reductions. With sufficient effort from all sectors, these national targets for carbon dioxide (CO_2) reduction can be achieved. This will show international leadership and set an example for others to act.

3.4 We want Government to reaffirm its commitment to the 20% goal in the revised Climate Change Programme and set out a stronger framework for action involving all sectors and committing to the policy measures listed below.

3.5 The major focus of future energy policy should be to reduce demand and to increase the uptake of renewable energy and other low carbon technologies. Energy policy should be considered in the context of the revised Climate Change Programme, the scale of emissions cuts required and the likely contribution from other sectors.

3.6 When considering which energy supply options should be promoted the whole life cycle environmental costs of each technology need to be identified and considered. In order to create a level playing field to enable decision-making the environmental costs of all energy technologies need to be internalised. Different schemes can then be judged on the same basis for their costs, impacts and benefits.

3.7 Many of the measures that are put in place to meet environmental goals can also help meet the social and security goals of energy policy:

- Energy efficiency is the most cost-effective way to address all of the goals of energy policy.
- Renewable energy comes from a diverse mix of energy sources, most of which are free and plentiful in the UK.
- Moving towards a much more diverse energy system with a mix of large scale and small scale localised generation will have energy security benefits.

3.8 Measures that contribute to all energy policy goals should be identified and promoted.

4. Energy Efficiency

4.1 Energy efficiency is identified in the Energy White Paper as the safest, most cost effective way to meet all of the energy policy goals, particularly the national goal to reduce CO_2 emissions by 2010.

4.2 In the second annual report of Energy White Paper the Government reaffirms that energy efficiency could contribute more than half the emissions reductions in our existing Climate Change Programme and further ahead, around half of the additional 15–25 MtC savings we are likely to need by 2020. This is achievable using currently available tried and tested technologies. Households and businesses will save over £3 billion per year on their energy bills by 2010 as a result.

4.3 Unless energy efficiency is addressed, any gains from switching to low carbon options could easily be lost through increased energy use overall.

4.4 The scope for greater energy efficiency in the industrial and commercial sector is substantial. Environment Agency research[55] found that industry could cut its energy consumption by 20% by 2020 if the right policies were put in place. The findings found that without new policy objectives, energy use would only be cut by 10%. Other research[56] explored the potential for energy savings from different industry sectors. It showed that savings could be made in chemicals, refineries, food and drink, and paper production—all from adoption of CHP in the near future.

4.5 We would like to see businesses given more support from Government and others to help them reduce energy consumption and to overcome barriers such as a lack of information or access to capital. The work of Envirowise and the Carbon Trust should be strengthened.

4.6 Economic instruments such as trading, and the Climate Change Levy, can be used to reward behaviour that helps meet climate change targets, and penalise behaviour that hinders action. We want to see the price of carbon embedded into the costs of energy and services so that people are paying the true costs. The price of carbon in the economy will therefore have to increase.

4.7 We share concerns that the target for domestic energy efficiency has been downgraded even as the overall share of this sector in energy and emissions is expected to grow. The target of 5 MtC in the Energy White Paper has been reduced to 4.2 MtC in the Energy Efficiency Action Plan. New measures will be needed

[55] *Potential for Energy Efficiency in Industry,* Environment Agency, 2002.

[56] *The Environment Agency Contribution Towards Achievement of Greenhouse Gas Reduction Targets.* R&D Technical Report P4-089/TR, Environment Agency 2001.

such as differentials in stamp duty or council tax to encourage investment in this sector. Also, the very welcome commitments to improve building standards must be enforced and the Government's Code for Sustainable Buildings should be adopted as the basis for its procurement on buildings and as a signal to industry of the direction of future Building Regulations. Recent proposals by Government to review the incentives for introducing energy efficiency in existing homes are welcome.

4.8 A comprehensive programme is needed to tackle CO_2 emissions from the transport sector. Traffic growth means the sector is responsible for a growing proportion of emissions. We need a package of measures including technological improvements, fiscal measures and transport policy solutions together with creating new space for cycling and pedestrians. Aviation emissions (not covered by the Kyoto Protocol) may well overwhelm the effects of measures under the UK Climate Change Programme. We support the government's plan to bring the aviation sector into the next phase of the EU ETS. If this is not possible then other interim measures should be considered including charges and bringing UK only flights into the National Allocation Plan.

5. EU Emissions Trading Scheme (EU ETS)

5.1 The EU ETS is an economy-wide instrument that can deliver emissions reductions efficiently. We supported a more stringent cap on emissions in the National Allocation Plan (NAP) from installations covered in its first phase.

5.2 The weakness of some of the caps set by Member States for the first phase undermines the effectiveness of the EU ETS, representing as it does a "business as usual" emissions path. The DTI's Updated Energy Projections show that, without any action, the power sector will achieve a 30% reduction in emissions between 1990 and 2010. The first phase cap thus represents a significant windfall for the sector as it will be allocated allowances in excess of those it needs to meet its target.

5.3 A Carbon Trust report *The European Emissions Trading Scheme: Implications for Industrial Competitiveness*[57] finds that the EU ETS does not threaten the competitiveness of most industry sectors in Europe, providing the EU Member States take a broadly consistent approach. The electricity, cement and paper sectors are shown to profit under all economic scenarios used in the study. Only the aluminium industry is expected to lose, despite, or indeed partly because of, the fact that it is not within the EU ETS system.

5.4 The UK government will need to set a tougher cap in the second phase, taking account the need to achieve the 20% target and the potential shortfall of other measures in the current UK Climate Change Programme. This would give the UK greater credibility in putting pressure on other EU Members States to tighten up their National Allocation Plans and the European Commission to tighten and ensure effective scrutiny of National Allocation Plans respectively.

5.5 The Environment Agency supports moves to expand the EU ETS to other gases and sectors such as the aluminium sector, parts of the chemical industry (for non-carbon dioxide greenhouse gases), especially those that have been under the UK ETS, as well as food and drink and engineering, and perhaps the vehicle sectors. Those sectors currently subject to Climate Change Agreements could most readily be included.

5.6 We are concerned that the interaction between existing mechanisms, such as the Climate Change Levy and Climate Change Agreements, and the EU ETS is not well understood. All aim to reduce emissions from the energy and industrial sectors. The Government should review the need for the continued use of the many different policy instruments to tackle emissions of carbon. The second phase of the EU ETS could be the main policy instrument to control carbon emissions, provided more parts of the economy are brought under the scheme. The revised set of projections should make transparent the relative contributions of each instrument to meeting the national targets.

6. Renewable Energy

6.1 We should encourage a more rapid but environmentally sensitive adoption of renewables to work towards the goal of 20% of electricity generation by 2020. More effort is needed to encourage diversity of sources for heat and power including solar photovoltaics, solar thermal, biomass (including liquid fuels), tidal currents and wave power.

6.2 Developers of new technologies need long term consistency in policy making and certainty for investment to assist their financial planning and for making the business case for projects to sell power.

6.3 The Government should do more to recognise and support generating heat from renewables sources. For example, they could implement the Royal Commission for Environmental Pollution's call for developers of new housing developments to use renewable heat and power.

6.4 We will play our part in supporting renewable energy developments where this does not compromise other environmental obligations.

[57] *The European Emissions Trading Scheme: Implications for Industrial Competitiveness*—Carbon Trust, July 2004.

7. Microgeneration

7.1 We welcome the development of the Government's Microgeneration Strategy. Local and small scale generation of low carbon heat and power will play a far larger part in meeting the needs of communities in future, in line with the Energy White Paper. Building integrated systems and local sources of heat and power use a diverse range of resources and technologies which can reduce overall emissions of greenhouse gases, contribute to security of supply, help provide affordable warmth, and promote competition in the energy economy.

7.2 We support the widespread adoption of microgeneration. This needs to be implemented in ways that are sensitive to the local environment. We would like to see:

- Clear roles set out for national, regional, and local players, and targets/actions for each in the strategy as this will help drive action.
- Guidance to reduce uncertainties around the planning implications of some installations such as solar thermal panels and roof mounted wind turbines.
- More practical and financial support to expand the uptake of microgeneration such as buyback tariffs, fiscal incentives and economic regulation that encourages embedded generation.
- Incorporation of microgeneration in buildings through changes in Building Regulations made possible through the Secure and Sustainable Buildings Acts and the Code for Sustainable Buildings.

7.3 The overall strategy needs to drive microgeneration while recognising the need for high standards of environmental protection. The risks of diffuse pollution needs to be guarded against through the adoption of high standards and monitoring the effects of large scale adoption of some technologies (eg possible air quality impacts of biomass).

7.4 The public sector needs to be an exemplar and the Environment Agency is taking steps to adopt microgeneration where practical, as we have with new offices at Wallingford.

8. Carbon Capture and Storage (CCS)

8.1 We acknowledge the need in the short to medium term of using fossil fuels in cleaner ways in order to achieve our domestic emissions targets. We recognise that CCS could provide a bridging option that supports a transition from our current dependence on fossil fuels to a future of more sustainable energy choices. However, as yet the science behind the long term viability of CCS has not been validated and we have significant concerns that the development and deployment of CCS technology will:

- distract effort from more cost-effective and proven solutions;
- prolong unnecessarily our dependence on fossil fuels, which is counterproductive for the environment overall given the associated emissions of acid gases, heavy metals and solid wastes; and
- lead to unacceptable environmental and social risks from slow or catastrophic leakage.

8.2 Nevertheless, we welcome the publication of the Government's *Strategy for Developing Carbon Abatement Technologies for Fossil Fuel Use,* that includes CCS, providing it fits within the vision of the 2003 Energy White Paper and is consistent with the UK Climate Change Programme. As the Strategy emphasises, CCS can only be part of the solution to climate change. It is only suitable for large point sources that make up about 35% of UK emissions. We do not want investment in policies to promote energy efficiency and renewable energy diverted to support a CCS programme.

8.3 A key issue for the Environment Agency is the legislative and regulatory framework for CCS activities. If these technologies are to exist in the UK, we want to see an effective system that adequately protects the environment and human health. The additional funding for CCS demonstrations should include studies on the potential for environmental impacts, the criteria for site selection and the options for monitoring and regulation. In parallel, Government should resolve the legal status of carbon dioxide as a waste and whether it is subject to waste legislation.

9. Nuclear Power

9.1 Until we have a sustainable long-term strategy for radioactive waste management—and public concern is properly addressed—any major changes of policy to encourage the construction of new nuclear generating capacity would appear to us premature. Doubts remain about viability and security of the technology and its flexibility and these need to be addressed. If nuclear power reflects the full costs of waste and clean up past experience has shown that the economics are not robust.

10. CONCLUSIONS

10.1 In order to avoid dangerous climate change we must put policies in place to meet the UK goal of 20% reduction in CO_2 by 2010 and to put us on the path to longer term cuts.

10.2 With a contribution from all sectors we believe these carbon reduction goals can be met. Government in its revised climate change programme should reaffirm its commitment to the 20% goal and set out a stronger framework for action.

10.3 There are links between energy security and environmental goals. Options that can contribute to both of these areas should be identified and promoted.

10.4 In considering future energy supply options the full environmental impact of different technologies should be taken into account.

10.5 We believe that energy efficiency and the development of renewable energy sources should remain the first priorities for energy policy and that both have a substantial contribution to make to energy security as well environmental and social goals.

10.6 The Environment Agency will play its part in working with business to achieve efficiency improvements and supporting the deployment of new low carbon energy supply technologies.

26 September 2005

Memorandum submitted by E.ON UK

INTRODUCTION AND KEY POINTS

1. E.ON UK is the UK's second largest retailer of electricity and gas, selling to residential and small business customers as Powergen and to larger industrial and commercial customers as E.ON Energy. We are also one of the UK's largest electricity generators by output and operate Central Networks, the distribution business covering the East and West Midlands. We are also a leading developer of renewable plant.

2. E.ON UK is part of the E.ON Group which is the world's largest privately owned energy service company. In addition to the UK, the Group has electricity and gas interests in Germany, Central and Eastern Europe, Italy, the Netherlands, Scandinavia, the USA and Russia. E.ON owns or has interests in 23GW of nuclear capacity, located in Germany and Sweden.

3. The electricity industry requires a massive investment in capital over the next decade to deliver reductions in carbon dioxide emissions, energy supply security and affordable prices. By 2015 up to 8GW of nuclear (subject to life-extension decisions) and 19GW of coal and oil-fired plant will need to be replaced.

4. Much of this plant will need to be replaced with low or zero carbon generating plant if the UK is to make effective progress toward its 2020 and 2050 goals for reducing CO_2 emissions. We and other energy companies are already investing in renewable technologies, and are considering further combined cycle gas turbine (CCGT) construction. However, replacement of all closing plant by CCGTs would not be consistent with delivering the Government's target of a 60% cut in CO_2 emissions by 2050, given that much capacity built in the next decade is likely to be still operating in 2050. We estimate that, under this scenario, CO_2 emissions from the power sector in 2020 would be $\sim$150MtC or only 5% lower than in 2004. It would also significantly increase the UK's future dependence on gas imports.

5. We believe that, to achieve the 2050 target, a range of low carbon technologies will need to be deployed to diversify technical and economic risks. The wider the range of options available to companies, the lower the cost is likely to be to the UK of achieving its CO_2 emission reduction targets. In this context, we do not see the pursuit of renewable technologies and new nuclear as mutually exclusive alternatives; they both have the potential to contribute to achieving national and global objectives.

6. We will therefore want to consider a wider range of investment options to achieve reductions in emissions and to diversify our portfolio of generating plant. These options could include coal and gas plant with carbon capture and storage, nuclear plant as well as new renewable technologies such as wave or tidal power and the increased use of biomass.

7. Government must create an environment in which companies can innovate and invest in a range of low carbon technologies. The Government needs to act soon to make additional options available. We believe that the Government's role is to:

- provide the right market framework to achieve government objectives within a competitive market environment. This should increasingly rely on long term broad ranging market based mechanisms, such as the EU emissions trading scheme, as the main driver to incentivise the most economic low carbon investments, encourage innovation in energy supply and support UK competitiveness;
- aim to achieve a broad international commitment to action to tackle climate change which shares responsibility across the major emitting economies; with any post-2012 agreement being consistent with investment timescales—10–15 years could be appropriate;

— resolve specific policy, legal, or institutional constraints which are limiting the choice of technologies;
— encourage the development and demonstration of emerging technologies with capital grants or similar support.

Inquiry Issues

A. *The extent of the "generation gap"*

(1) *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

8. In electricity, up to 8GW of nuclear (depending on the extent to which the lives of nuclear plants can be extended) and up to 19GW of coal and oil-fired generating plant, or about one third of total UK power plant, will close by 2014–15. This capacity will need to be replaced and about 7GW of additional capacity will need to be built to meet demand growth to maintain plant margins (the additional amount of capacity needed to help ensure demand can be met, allowing for plant breakdown and demand uncertainties) at current levels of around 20%. This assumes average growth in demand met through the Great Britain transmission system of 0.8% per annum, consistent with NGT's own base case in their seven year statement.

9. Bearing in mind that many of these plants may have operating lives of around 35 to 60 years, much of this plant will need to be replaced with low or zero carbon generating plant if the power sector is to contribute to a continued reduction in CO_2 emissions in line with the Government's objective of reducing emissions by 60% by 2050 from 1990 levels.

B. *Financial costs and investment considerations*

(2) *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

— What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

10. Subject to developments in the market and the regulatory environment, the large-scale options that generators are likely to consider for the UK over the next decade are: gas-fired CCGTs, coal-fired capacity using clean coal technologies with or without carbon capture and storage, renewables (principally on-shore and offshore wind) and nuclear plant.

11. There may be additional niche opportunities for gas-fired co-generation and biomass, for example, but these are not likely to provide large scale development opportunities.

12. The estimated life-time cost of different technologies is each dependent on a range of estimated input prices and business risks. Therefore, the table below shows a range of lifetime cost estimates for plant commissioned in the next decade:

Generation Type		*Cost range p/kWh (2005 prices)*	
CCGT		2.2–4.9	
Coal with FGD & SCR		2.8–5.2	
Carbon capture & storage		3.3–5.6 gas	
		3.9–5.1 coal	
Wind	Onshore	4.2–5.2	Excludes costs of back-up capacity
	Offshore	6.2–8.4	
Nuclear		2.5–4.0	

13. These estimated costs exclude any benefits which might arise from Government support, fiscal or regulatory measures. The following explanation may be helpful in understanding the ranges provided:

(a) CCGTs: The expected cost of generation from new CCGTs is most heavily influenced by the future cost of gas and carbon dioxide emissions: the figures are based on a gas price in the range 20–40 p/therm gcv and carbon, 0–50 €/t_{CO2}. The EU ETS is at a very early stage of development and there is currently no certainty that it will exist beyond 2012, which justifies the 0 €/t lower bound for investments commissioning around that date. At current gas prices of above 50 p/therm, CCGTs would be more expensive than the top of the range shown.

(b) Coal-fired plant: We expect the cost of international coal to be less volatile than gas and so, for simplicity, have estimated the cost of conventional coal plant at a constant coal price of 1.4 £/GJ ncv, but the same range of carbon prices. Conventional coal produces approximately twice as much carbon dioxide as CCGT plant per kWh.

(c) Coal or gas generation with Carbon capture and storage: Commissioning large scale carbon capture and storage plant may become a real possibility in the next decade. This could be done either by fitting post combustion capture equipment to conventional gas or coal plant, or by building gasification plant of a variety of types. The technology for this is not yet proven at large scale and therefore the cost range reflects the uncertainties of the cost and reliability of such developments. The legal and regulatory environment does not yet exist for off-shore storage of carbon dioxide and this would need to be settled before large scale investment was committed. Carbon capture and storage is only likely to be deployed if there were to be a belief in the long-term market value of avoiding carbon emissions.

(d) Wind: On-shore and off-shore wind developments will continue to be deployed provided they are supported by the Renewable Obligation and capital grants, as at present. The cost range above reflects the variability between higher cost offshore sites and those onshore, before these support mechanisms. We expect the cost of sites to increase over time as the best sites are used first, but the costs offshore of equipment and installation should reduce as more experience is gained and larger units are installed. The economics of wind power are heavily influenced by the wind resource available at particular locations. Wind is intermittent and hence not directly comparable with other large-scale generation alternatives without including the cost of either back-up capacity or energy storage. The cost of supplementing wind capacity with additional resources is not that material at the current low levels of penetration, but would increase if it were to become a more significant proportion of the total system capacity.

(e) Nuclear: The estimated cost of new nuclear developments is chiefly influenced by the uncertainties surrounding planning and regulatory processes as these affect expected capital cost, development and construction schedule and the competitiveness of the plant supply market. If the Government is able to mitigate the effect of these uncertainties promptly and effectively, then it would be feasible to commission new nuclear plant in about 10 years. The timing of new build would also be heavily influenced by price expectations in the gas and carbon markets.

— With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

14. Recent experience in Finland suggests that it is feasible to plan, license and begin construction of new nuclear plant to internationally accepted standards in a cost-effective manner within a 10 year period. Whether this experience could be repeated in the UK would be heavily dependent on the planning and regulatory processes which might be put in place to support a new build programme. Because of high first-of-a-kind costs and operational overhead, new nuclear build would be more cost effective if a programme of 8–10GW were to be built.

15. The accuracy of cost estimates for new nuclear plant is difficult to confirm until designs have been licensed for operation in the UK and the construction cost is firmed up in the light of tenders from suppliers. This is particularly true for new designs which have yet to be deployed commercially. The certainty of costs estimates could be improved if the licensing process permits progressive comfort to be gained that standardized international designs from competing suppliers will be able to be licensed for operation in the UK. A planning and licensing process which permits effective competition between suppliers should reduce final capital costs. A planning and licensing process which imposes unique design requirements in the UK would inevitably increase costs.

Waste Management and Decommissioning Costs

16. Discounted waste management and decommissioning costs should make up a relatively small proportion of the total cost of electricity from new nuclear plants as these are designed with the aim of minimizing these costs over a 60 year operating life. However, investors will wish to be assured that a secure route for the safe disposal of long-lived high-level waste will exist at the end of a plant's life and that the Government will ultimately accept ownership and responsibility for such waste.

17. The costs of dealing with the UK's legacy waste and the decommissioning of existing nuclear facilities are expected to be much higher than for new build because of the early entry of the UK into a civil nuclear programme and the technology choices made in the past: eg Magnox, reprocessing.

18. Low level waste disposal would arise over the life of the plant and is expected to be disposed of in a similar manner to at present; costs would be met on a continuing basis.

19. Spent fuel and operational Intermediate Level Waste (ILW) could be stored at the plant, whilst it is generating electricity, and either disposed of periodically or at the end of the plant's life; additional ILW will arise at decommissioning. Reprocessing of spent nuclear fuel is currently uneconomic and is not a factor in considering future waste disposal routes.

20. The Government is the natural legatee of spent fuel and ILW because of their very long-lived nature and should have long-term responsibility for ensuring their safe storage or disposal. However, responsibility for the costs of long term storage or disposal is accepted by nuclear plant owners. Funding of a secure disposal route could be provided through, for example, a tariff on nuclear fuel used, in return for a commitment by Government to accept liability for long-lived wastes at the end of plant life.

21. Decommissioning costs could either be met through ring fenced funds established during the period of plant operation (as adopted in different forms in the UK, Sweden and the US) subject to independent audit and control or by ensuring there is sufficient provision on the owner's balance sheet (as in Germany). As part of any assessment of the role of nuclear construction, the Government will need to review alternative models and determine what is most appropriate in a UK context, bearing in mind which route carries most public confidence.

Insurance and Security

22. The nuclear industry meets the cost of statutory third-party liability insurance up to a cap (expected to be raised in 2006 to €700 million). The Government manages any very small residual risk through the high level of safety regulation imposed through the Nuclear Installations Inspectorate. The costs of the NII's activities and any changes to plant or operational practices it imposes are met by the industry.

23. The costs of plant security are generally met by industry as part of construction and operational costs. The costs of security of fuel fabrication and waste disposal are expected to be reflected in the price of these services. The effectiveness of security arrangements is overseen by the Office of Civil Nuclear Security, the majority (94% in year to March 2005) of whose costs is met by industry.

24. On balance, there do not appear to be hidden costs which could not be met economically by a nuclear new build programme.

— Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

25. Renewable plant will not on its own be able to fill the capacity gap left by closing nuclear and coal plants. It may be possible to accelerate the construction of renewable plants somewhat by adjusting the level of the Renewables Obligation and by making additional capital grants available but the resultant cost to the consumer of providing this further level of support may not be justified and local planning and grid connection issues are likely to limit the total level of development.

— What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

26. These technologies, particularly micro CHP, may be able to make a useful contribution, depending on their economic potential. An HPMI Demand Analysis study funded by DTI (2004) estimates that by 2015 micro CHP could in principle meet up to 1–2.3GW of demand by 2015, and ultimately 12GW by 2030. However, at this early stage in its commercial deployment, the extent of take up is uncertain and in its early stages will depend significantly on Government support. Micro CHP, in common with other micro generation technologies, does not operate baseload so that a direct capacity comparison with, for example, nuclear is not appropriate.

(3) *What is the attitude of financial institutions to investment in different forms of generation?*

— What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

27. We would expect institutions providing finance, like all investors, to want to be satisfied that investment returns reflected the investment risks, whether these arise from market, energy policy or regulatory uncertainties.

28. Compared to CCGT and renewables, nuclear currently suffers high levels of political and regulatory risk arising from the uncertainties surrounding planning and licensing processes, the regulation of safety, waste disposal and decommissioning and perceived volatility in political support. The mitigation of many of these risks lies in the hands of Government. Investors' pricing of these risks will ultimately be heavily influenced by the success of Government actions in this respect.

29. To the extent that new nuclear construction relies on energy policy instruments, such as a carbon price created by an emissions trading scheme, investors will need to be satisfied that the energy policy framework is stable and not subject to changes which will undermine the project value. Similar issues arise in investment in renewables, which relies on stability in the Renewables Obligation.

30. We expect sufficient funds to be available for new nuclear build if these key issues of risk are addressed.

— How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

31. We do not expect the Government, in a competitive energy market, to provide direct cash subsidies for nuclear plant, given that it is a well established technology. However, any private sector company looking to invest in new nuclear plant is likely to want assurances from Government on a number of points:

— A long term commitment by Government and the EU to the EU emissions trading scheme as its primary means of incentivising low carbon investments. Investors would need to reach their own view on whether a particular price of carbon generated by the scheme was required to support new nuclear investment. That price would depend on other factors, including anticipated wholesale power prices and fuel costs, excluding the effects of the EU ETS;

— Efficient and effective planning and safety regulatory processes, which recognise the need to facilitate competition between the suppliers of plant and operational services;

— Government assumption of responsibility for the safe long term storage or disposal of radioactive waste (albeit with the cost funded by the investor);

— Government assurances that its policy toward nuclear plant decommissioning and plant lifetimes will remain stable, given experience in some counties where the Government has intervened to require early closure.

— What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

32. We would not expect to diminish our investment in renewables or energy efficiency, if we also committed investment to new nuclear construction. Substantial investment in a range of low carbon technologies will be required to deliver the UK's climate change targets. We do not see investment in all these areas as mutually inconsistent. In particular new nuclear plant would operate baseload and will replace existing nuclear plant. Investment in new nuclear capacity will avoid investment in gas-fired plant with higher CO_2 emissions, rather than renewables.

C. Strategic Benefits

(4) *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

33. We do not expect the Government to provide direct cash support for new nuclear plant construction. However the Government has intervened in the market through the EU ETS to provide incentives to encourage investment in low carbon plant as a whole. Government guarantees or assurances to encourage private sector investment would be primarily justified on environmental grounds.

— To what extent and over what timeframe would nuclear new build reduce carbon emissions?

34. As a broad indication, CO_2 emissions will be reduced by about 3Mt CO_2 a year (assuming that nuclear is replacing CCGTs) for every 1 GW nuclear built (ie about 0.5% of UK 1990 CO_2 emissions). A 10GW replacement nuclear programme would be equivalent to a 5% reduction in 1990 CO_2 emissions.

— To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

35. Nuclear power plant takes a long time to plan and build and, once built, operates at base-load; as such it does not contribute significantly to short-term security of supply.

36. However, diversity of fuel supply is also important for physical and economic security of the system. The raw material for nuclear fuel, uranium ore, can be obtained from a number of stable countries (eg Australia, Canada) and can be easily stored at a number of points in the supply chain. The cost of nuclear generation is insensitive to changes in the cost of fuel.

37. At present the UK economy is becoming increasingly reliant on gas an increasing proportion of which may be imported. Although supply security can be maintained with higher levels of gas consumption, this may pose economic risks as gas prices will begin to have a significant effect on the UK economy. This effect may be accentuated as the UK becomes more subject to continental gas market conditions where there is a strong correlation between gas and oil prices which is likely to persist for some time. Nuclear, as well as other fuel types such as coal, can reduce this effect.

38. We believe a balanced portfolio of fuels can contribute to maintaining security of energy supply at an acceptable cost, by diversifying risk and avoiding over-reliance on a single fuel.

— Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

39. This is a matter for Government to assess. However existing nuclear reactors have been operated for decades during periods of terrorist activity in the UK and elsewhere. Modern plants are designed to resist known risks of this nature.

40. Civil nuclear power plants are subject to international control to ensure that nuclear materials are not diverted to weapons use. Compliance with these safeguards would not be an issue in the UK.

(5) *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

41. We do not see investment in these options as incompatible. Indeed it is important that they are all available, as companies need the widest range of options to be able to deliver a low carbon economy at the lowest possible cost to the UK economy.

D. Other Issues

(6) *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

42. A paper contributed to the ExternE project by AEAT of June 1998 suggested that, within the limits of accuracy and durability of such a study, the life cycle global warming impact of nuclear is broadly comparable with wind generation, for example, but importantly both produce a small fraction (< 5%) of that from CCGT; coal produces broadly double that from a CCGT.[58]

43. A market framework that prices the external cost of global warming emissions should progressively lead to innovative approaches for all technologies along their value chain, possibly changing these relationships.

(7) *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

44. We believe that a firm Government decision on its approach to the disposal of highly radioactive waste, which reflects the outcome of a thorough process of public consultation, is a reasonable precondition for any nuclear new build. However, this should not mean that a disposal site needs to be identified and put in place before new construction begins, since the first spent fuel and ILW is not likely to be exported from a new nuclear plant for many years in the future.

45. Other developed countries (eg Finland, Sweden, and USA) have agreed programmes for the long-term disposal of long-lived nuclear wastes; this should also be possible in the UK.

19 September 2005

Memorandum submitted by Professor Ian Fells CBE FREng FRSE

Two urgent imperatives have emerged since the publication of the Energy White Paper in 2003. They are security of energy supply, particularly electricity: and environmental protection. The power cuts in the US, UK, Italy and Scandinavia in 2003 and the growing consensus that man is affecting the climate by burning ever-increasing amounts of fossil fuel and causing global warming by stimulating the Greenhouse effect, has given a "wake up" call to politicians. The two problems are interlinked and require a joint solution.

1. In the UK 77% of the electricity is generated by burning coal or gas which puts carbon dioxide, a potent greenhouse gas, into the atmosphere; coal is the major culprit as it puts 1Kg of CO_2 into the atmosphere for each unit of electricity generated, the figure for gas is 0.5 Kg and for nuclear power, wind and hydro the figure is less than 10g/unit each (ETSU Lifecycle analysis 1999).

2. It is clear that if we are to reduce CO_2 emissions we must switch out of fossil fuels and into renewable and nuclear power. Perversely, government policy has only taken on board half of this process and whilst it stimulates renewables, particularly wind power, with subsidy of one sort and another, to the tune of £1 billion per year (HoC Public Accounts Committee, 6th Report, September 2005), at the same time it is bent on reducing nuclear power output to zero. As nuclear provides around 22% of UK electricity at the moment, to replace it with renewable electricity will be an impossible task; the Public Accounts Committee suggest if all government incentives work we could just make10% renewable by 2010 but give a more cautious figure of 7.5%. To get to the "inspirational" target of 20% by 2020 is even more problematical. Currently wind provides 0.4% of electricity, and total renewables 4%, already slipping behind the target of 5% by 2005.

3. The UK's ageing nuclear stations are already being decommissioned; by 2010 nuclear's output will have fallen to 16% and by 2020 to 7%. To make matters worse the UK coal stations, which provide 35% of electricity, are also ageing and falling foul of new EU emissions regulations which come into force in 2008 and, by closure, could reduce supply by another 25% by 2020. We could be short of 40% of electricity supply by 2020.

[58] It estimated that the external cost of global warming (in mECU/kWh) on a life-cycle basis for various technologies is about 0.25, for wind; 0.37, nuclear, including fuel reprocessing; 12.9, CCGT; and 28.7 coal, including FGD and low NOX burners.

4. Decisions have to be made now (yesterday really) if we are to ensure a secure supply of electricity through the coming years. Shortages could cut in quite soon. The easiest solution could be to replace the nuclear and coal stations with gas, but gas supplies will have to come from Russia, Qatar, Nigeria and points east. We will be in competition with China and Japan (also for oil) and the US, for sea-borne gas. The price has doubled in the past year and will continue to rise. We will find ourselves 80% dependent on imported gas for our electricity supply by 2020, with ominous implications for security of supply.

5. Much has been made of the supposed uneconomic cost of nuclear power. Separate studies by the Royal Academy of Engineering (2004) and the Paul Scheerer Institute in Switzerland, show nuclear power generating costs coming in on a par with gas and half the price of wind power. The contrast with wind is even more striking if the huge subsidy identified by the Public Accounts Committee, £5 billion for renewables up to 2010, is included.

6. Finland has just started building a new nuclear power station, Olkiluoto 3; it will be the most economic solution to Finland's future energy demand, it will also provide CO_2 free electricity and strengthen their security of supply, making them independent of imports from Russia. Radioactive waste will be stored in a deep, geological repository which has been accepted as a satisfactory method of storing waste by the population at large. Some UK members of parliament have been to see the site. Lord Flowers in his 1976 report *"Nuclear Power and the Environment"* 6th RCEP report, said "There should be no commitment to a large programme of nuclear fission power until it had been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived, highly radioactive waste for the indefinite future". In *Hansard* of 12 January this year Lord Flowers is quoted ". . . safe disposal . . . namely underground storage . . . has been demonstrated beyond reasonable doubt in other countries, especially Finland." It is worth noting that the new designs of nuclear power stations, such as the Westinghouse AP1000, produce only one tenth the radioactive waste of current stations.

7. If the UK nuclear component is not rebuilt there is no chance that we will even approach the 60% reduction of CO_2 target set by the PM for 2050 (see paper by Fells, Fells and Horlock, TCE July attached to this e-mail). A large slice of replacement supply will have to be provided by gas which emits CO_2. A balanced electricity supply portfolio is required to give reduced CO_2 and also security of supply, not one dominated by imported gas which is what a simplistic, market-led policy will deliver; something like a mix of 10% renewable (the current policy) but backed with percentages for the other fuels, 30% gas, 30% nuclear and 30% coal with carbon capture. The market could operate within this framework but it will need a defined government policy. The notion that renewable energy will come and save us all is a dangerous conceit but seductive for those predicated on a green, rather than a practical and effective agenda.

16 September 2005

Memorandum submitted by Robert Freer

1. My name is Robert Freer and I am a Chartered Engineer and a Fellow of the Institution of Civil Engineers. I have about 50 years' experience of the design and construction of power stations and I am now an independent consultant.

2. I understand the Committee wishes to examine: "the options for investment in meeting future requirements for new electricity generating capacity".

3. I wish to make the point that there is a fundamental difference between, on the one hand, investment in base load power stations such as coal, gas or nuclear and on the other hand investment in renewable sources such as wind, wave and solar. These two sources of energy are as different almost as chalk and cheese and it is not possible to make a direct comparison for the purpose of investment, and especially investment for the purpose of trying to reduce carbon emissions.

4. Investment in power stations which generate base load will ensure security of electricity supply which is of prime importance for an industrial and commercial country such as ours. For example so much of our industry is now controlled by computers that any interruption in the electricity supply could bring the country to a standstill. Power stations fuelled by coal, gas or nuclear fuels can produce as much power and energy as required and it would be far sighted to ensure we have sufficient capacity in these power stations to supply our base load demand of about 35,000 MW.

5. Investment in renewables, at least in the government-supported renewables mainly wind and solar, will never ensure security of supply because their output depends on the weather which is unpredictable. Therefore their energy output is intermittent. Also their output is very small and these two sources will never do more than scratch the surface of the national demand. The present output from the wind turbines is less than 2 TWh per year whereas our national consumption is about 375 TWh per year and rising by 3 or 4 TWh per year. Therefore the wind turbines do not even keep pace with the increase in consumption. It has already been said that, without the government subsidies, no-one would be building wind turbines.

6. The claim that wind turbines are a source of clean energy needs careful consideration because their manufacture is energy intensive which produces green house gases, and offshore turbines create more green houses gases if their location causes the diversion of shipping and fishing boats and their maintenance requires access by helicopter.

7. There some forms of renewable energy which have the potential to supply the base load but inexplicably they are less well supported by the government. Mainly the conversion of wastes to energy using straw, chicken litter, forestry trimmings or municipal solid waste will provide base load energy and with an estimated output of about 30TWh per year. Another source is the methane escaping from old coal mines. All these sources have the benefit of not only producing energy but also solving the environmental problem of what to do with the waste.

8. Conclusion. Government investment and subsidies for wind turbines are a complete waste of money and should be stopped. They produce only a miniscule amount of energy, make no contribution to security of supply and their influence on greenhouse gases is doubtful. If the Government wants to support renewables they should invest in energy from waste power stations. The best investment from a national point of view is to build nuclear power stations and the number we need to supply the national base load using AP1000s is not 8 but 32.

21 September 2005

Memorandum submitted Friends of the Earth

Friends of the Earth has welcomed the UK Government's emphasis on climate change but is highly critical of the performance thus far achieved to cut the emissions causing the climate change threat. Since 1997 carbon dioxide emissions have risen by 5.5%, and as a consequence the UK is now no longer on track to meet its Kyoto Protocol commitments.[59] This failure to control carbon dioxide emissions has occurred during a period when scientists have provided further compelling evidence that the bulk of existing and expected climate change is human induced and that the rate and scale of change poses a grave threat to society, the economy and the environment. The Government's own Chief Scientist has issued dire warnings of the consequences of the rapid increase in global average temperatures that is now taking place because of greenhouse gas pollution.

It is clear that energy policy, and policies in areas such as transport, must now be driven by the overriding need to reduce carbon dioxide emissions. In this context, the Labour Government must not only meet its Kyoto target to reduce emissions of six greenhouse gases by 12.5% (carbon dioxide equivalent) but also deliver on its manifesto commitment to reduce carbon dioxide emissions by 20% by 2010 compared with 1990 levels (a policy objective that is now supported by the other main political parties).

The divergence from the emissions path needed to meet our Kyoto target, never mind our more challenging domestic goal, means that urgent action is now needed. The means to do that will need to be set out in the Climate Change Programme Review that Government is now conducting. Ministers have stated that this review is the means to get the UK back on track toward meeting its 20% reduction target. The review has, however, been repeatedly delayed and is now not expected until 2006.

Rumours abound of inter-departmental wrangling and delay driven by disagreement about what can be delivered by when. A situation that is all the more disappointing considering that the 20% target has been a manifesto promise that has been repeated at all three of the last General Elections. It is difficult to imagine a clearer mandate for action, especially from a Government that has enjoyed such strong majorities in Parliament. There is a risk that the new Climate Change Programme Review may not be published until after the first Meeting of Parties of the Kyoto Protocol. This is all the more damaging given that the UK Government has shown international leadership on climate change. This has been vital in keeping global political momentum on this most critical of issues. The UK's leadership role has been especially important since it is effectively unique.

The main reason why domestic targets are not being met, and thus why our international leadership role is being undermined, is because Government does not have an overarching strategy for emissions reductions, let alone the levers that can control them. Rather, there is a piecemeal collection of policies. Many of these are individually positive, but do not amount to a credible programme to meet the targets set. Worse still, individual sectors are cancelling one another out. For example the benefit of wind turbine installation is being wiped out by the current market-driven switch back from gas toward coal.

With this in mind, Friends of the Earth and others are now convinced that a legal duty is needed to require governments to cut carbon dioxide emissions by 3% per year. The vital shift we must make is to have an annual review of performance against an annual target that is allocated across the whole economy, to all sectors and delivered by all Government departments.

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[59] Figures for primary fuel inputs for inland energy consumption were taken from Digest of UK Energy Statistics, published 25/8/05. (See www.dti.gov.uk/energy/inform/dukes/) Friends of the Earth converted volumes of primary energy consumed in millions of tonnes oil equivalent (Mtoe) to millions tonnes of carbon emissions (MtC)

We are therefore supportive of and campaigning for, the Climate Change Bill, which was launched with cross-party support earlier this year. The Climate Change Bill, if passed, would require annual reporting on carbon dioxide emissions and corrective action should emissions deviate from the desired reduction trajectory (of the 3% per year needed to meet the scientifically-determined 75% reduction target needed for greenhouse gas concentrations to remain below 450 parts per million).

Successive governments would be free to decide how the reduction target would be met. The point is that the obligation would be there for years to come and would be an expected and embedded part of the programme of any government—no matter how fashionable the issue happens to be at any one time. Having said that, Friends of the Earth does recommend the introduction of sector targets and in our view it is likely that the electricity supply sector would need to take the brunt of the reductions up until 2020 (annex one).

Questions Raised by the Committee

The Committee has raised a number of questions regarding energy supply, including; whether any generation gap will emerge with the closure of nuclear power stations and some coal stations, the costs involved in generating power more cleanly, and particular questions around nuclear power. Friends of the Earth would like to respond to these questions through introducing to the Committee some energy modelling work that Friends of the Earth is carrying out together with WWF, explaining our thoughts on energy security and through explaining our position on nuclear power.

1. *Friends of the Earth Electricity Model*

Friends of the Earth is carrying out electricity modelling so as to investigate the carbon dioxide reduction potential and the electricity demand requirements based on different generation scenarios. We intend to publish this research later this year, but we are pleased to share some preliminary findings with the Committee in advance. The draft model is submitted as an excel spread-sheet form and a draft report will be forwarded to the Committee in due course. The model looks at three scenarios (coal to gas, biomass co-firing/coal retrofit, mix of gas and biomass/coal) and projects potential emissions reductions attainable through closure or conversion of old plant, adoption of higher efficiency plant, biomass cofiring, and carbon capture and storage.

The model firstly aims to identify the likely scale of "generating gap" caused by the phase-out of much of the existing nuclear and coal stations. This is done by taking available data and/or making assumptions about trends in the following areas:

- A modest reduction in UK energy demand to 380 TeraWatt-hours/year by 2020 (including auto generators);[60]
- the de-commissioning of the nuclear stations—estimated dates for closure programme;
- the commissioning rate for new Combined Heat and Power capacity—CHPA aspirational target of 20 GWe by 2020 selected;
- the commissioning rate for renewable electricity capacity—Renewable Power Association target of 100 TWh by 2020 selected;
- interconnectors and other (eg oil—fired capacity)—reducing to net zero as renewable electricity peaks are exported;
- possible closure rate of existing Combined Cycle Gas Turbine capacity—retirement of ageing less efficient plant—estimated 20 year life span;
- possible phase-out rate for existing coal stations—mainly due to the Large Combustion Plant Directive.

The possible commissioning of an IGCC plant is also considered in the model.

The remaining demand after subtracting the above supply categories shows the potential scale of the "generating gap". It is then assumed that this gap would be filled, for the purposes of this exercise, by either predominantly new CCGT or coal plant (including retro-fitting existing stations) or a mixture of the two. The scale of the carbon dioxide emissions are then calculated based on available data for existing plant and industry estimates for "next-generation" CCGT and coal technologies. A reduction in efficiency in load-following operational conditions has been included to account for the increasing renewable capacity and its variable output on the grid system, though increasing Combined Heat and Power capacity may partly offset this.

[60] Please note that this is a very modest energy demand reduction target. According to a report by ILEX for WWF, energy demand could be reduced to 358 TWh/Yr by 2020, simply through an effective implementation of the Energy White Paper (and this does not take into account potential further reductions than may arise thanks to European Union planned legislation on minimum efficiency standards for all products sold in the internal market).

Friends of the Earth believes that a continuation of a switch from coal to natural gas in electricity generation is desirable for the purpose of reducing emissions in the UK to the levels scientists say is necessary. This does not create as serious a challenge for security of supply as some media coverage and some lobby groups tend to claim (see evidence provided below) because new imports will come from reliable and friendly countries such as Norway and from a variety of other sources thanks to the construction of new LNG terminals and pipelines. Of course Friends of the Earth believes natural gas is also a bridging fuel rather than the real solution to climate change, as it does produce greenhouse gas emissions (although to a smaller extent than coal) and that the ultimate solution to both security of supply and climate policy lies in the growth of renewable energy and ambitious programmes to reduce demand, where a large economic potential remains untapped.

The main scenario Friends of the Earth would like to submit to the committee proves that it is possible to achieve considerable emission reductions in the power sector with a, "gas growth". This is a predominantly Combined Cycle Gas Turbine scenario—a programme which would fill the generating gap with next-generation CCGT. Construction times would be around 30 months per station

This scenario replaces coal-fired plant with advanced gas at a fast rate. Existing gas plant is also replaced, reducing emissions from 410g/kWhr from existing plant, to 370k/kWhr for advanced CCGT. Variables in this model include whether carbon capture and storage are used. This model shows that with a healthy uptake of renewables and CHP, significant cuts in carbon dioxide of up to 64% can be achieved by 2020 (reducing the sector's emissions to 23 MtC from a 1990 baseline of 64.3MtC) with carbon capture and storage able to increase reductions to 83% (11 MtC).

However, the organisation also recognises that considerable dependence on natural gas imports in the long terms is considered by some as undesirable, and that to some extent a switch back to coal burn is already happening because of current price differentials between coal and natural gas and because of overallocation in the Emissions Trading system, which creates insufficient market signals to switch to cleaner fuels. Therefore, based on this realistic assessment of the need to consider ways to make the current coal fired stations more efficient if they remain in operation, Friends of the Earth has decided to analyse the option of reducing emissions in the UK through a variety of options, including increased use of retrofitted coal technologies with considerable biomass co-firing and carbon capture and storage.

This has lead to two alternative scenarios based on growth of biomass co-firing/coal retrofit. The scenarios keeps open some of the existing coal-fired power stations but steadily upgrades them through the introduction of more efficient advanced supercritical boilers and feedwater heaters. Upgrades to plant could result in CO_2 emissions reductions, from a current level of 943 g/kWhr, to 545 g/kWhr, or as low as 465 g/kWhr with 20% biomass co-firing. However, the emission reductions are somewhat comparable (though still lower) to those achieved through a switch to natural gas only if a 20% biomass co-firing is achieved in these stations.

The main conclusion from all these models, whatever the energy mix, is that the UK can easily move away from nuclear power without suffering from a supply shortage, as long as efforts are made to promote other technologies, especially renewable energy and energy efficiency.

The second conclusion is that Scenario 1 "gas growth" offers greater emissions reductions, and Friends of the Earth currently recommends this as the preferred option for future energy generation. This is mainly because security of supply concerns on natural gas appear to be often overstated (and coal would have to be imported into the UK as well, some of which may come from potentially unstable countries as well). This scenario also relies on commercial technology as opposed to technologies to clean up coal and burn biomass in coal stations in large amounts, which have not yet been deployed on a large scale. Of course, if optimistic assumptions about the potential for these technologies to reduce emissions considerably and to compete with emission reductions from natural gas prove to be correct, we will change our recommendations.

As stated above, Friends of the Earth prefers for the regulatory environment to promote a switch from coal to gas, as this is a proven way to reduce emissions, unlike so-called "clean-coal" technologies that are either in demonstration phase or have never been implemented on a large scale before. However, if in the light of current market conditions and unsatisfactory regulation, coal stations continue to be higher up in the merit order than they would otherwise deserve, we must ensure that these coal fired plants that continue to operate start co-firing locally sourced biomass and are urgently retrofitted with the best available super-critical technologies to increase efficiency and reduce CO_2 emissions and other pollutants. The model's default scenario includes 20% biomass co-firing in all coal plant retrofitted with advanced supercritical technology, and coal retrofit also offers the option of biomass fired feedwater heating (not included in the model). Capture and storage of emissions from the biomass component would be carbon-negative as distinct from carbon-neutral.

Note that the modelling does not include emissions associated with extraction and transport of the fuels or in the case of gas the energy costs of liquefying it when transporting it by ship. This is due to the lack of reliable data in this area. Emissions from these may change results slightly but are unlikely to alter the position of gas as the least damaging of the fossil fuels and the best option as a bridging fuel leading us towards a low carbon energy economy.

The modelling includes potential additional reductions that could be obtained through carbon capture and storage. Friends of the Earth does not currently support large-scale implementation of carbon capture and storage (CCS) due to the legal, regulatory, permanence and liability issues that still need to be resolved. Also, in Friends of the Earth's view, there needs to be internationally agreed criteria on storage standards, site selection and acceptable leakage rates (which should be as close to 0 as technically possible).

However, in view of the enormity of the threat of climate change, CCS may end up having a potential role to play, and Friends of the Earth believes that any new gas or coal plant constructed should be built as a "capture ready" plant, ie that can easily implement CCS in the future. CCS would require substantial investment in new infrastructure for transport and storage, but this should not receive government subsidies or other forms of public support (which should focus instead on promoting more long-term and cost effective energy efficiency and renewable energy options).

Our modelling does not yet involve an investigation into costs. It is possible that the shift to a more sustainable electricity industry may lead to somewhat higher electricity costs. However, this largely depends on many variables, including the relative price of natural gas and coal (coal prices have been increasing as well as gas prices), and on the extent to which electricity companies are allowed to pass on additional costs to their customers. In any case these price increases can be largely mitigated through the adoption of ambitious energy efficiency policies.[61] In this context it is worth noting that there has been a significant reduction in real terms of the cost of electricity to domestic and industrial customers from 1990 levels. In 2004 the average industrial electricity price was the second lowest of the G7 and the fifth lowest in the EU 15.[62] It is also worth noting that any potential costs due to climate policies in general are well below the potential astronomic and incalculable costs our society will face if nothing is done to slow down climate change.

In any event, whatever the generation mix there will be a need to improve energy efficiency, and this will help to reduce costs. Redoubled efforts to reduce the average electricity consumption of products sold to consumers and businesses through European Union product legislation and/or the enforcement of ambitious minimum energy efficiency standards in the UK will be vital in driving up efficiency. Redoubling efforts to promote the development of energy services companies through mandatory energy efficiency targets will also greatly help to tap into the very large potential for reducing energy demand.

As an example, at least 6% of domestic electricity demand and an unknown amount of electricity in the commercial sector in the UK are currently wasted simply to keep products on "standby", ie always switched on despite not being in use. This percentage is rapidly growing. Cost-effective technology to reduce these losses by up to 90% exists, but manufacturers are not using it because there is currently no legislation requiring them to do so. Legislation at EU and UK level on energy efficiency issues such as this would be an overwhelmingly more cost-effective option for overcoming any problems with supply shortfall rather than prolonging the life of nuclear power stations or building new ones. The UK must support current European Union efforts to legislate in this area.

These provisional findings therefore suggest that reductions greater than 60% of CO_2 can be achieved by 2020 from 1990 levels through:

- Bold action in the short term to reduce the growth in electricity demand and, in the medium-term to achieve absolute reductions in demand.
- Ensuring that 25% of electricity requirements, or at least 100 TWhrs/year are produced through renewable power by 2020 (including biomass CHP).
- Boosting combined heat and power (CHP) usage at all scales (from large scale to micro CHP) to 98TWhrs/year by 2020 (excluding biomass).
- A phased switch from existing coal to new gas CCGT generating capacity, with possibly some upgraded coal capacity retained.
- Ensuring that any coal power plants used during this period are upgraded to advanced super-critical technology to boost their efficiency and that the use of sustainably sourced biomass in these plants is increased to the maximum possible extent.
- New or upgraded gas or coal plants should be made "capture and storage ready".
- These reductions can be achieved at the same time as phasing out our existing nuclear plant. Considerable attention is given to a potential energy gap posed by nuclear phase-out, and this is discussed below.

[61] "The power to save our climate", report for WWF UK by ILEX Energy Consulting, November 2004, pages 24–25.
[62] DTI, August 2005 update to Quarterly Energy Prices.

2. Energy Security

The Prime Minister said in his Labour Party Conference speech "how much longer can countries like ours allow the security of our energy supply be dependent on some of the most unstable parts of the world?" He used this to justify a new consideration of the role of nuclear power. When examining this issue it will be important to consider facts and not just rhetoric. According to the Department of Trade and Industry[63]:

- The UK's chief supplier of piped gas for the foreseeable future will be Norway.
- The Netherlands and Norway have around 4 trillion cubic metres of gas reserves (2004 estimate).
- Our import dependency on gas will grow to perhaps 40% by 2010–11.
- New LNG terminals are being built to allow a larger diversity of sources of gas in the future (and hence security).

The UK's Energy Sector Indicators, published in 2005[64], also provide useful information, such as:

- The UK was only one of six OECD countries to produce more energy than it consumed in 2002. The Netherlands, United States, Switzerland, Germany, Austria, Spain, Japan and Italy are all major energy importers. France, Italy, Germany and Japan have all lived with importing large amounts of energy for the last 25 years.
- 70% of crude oil imports are from Norway.
- The average house in the UK only has an energy efficiency rating (SAP rating) of 51.3 out of a maximum of 120.
- Only 55% of potential households had 80% or more of their windows double-glazed in 2003, and only 18% of households full insulation.
- Electricity generators lost all but 38% of the energy of their fuel through inefficient technologies, and that does not take into account large transmission and distribution losses.

In Friends of the Earth's opinion we need to keep energy security issues at front of mind but not overstate any threat so as to promote unsustainable technologies, such as nuclear power. The most sustainable and sensible response to the energy security challenge would, in our view, be to vigorously promote energy efficiency, more actively harness the UK's sources of renewable power, and ensure maximum efficiency from existing fossil fuel generation. Given increased reliance on natural gas, the UK should reach levels of storage capacity which are at least comparable to those of Western European countries with more experience as gas importers.

In addition, if we are concerned about security of supply, we must ensure that we analyse what the dangers for supply disruptions really are, given that in any electricity market, no matter what the energy mix, temporary supply shortfalls may occur. These dangers, despite rhetoric stating the contrary, have far more to do with inadequate market regulation than with environmental policy. And the answer to these crises (as in the case of California) has been to implement emergency demand response options.

The UK must urgently implement recommendations by the International Energy Agency, which has recently published two reports: "Saving Energy in a Hurry" and "Saving Electricity in a Hurry"[65]. These reports are based on experiences in California, Brazil, Norway, New Zealand and Japan and other parts of the world, where temporary shortfalls in energy supply and/or price spikes have been successfully dealt with through energy efficiency measures. Implementing these efficiency measures appears to be particularly urgent in the UK, in the light of a possible cold winter in 2005–06 and currently high natural gas prices (because of their link to oil prices) at a time of a temporary potential low import capacity because LNG terminals are not yet ready, potentially causing a temporary mismatch between supply and demand.

Some examples from the reports include:

- California encouraged electricity conservation by offering rebates to consumers that cut their electricity use by more than 20% compared to the previous year.
- During a day-long shortage in the winter, Sweden encouraged its consumers to briefly lower thermostats and to postpone non-essential electricity-consuming activities.
- Brazil and California distributed tens of millions of compact fluorescent light bulbs (CFLs) and encouraged consumers to buy more. Each CFL replacement of an incandescent bulb cut electricity demand about 75%. The market for CFLs in California was permanently transformed and continues to be several times larger than in the rest of the United States.
- California replaced almost a million lamps in traffic signals with high-efficiency Light Emitting Diodes (LEDs) and saved over 60 Megawatts—enough electricity to supply 60,000 homes.

[63] DTI, 2005, Secretary of State's first report to Parliament on security of gas and electricity supply in Great Britain.
[64] DTI, 2005, UK Energy Sector Indicators 2005.
[65] IEA 2005.

In addition to these methods, there are a number of other cost-effective methods for quick demand response that are technically available and only need political support and better regulation in order to be taken-up in the market. Implementing these systems would be far cheaper than spending taxpayer money for nuclear power. One example among many is the concept of dynamic demand.[66]

The UK's wind resource represents 40% of the total available wind energy resources in Europe, and could theoretically meet the country's electricity needs eight times over from wind power.[67] Other renewables deserve much greater attention: it has been estimated that wave power could provide around 15% of UK electricity demand, tidal stream power could provide approximately 6.5%, and tidal lagoon schemes could generate an additional 8–10%. From our scenarios, it is also clear that more efforts need to be made to promote the growth of biomass. This will not only have a positive effect on climate policy, but will also benefit the agriculture and forestry industries.

Combined Heat and Power and other forms of decentralised generation also need to grow at a faster rate than is currently the case. It is worth noting that during serious blackouts which force the entire electricity grid to shut down, Combined Heat and Power and other forms of decentralized power are able to continue producing electricity.

While the UK works towards more ambitious renewables targets, the electricity model referred to above demonstrates how improvements to the efficiency of our fossil fuel use could amply accommodate nuclear phase-out while ensuring security of supply. A "replacement" new-build nuclear programme for the UK might consist of 10 AP1000 stations (1.1 GW capacity) producing 87 TWhrs/yr (equivalent to current UK nuclear output) and would not have a load-following capability. Alternatively, a programme comprising next-generation CCGT technology generating 85 TWhrs/yr would require 12 GW of CCGT capacities. Such a programme starting in January 2008 might be completed within five years given a build time of about 30 months.

Even an ambitious coal station retro-fit programme with an increase in biomass co-firing (which, as stated above, may not be necessary) starting in January 2008, would after five years, have completed the conversion of about 7 GW of coal station capacity capable of generating around 86 TWhrs/yr. Such gas or coal plant could be "capture-ready" and completed by 2013, probably two years before any new-build nuclear power stations could be commissioned.

3. Friends of the Earth and Nuclear Power

Friends of the Earth do not believe that nuclear power is a desirable or necessary source of generation to combat climate change. The scope for emissions reductions through a replacement programme of new nuclear power plants is not that great. Nuclear power is currently responsible for about 22% of our electricity generation. But electricity generation, in turn, is only responsible for about 30% of the UK's carbon dioxide emissions. Carbon dioxide is responsible for 85% of our overall greenhouse gas emissions.

Nuclear's electricity contribution is expected to fall significantly by 2020 and finally reach zero when Sizewell B shuts in 2035. Other things being equal (an extremely unlikely scenario), this would increase greenhouse gas emissions in the UK by about 8%.

Replacing nuclear with nuclear would keep greenhouse gas emissions at their existing level but at the same time:

— Increase almost five-fold the amount of spent fuel in the UK's radioactive inventory.

The Committee on Radioactive Waste Management (CORWM) has estimated the impact of replacing nuclear with nuclear on the UK's nuclear waste and materials inventory[68]. Using the AP1000 reactor type, it concluded that the tonnage of spent fuel would rise from 4,700 tU to 18,700 tU—an increase of almost 400%.

Spent nuclear fuel is highly radioactive and generates heat[69]. Once packaged for disposal, the spent fuel created by a new programme of AP1000s would occupy 31,900 m^3—which is substantially more than the combined volume (19,970 m^3) of the spent fuel, uranium, plutonium and high level waste already produced or expected to be produced by existing reactors. It would add substantially to Britain's nuclear waste problem.

[66] please see http://www.dynamicdemand.co.uk

[67] New Economics Foundation, June 2005 "Mirage and Oasis, Energy Choices in an Age of Global Warming".

[68] Committee on Radioactive Waste Management, 2005, Corwem's radioactive waste and materials inventory, corwem document 1279, para 5.32–5.34, 6.16–6.22 and p 35.

[69] Committee on Radioactive Waste Management, 2005, How should the UK manage radioactive waste, second consultation document, p 8.

Require substantial subsidies that are better spent on achieving emissions reductions through other means

In 2002, the Cabinet Office Performance and Innovation Unit forecast the costs in 2020 of electricity generated by nuclear power. It concluded that electricity from nuclear power was likely to prove more expensive than electricity from on-shore or off-shore wind, many energy crops and micro-CHP. It also demonstrated that overall UK demand for energy could be reduced by 30% by measures that are already cost effective[70].

Further assessments have been completed since then. The Parliamentary Office for Science and Technology has pointed to the importance of assumptions about discount rates in influencing overall costs[71]. Assumptions about reliability and decommissioning costs are also important. POST concluded "the basic problem in all these comparisons is that the situation is a classic catch-22. Only the construction of a new reactor could verify the cost assumptions made by the nuclear industry." The scale of the investment required precludes an experiment while in any event this would take years to complete—years during which we will need to be aggressively reducing emissions if we are to meet our short-term, let alone medium and longer term targets.

According to a recent article on Scientific American, delivering a kilowatt-hour from a nuclear power plant costs at least three times as much as saving one through efficiency measures.[72]

Send a dangerous signal to countries throughout the world

Britain prides itself on being a world leader in the fight against climate change. A British decision to use nuclear power in that programme will prompt other countries to follow suit (whether their intent is sincere or otherwise).

This could be highly problematic. Many aspects of the technology used in civilian nuclear power systems are also used in nuclear weapons programmes. Specific examples include uranium enrichment and back-end reprocessing technologies, but even the existence of a nuclear skills base increases the potential for a country to acquire weapons. The on-going cases of North Korea and Iran demonstrate the danger.

Using nuclear power to tackle climate change would substantially increase the risk of proliferation. Climate change is a global problem. Its mitigation will eventually require controls on the emissions of most, if not all, countries. Negotiations over controls already entail discussion of technology transfer. If the UK were to use nuclear power to limit climate change, it would be difficult to deny this technology to others—especially if we were expecting them to control their emissions. Merely adding concerns over proliferation to already tortuous climate negotiations would make those negotiations more difficult. In this regard it is of note that earlier this year the Iranian Ambassador to London claimed that his country's nuclear power programme will aid the implementation of the Kyoto Protocol.

In terms of energy security there is also the threat of terrorism against nuclear facilities and transports. This threat should not be underestimated. It is worth noting that the 911 Commission in the United States found that the masterminds of the terrorist attacks of September 11, 2001, had considered flying planes into nuclear power stations. This was later ruled out but future attacks of this kind cannot be ruled out and contribute to making new nuclear power stations extremely undesirable.[73]

Finally, given existing licensing procedures, it will be at least a decade and probably much longer before construction on any nuclear power plants can begin. By contrast, many measures to promote energy efficiency and renewable generation can proceed very quickly.

Appended is a report recently published by Friends of the Earth Australia which covers these issues and others in greater depth.

Conclusions

The present Government is failing in its duty to cut carbon dioxide emissions. The electricity generation sector is a sector where substantial cuts could be made quickly without endangering energy security. There remains scope for reducing electricity consumption and greatly increasing the role of renewable energy. The discussion on whether nuclear power is needed is a dangerous and unwarranted distraction from the urgent priority of establishing a genuinely sustainable energy policy. Action on climate change is desperately needed. Prevarication, dithering and inaction are not.

[70] Performance and Innovation Unit, 2002, The Energy Review.

[71] Parliamentary Office for Science and Technology, 2002, The nuclear energy option in the UK, POSTNOTE 208.

[72] Amory B. Lovins, "More Profit With Less Carbon", Scientific American special issue, Sept 2005, p 82.

[73] The 9/11 Commission Report, page 245 http://www.9-11commission.gov/report/911Report.pdf

Annex 1

SECTOR TARGETS FOR CARBON DIOXIDE EMISSIONS

Friends of the Earth has suggested sector targets to help drive the required carbon dioxide cuts across the UK economy. Our analysis suggests that some sectors will need to take greater reductions than others, due to technical and political constraints. The suggested sector targets are in the table below.

Sector	*1990*	*2000*	*2010 target*	*Friends of the Earth suggested 2020 target*
Energy supply	64.3	53.5	38.3	25.72 (60% cut from 1990)
Manufacturing and construction	26.6	23.7	23.3	21.3 (20% cut)
Road transport	30.1	32	30.1	26.7 (12.7%)
Aviation	4.6	8.8	4.2	3.2 (30%)
Commercial and institutional	8	8	6	5 (37.5%)
Residential heat and gas-fired hot water	21.1	23.3	18.5	16.4 (22%)
Others	9.5	8	7.2	7.2
Total suggested targets			127.6	105.5
Government targets—2010 20% CO_2 cut from 1990, 2020 EU 30% greenhouse gas reduction (equates to 40% CO_2)	165.1		132.1	99
Shortfall from target				6.5 (potential to meet from manufacturing and residential)

Annex 2

FRIENDS OF THE EARTH AUSTRALIA NUCLEAR POWER REPORT, SEPTEMBER 2005

This report is submitted as a separate PDF report.

The summary document is available at:

http://www.melbourne.foe.org.au/images/nukesdoc/summaryweb.pdf

The full report is available at:

http://www.melbourne.foe.org.au/images/nukesdoc/nukesweb.pdf

	CO_2 emissions g/kWhr	
Coal retrofit with 20% biomass	465	
Coal retrofit with 0% biomass	545	
Emissions increase	4	
CHP	300	
Coal current	943	
Coal IGCC	0	
CCGT current	410	
CCGT advanced	370	
Carbon capture costs	25	per cent. Note: to remove C capture from modelling, set date in cell B19 to 2021 or above.
Carbon capture rate	85	per cent
CO_2 to carbon	0.27272727312	

October 2005

Memorandum submitted by Fuel Cell Power

1. Fuel cells could replace central power stations and enable the heat produced when electricity is generated to be utilised. Fuel cells are efficient, clean and quiet in operation and if used in conjunction with renewable energy, no global warming gases are emitted.

2. The aim of Fuel Cell Power is to implement the introduction of lower cost fuel cell systems to provide CHP or to enable the storage of intermittent renewable energy supplies. The introduction of fuel cells will enhance markets for small scale renewable energy technologies. Intermittent supplies of electricity from wind or solar power can be stored as hydrogen for use when required.

Generation Gap

3. Present nuclear capacity of 12GW is expected to reduce to 6GW by 2010 and 1GW by 2020. It would be possible for coal to continue to provide substantial back up.

Investment Options

4. There is little information about the costs of generating electricity from renewable energy sources which are not grid connected. Fuel Cell Power has in the past sought Government support for evaluations of renewable energy and hydrogen fuel cell systems, but there was no interest. Small generators may be discouraged by the low price paid if they sell electricity to the grid and there is not a guaranteed market under the terms of the Renewable Obligation.

5. A fundamental re-appraisal of our built environment and energy infrastructures is needed. Renewable energy should be used in well designed buildings where it will not be wasted. With the advent of LED lighting, new batteries and fuel cells, markets are opening up for micro wind turbines producing relatively small quantities of electricity. Micro wind turbines range from 200W systems with battery storage to 3 kW units. They could be the forerunner of a changing electricity infrastructure, encouraging a new perception of energy, from the throwaway attitude to one of conservation.

6. A low cost non-grid connected system could include LED lamps with small battery or fuel cell storage, which would be activated by movement or by a zapper. It would power computers, TV, possibly fridges and emergency controls for central heating in the event of grid failure. There would be export potential in developing countries which do not have their own electricity infrastructure. As fuel cell technologies are commercialised and costs come down, micro wind turbines, combined with solar energy, will be suitable for powering all electrical household appliances.

7. Micro wind turbines are being designed to utilise wind from any direction at speeds as low as 3 mph. Once volume production is achieved, a system producing about 1,000 kWh per annum would cost approximately £800 including installation. Life time is estimated to be at least ten years. Larger 2 kW units under development which would produce on average 5,000 kWh per annum would cost about £4,000. It is estimated that 10 million units could be installed at suitable UK properties, providing at least 10,000 GWh or about a third of the renewable electricity objective of 35,000 GWH by 2010. An additional 30% electricity may be generated from these systems with an innovation yet to be patented.

8. Solar thermal and photovoltaic panels could contribute to heat and power requirements in buildings. Costs will come down in volume production and new technologies such as the Tandem Cell developed by UK based Hydrogen Solar Ltd and the Dye Solar Cell are projected to be more cost effective. In Germany the commercialisation of photovoltaic panels is encouraged with a subsidy of over €0.50/kWh.

9. Many other technologies will contribute to our energy needs. Low head hydro is unexploited and ground source heat pumps can provide constant background warmth. Energy crops, forestry and farm residues, waste food and sewage can provide biofuels or hydrogen for fuel cells. The Grünhaus, which is planning a new centre in Liverpool, has a database covering many energy efficiency and renewable technologies which could be developed to meet our energy demands.

Capacity Building Policies for Renewables

10. In view of the run down of British engineering industries in recent decades, the Government should treat it as priority to help bridge the large gap between the funding of R & D and the commercialisation of new energy technologies. Most innovators are held back by lack of funding and there is little incentive for financiers to invest in energy saving.

11. Even if an innovative energy company achieves sufficient funding to bring its product to market, Government funding programmes, such as the RO and the EU Climate Trading Scheme, are only applicable to CHP units which are grid connected. The public does not have a choice, but according to the National Audit Office, will have to pay about £1 billion per annum by 2010 in order to get 10% of UK electricity from renewables, mainly from large scale wind farms.

Comparative Efficiencies

12. Micro CHP systems are generally at least twice as efficient as conventional systems as they produce both electricity and heat from the same quantity of fuel which at present is used to generate only electricity. It is uneconomic to transport the vast quantities of heat produced when electricity is generated in large central power stations but it is estimated that it would be sufficient to heat every building in the country. The primary energy efficiency of a CHP unit is about 85% compared with only 35% for the UK's electricity grid.

13. Fuel cells can be designed to provide both electricity and heat or to generate electricity up to 70% efficiency in conjunction with other systems such as heat pumps or solar thermal panels. Heat pumps operate at an efficiency of about 300%, producing three times the heat from a given electrical input. Hydrogen fuel cells can also be used with solar PV and micro wind turbines to provide electricity and heat when there is no wind or solar power available.

Back Up for Large-scale Wind and Marine Energy

14. Hydrogen fuel cell systems can provide grid back up for large scale wind and marine energy farms. Studies in the USA have shown that in the longer term, when cars are powered by hydrogen fuel cells, during the 95% of the time that they are parked, they could generate all the nation's electricity ten times over. This could provide a massive energy supply and reserve capacity in 10 to 20 years time.

Future Investment

15. Financiers generally require a lead from Government but in the UK they have had no encouragement to fund the development of fuel cells powered by renewable energy. Major Government funding of central electricity generating stations would continue to discourage financiers of local renewable energy infrastructures. However, if sufficient finance is made available to establish micro CHP units powered by renewable energy, this will considerably reduce the need for large scale capital investment in the national grid.

Security and Safety

16. Efficiency measures, combined with local CHP generation using indigenous energy sources, would ensure that the UK is not so vulnerable to terrorist attack or global price rises or shortages. There would be no addition to the volume of nuclear waste which must be disposed of and, if renewable energy were used in the production, transport and operation of fuel cells, there would be no further anthropogenic emissions of global warming gases.

17. In view of scientific evidence given at this month's meeting of the British Association indicating that reductions in carbon dioxide emissions to meet the UK's Kyoto target in 2010 will probably be offset by CO_2 emissions from the warming soil, the implementation of efficient, non carbon energy technologies is essential. The UK's 2010 target for CO_2 emissions reduction should be at least doubled to take into account the additional emissions from our soil and the 2050 target for 60% reduction brought forward. We should take a leading role in the implementation of new technologies in developing countries so that they can also meet stringent targets under the principles of Contraction and Convergence. The Government should tell the nation what is happening and take a lead in effective action to change from burning fossil fuels.

21 September 2005

Memorandum submitted by Mr B Gerrard

My understanding is that the inquiry is assuming that at least eight AP 1000 reactors would be built, if the nuclear option is chosen.

I also understand that an AP 1000 is an advanced Pressurised Water Reactor, which has been developed by a subsidiary of BNFL; and that none have been built or sold.

Regarding the Generation Gap Question:

> Our local power station, Fiddlers Ferry, is a coal fired station. It did not meet the "2002 Renewable Obligation Order" requirements to burn renewable fuel. It was too old, and hadn't had all its old boilers replaced with new ones. The Government changed its rules, and now the power station is burning renewable fuels, and has recently been given the go ahead, by the Government to install a "Flue Gas Desulphurisation Plant". The power station's new owners "Scottish and Southern",

are developing clean coal technology. At a recent visit to the power station, staff told me that the station could be updated, with this clean coal technology, and this would extent its life, past the 2015 decommissioning date announced in the press.

If other "Old" coal power stations were updated like ours, then the Generation Gap would not be so great. This would allow the lights to stay on in Britain, while Renewable Energy Schemes have more time to come on line.

Financial Costs and Investments consideration:

This is an interesting question. Liverpool, a city near me, planned and costed a Tramway system. Steel prices have risen so much, that now the Tramway will not go ahead, unless the Government, increases its grant to the project. This example shows that electricity generators, which contain a lot of steel, such as Wind Turbines, would be less competitive now, than when Liverpool first planned its Tramway system.

If concrete prices were to rocket, then large users such as Nuclear Power Stations could become too expensive to build. So, what a power station is made of, can be more economically important than what technology is used.

We were told that nuclear power would produce electricity too cheap to monitor, how wrong they were.

Previous Governments have tried to get companies to invest in Nuclear Power Stations, but this was a disaster. Only two Aluminium Companies—one in Anglesey and the other in Scotland—invested in Nuclear Power Stations, to keep their huge electricity bills down.

ICI Runcorn, a company near me, is a large electricity user, but it, like all the Steel Manufacturers in Britain, did not get involved in building Nuclear Power Stations. I can not see Large electricity users such as Aluminium Companies, steel Manufacturers, or the Chlorine Industry, getting involved in any future Nuclear Power Programmes.

The Nuclear Industry has been on a life support system for nearly 50 years; they kept telling us that Nuclear Fusion was just around the corner. Its time the Government switched off the nuclear life support machine, and invested the money saved, into a National Water Pipeline System. This pipeline could supply water to all Britain in times of drought, brought about by Global Warming.

Strategic Benefits:

Nuclear Power should be kept as the last option, in case the other options fail. We do not have economically mineable quantities of Uranium, which means importing the material. A previous British Government ignored a UN ban on Namibian exports, and exported Uranium from Namibia to Britain, to keep British lights on. We should not rely on Uranium imports, when some of the countries, are politically unstable.

If any new Nuclear Power Stations were to be built, they should come under the UN Atoms For Peace Programme. They should not have online refuelling, or sections in the reactor, which have the necessary Neutron Flux Density, for weapons grade Plutonium to be made.

Finally, I live close to the only Nuclear Enrichment Plant in the Country. The wagons that transport the Uranium Hexafluoride material, pass through my town, they do not have police escort or armed guards, accompanying them.

I have seen these radioactive wagons pass along Birchfield road. This is in an area with high density housing, several schools, a Technical College, and a large superstore. The area would be devastated by radioactivity, if terrorists attacked these unaccompanied wagons, with rocket propelled grenades.

The Enrichment factory contains large amounts of Uranium Hexafluoride, which would make Merseyside a radioactive wasteland, if terrorists attacked the factory directly, or attacked the power lines that supply electricity to the centrifuges.

15 September 2005

Memorandum submitted by Professor John H Gittus

An Answer to EAC Question C4: "To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?"

By Professor John H Gittus. F R Eng. D Sc (Physics, London University). D Tech (Metallurgy, Royal Technical High School, Stockholm). B Sc (Mathematics, London), F I M. F I S. Consultant to Chaucer Syndicates, Lloyd's of London Insurance Market. Royal Academy of Engineering visiting Professor, University of Plymouth.

SUMMARY

1. Currently the Security of Electricity Supplies in the UK is the highest among the G8 Countries.

2. This is largely because the UK is almost completely independent of imported fuels.

3. In 2024 the situation will, on present forecasts, be reversed and the UK's Supplies of Electricity will be the least secure among the G8 Countries.

4. This is largely because, by then, the UK will be uniquely dependent on imported fuels, particularly imported gas.

5. Historically, the UK's Gross Domestic Product has been reduced by an amount equal to the magnitude of each of the major, politically-inspired blackouts that have occurred.

6. The magnitudes of the Blackouts forecast to occur when the UK is reliant on imported fuels are much greater than those that have occurred in the past.

7. Such blackouts would, on past experience, lead to such large losses of GDP that the UK could not reasonably be expected subsequently to recover its position in the Global economy.

8. If instead of importing so much gas from outside the EU, the UK builds nuclear power stations to replace the present ones, which are near the end of life and makes more use of the renewables then the Security of Supply can be preserved. One way of doing this, without Government Subsidies, would be to introduce Security of Supply Obligation Certificates, SOSOC's, similar in principle to the present Renewable Obligations Certificates, ROC's.

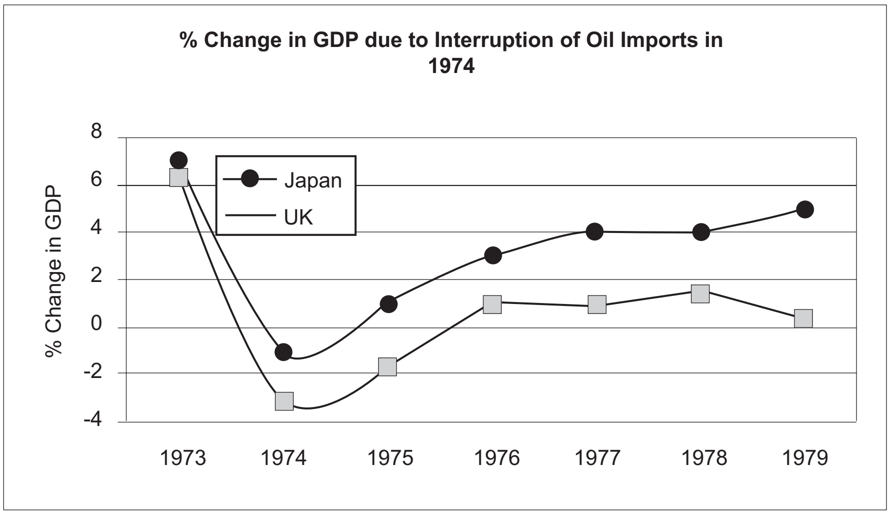
INTRODUCTION

This work is an extension of an analysis of the Security of Electricity Supplies in the UK that I did in 2002–03, to assist with the UK Government's Energy Review[74]. In that analysis I focused on the likely frequency and magnitude of Electricity Blackouts in the UK, due to all causes, including Political Risks, bad weather, industrial action and accidents. I used Meteorological Models, Insurance and Political Risk Data-Bases. In the present study I extend the earlier work to cover the G8 countries, forecasting the frequency of electricity blackouts due to Political Risks, Industrial Action and Terrorist Risks.

POLITICALLY-INSPIRED INTERRUPTIONS OF OIL SUPPLIES HAVE REDUCED GDP OF UK AND JAPAN

Disruption of UK oil and coal supplies due to political activities has occurred twice per decade in the last 50 years. Fig 1 shows how the interruption that occurred in 1974 reduced the GEP of both the UK and Japan.

Figure 1: % Change in GDP of Japan and UK due to Interruption of Oil Imports in 1974

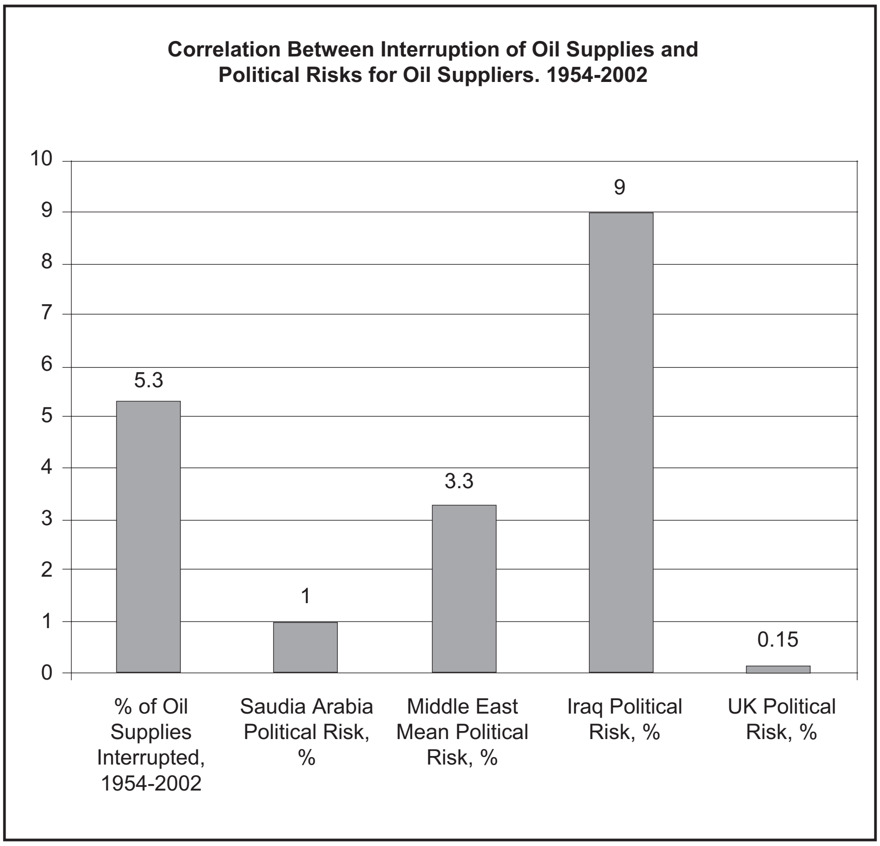


[74] My work on Security of Supplies in the UK is summarized in BNFL's Submission to UK Government Consultation on Energy Policy. 5 September 2002.

Indices of Business Risk Correlate with Disruption of Oil Supplies

Figure 2 shows that the history of disruptions to oil supplies correlates well with indices of Business Risk based on experience in the Marketplace.

Figure 2:Correlation Between Interruption of Oil Supplies and Political Risk for Oil Suppliers. 1954-2002



For the countries of the Middle East that have the greatest oil reserves and which are shown in, the average Political Risk Insurance Premium in 2002 is 3.3% and the range is from 1% for Qatar to 9% for Iran. These figures do not differ significantly from the actual percentage, 5.3%, of our oil supplies that the UK lost, due to political action, in the period 1954 to 2002.

Forecasting the Future Disruption of UK Oil, Gas, Uranium and other Fuel Supplies

Above I showed that the actual Risk, in percentage terms, presented by Politically-motivated interruptions to oil supplies over the last half century is numerically similar to the Political Risks to Business in the countries of the Middle East from which this oil was imported. These Political Risks were represented by the Premiums needed to insure them.

Those Premium-values are similar to the Premiums for the countries from (and through) which the UK and other countries will be importing most of its gas in 2024 and the years leading up to 2024.

I have used these indices to calculate the frequency and magnitude of future interruptions of supplies, to the UK, of oil, gas, and uranium and of the other fuels that we shall be using to generate electricity.[75]

If interruptions of gas supplies follow the pattern of historic interruptions of oil and coal supplies in terms of duration and frequency, then we can expect them to occur at intervals of order 10 years and to last a significant part of a year on each occasion.

[75] The Indices for Political Risk used in this work have been developed from a Data Base prepared by The PRS Group, Inc, 320 Fly Road, Suite 102, PO Box 248, East Syracuse, NY 13057-0248, USA. The forecasts extend to 2009 and have been extended to 2025 for the present study. The Data on Political Risk Insurance Premiums have been developed from a Data Base prepared by AON Plc. 8 Devonshire Square, London EC2M 4PL. These Premiums are based on historic losses.

EVIDENCE OF INTERRUPTION OF GAS SUPPLIES TO EUROPE FROM RUSSIA

It might be argued that it is unfair to forecast the interruption of gas supplies from Political Risk Indices alone, even though those indices correlate well with the historic interruption of oil supplies. However there have already been several interruptions of supplies of natural gas to Europe from Russia and this raises our confidence in the forecasts. For example:

1. On 18 February 2004, Russia's gas holding Gazprom stopped gas supplies to Belarus. As a result, Russian gas supplies to Poland, Lithuania and the rest of Europe through Belarus were halted. This radical step on the part of Gazprom was due to the fact that "The Belarussian state-owned company Beltransgaz has not fulfilled all of its transit obligations."
2. Again, several times in the first half of 2002, Russian companies cut off natural gas supplies to the Ukraine and Georgia to force payment of debts. Russian gas giant Gazprom is now suing Ukraine to pay for gas that Kiev has allegedly siphoned from the pipeline transiting its territory. Longer, less frequent stoppages may easily be envisaged.
3. An interruption in gas flows from Russia, Turkey's main supplier, put Ankara, Istanbul and Bursa in the dark and the cold. Although Russia's national gas company, Gazprom, has made assurances that interruptions in gas supplies were out of the question, few people in Ankara and Istanbul are relieved. "We have never seen Russia as a reliable gas supplier," said one Istanbul businessman. "And recent failures in gas supplies proved us correct."

My earlier, detailed analysis led to the forecast that, in a typical year in the coming decade:

There will be no gas flow from Russia to the UK for a few percent of the time.

For about 15% of the time, Russian gas will flow to the UK at no more than 50% of the intended rate.

FORECASTS OF BLACKOUTS IN THE G8 COUNTRIES, 2004 TO 2024

Using the methods of analysis summarized above, I have extended the study of Security of Supply to cover all sources of electricity and each of the G8 Countries.

First, to exemplify the methodology, are shown Figures containing some of the data used in making these forecasts:

Figure 3 shows the Political Risk Indices for countries that export most of the World's coal.

Figure 4 shows the Political Risk Indices for countries that export most of the World's uranium.

Figure 5 shows the cost of Intermittency for renewable sources of electricity.

Figure 6 shows the sources of UK electricity for the period 2004 to 2024.

Figure 7 shows the sources of US electricity for the period 2004 to 2024.

Figure 3: Political Risk, %, for Coal Exporting Countries.

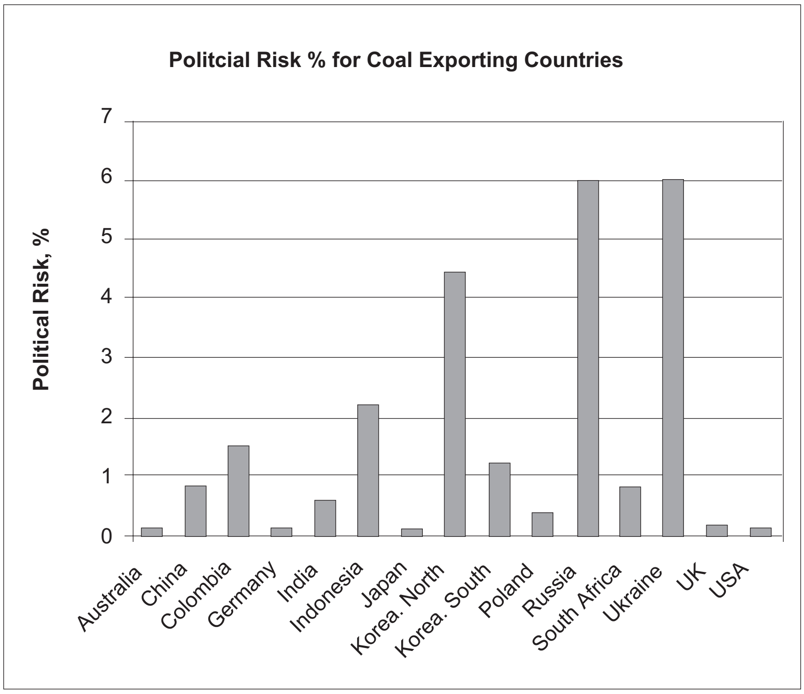


Figure 4: Riskof Interruption to Supplies of Uranium from Stated Countries and their Reserves

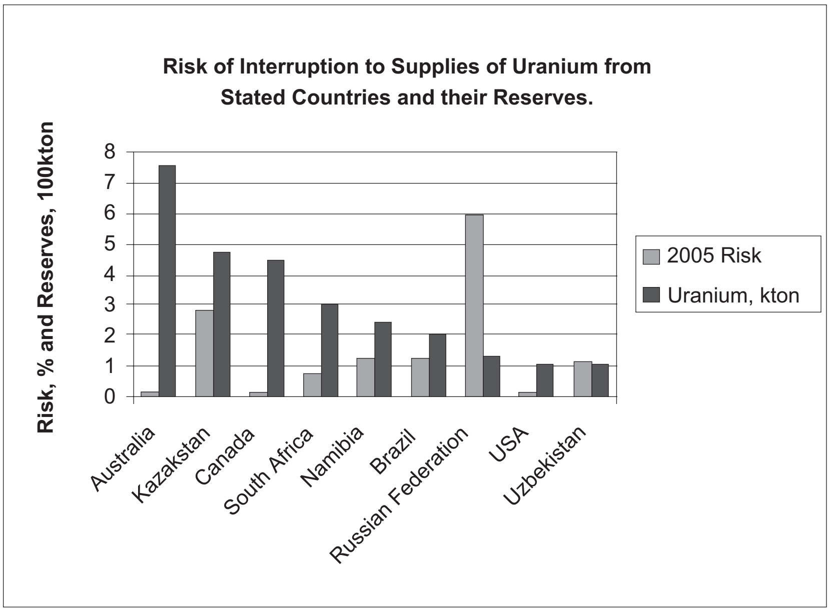


Figure 5: Cost of Intermittency for Wind etc, p/kwh

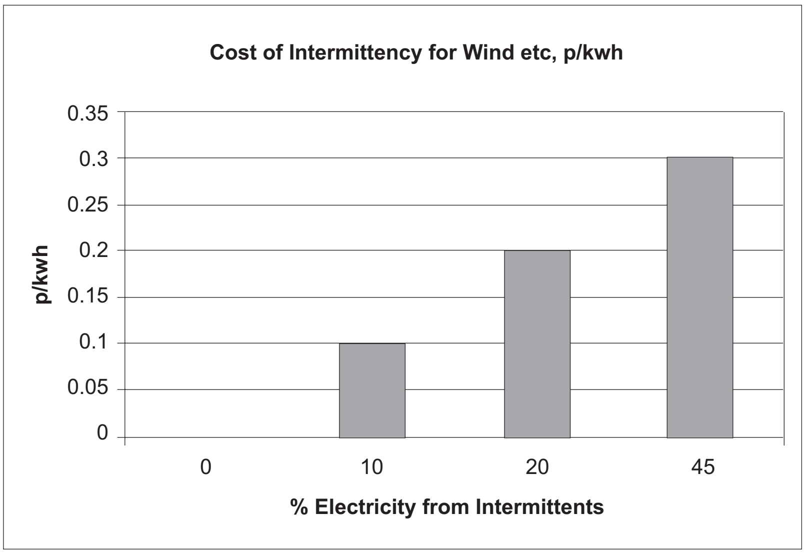


Figure 6: Sources of UK Electricity in Future Years.

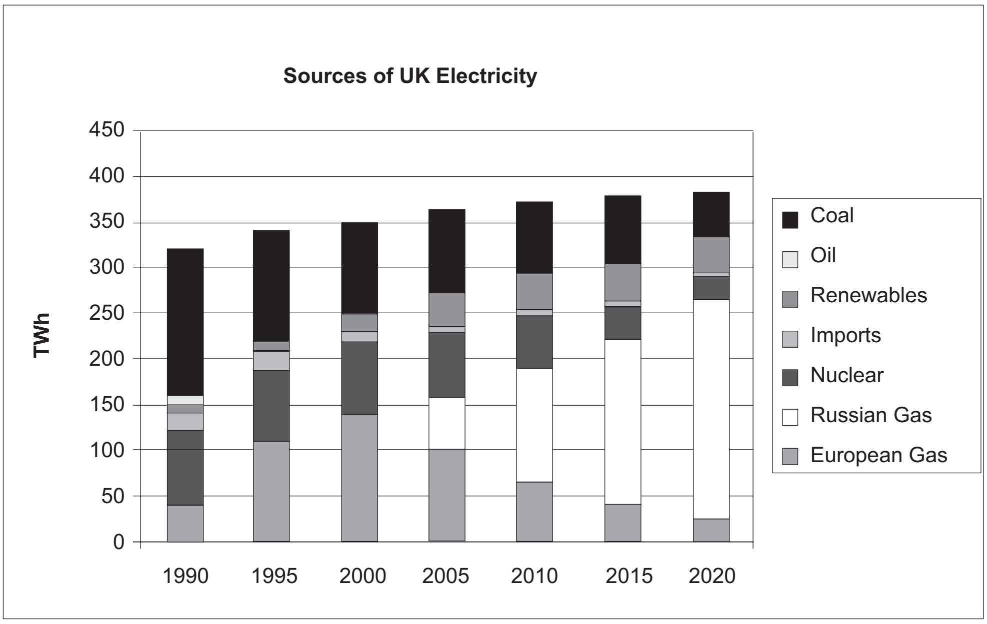
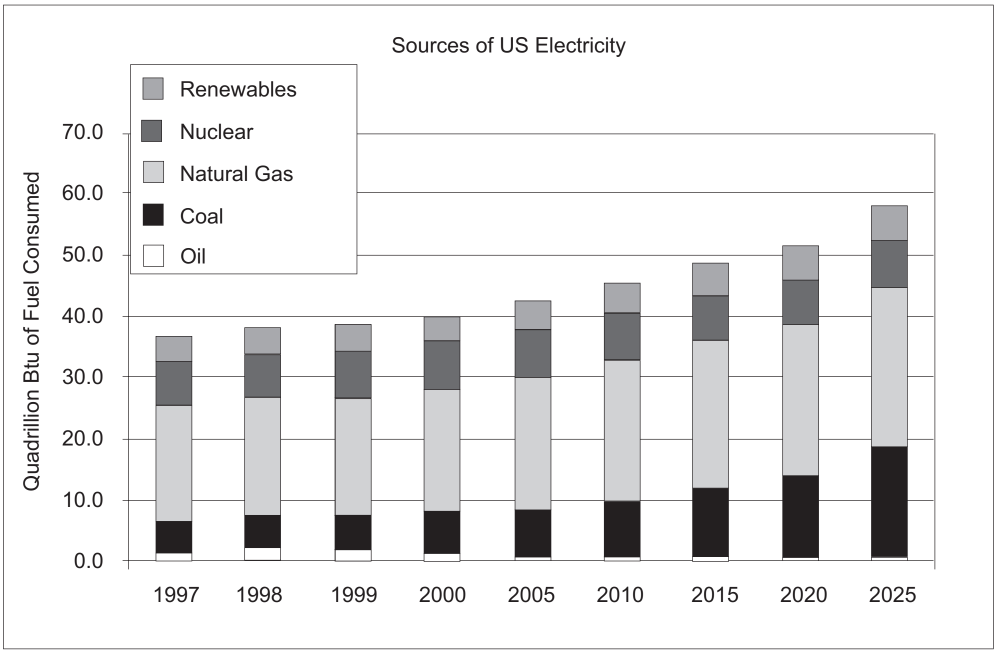


Figure 7: Sources of USA Electricity in Future Years



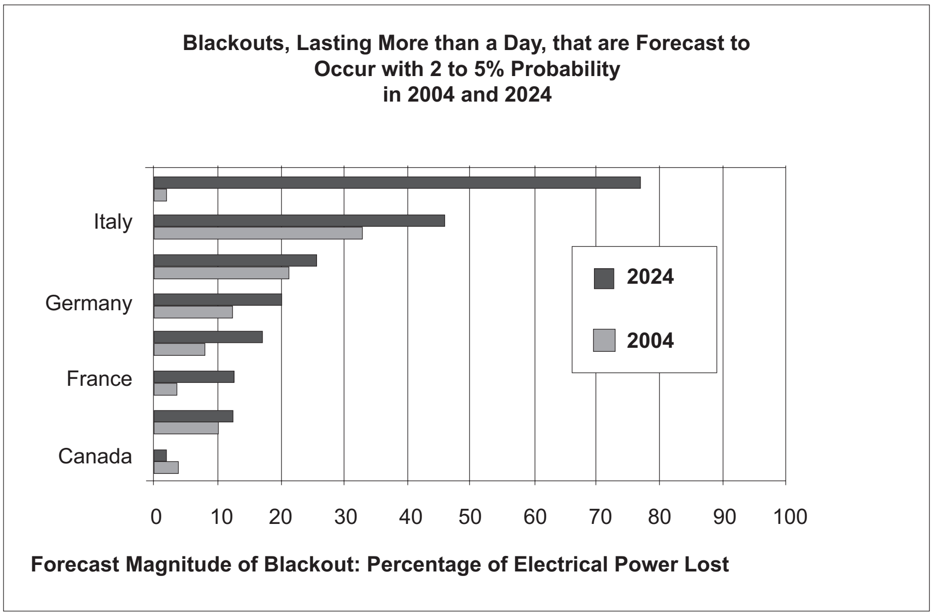
I have amassed and analysed similar data for:

— All of the G8 countries and

— All of the fuels that they import, and that they will import, for the purposes of generating electricity.

Figure 8 then shows the magnitude of the Blackouts that are forecast to occur in each of the G8 countries, with a Probability of between 2% and 5% in 2004 and 2024.

Figure 8: Blackouts, Lasting more than a Day, that are forecast to occur with 2% to 5% Probability in 2004 and 2024



By comparing the blackouts that have occurred historically in the UK with the Gross Domestic Product I have found that there is a one-for-one correlation: a prolonged blackout that led to a loss of 5% in the UK's electrical supply also caused a 5% loss of GDP.

Use of Security of Supply Certificates

We cannot tolerate the situation portrayed in Figure 8.

It implies a loss of security of electricity supplies so great that the UK's economy would never regain its place in the world. What can be done about this?

One solution, which I put forward to exemplify a suitable course of action, is to introduce Security of Supply Obligation Certificates, SOSOC's. The would operate in the same manner as Renewables Obligation Certificates, ROC's. Figure 1 shows first estimates of the effect of SOSOC's upon the mixture of different sources of electricity that would be used in the UK in 2020.
The amount of gas imported from Russia and other countries outside the EU would fall and the amount of nuclear power and renewable power would increase to make up for this.

Figure 1: First Estimates of the Potential Effect of Security of Supply Obligation Certificates on Sources of UK Electricity in 2020.

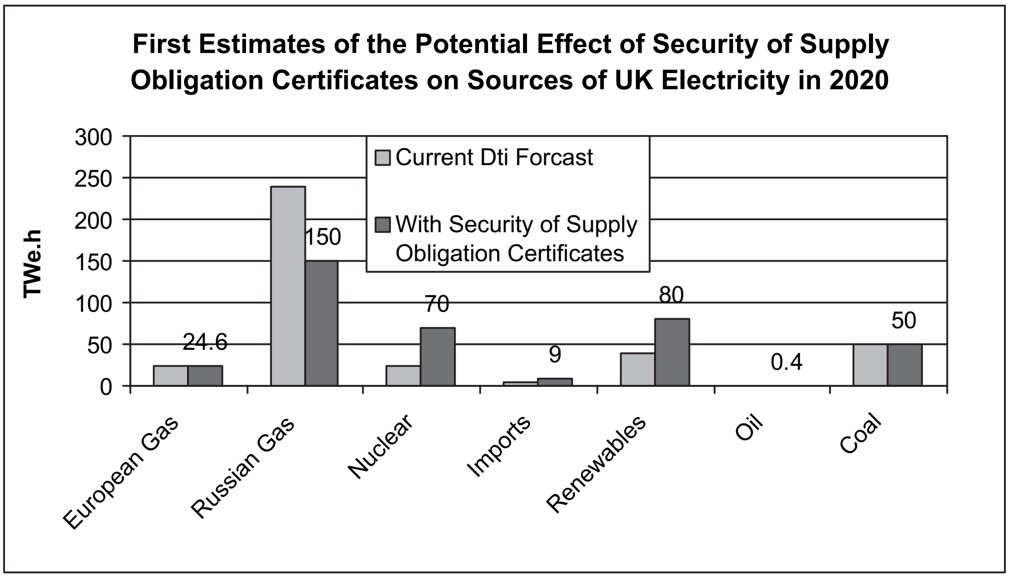


Figure 2: Initial Computation: Blackouts Lasting More than a Day, forecast to occur with 2% to 5% Probability in 2005 and 2025.

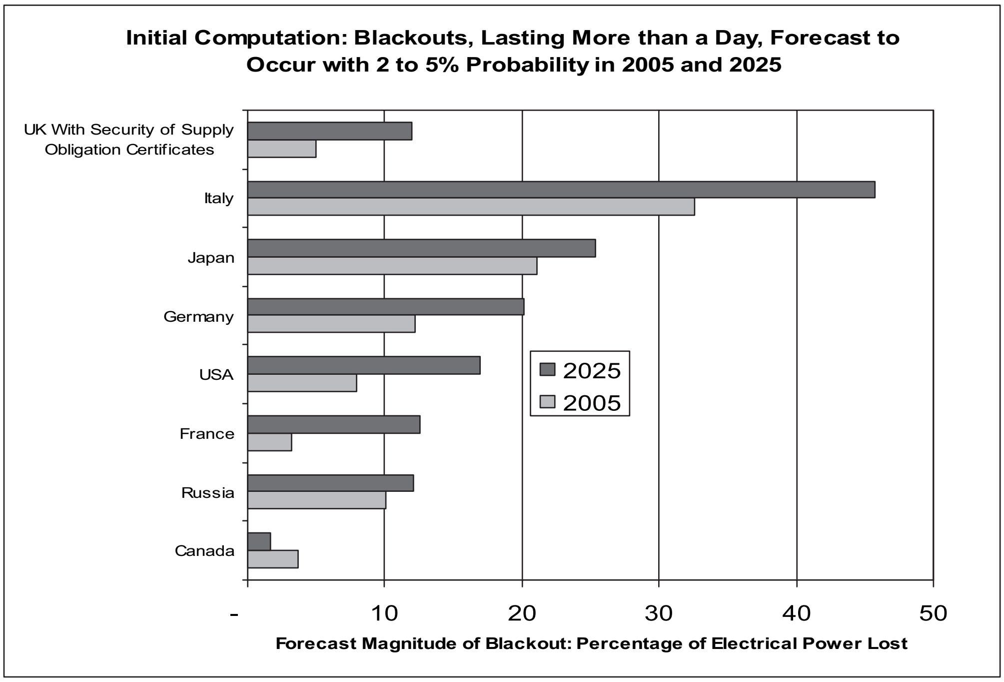


Figure 2 shows that the increase in nuclear and renewable generation, instigated by the use of SOSOC's, is forecast to remedy the lack of security of supply that would otherwise prevail in the UK in 20 years' time. Now the Security of the UK's electricity supplies is third or fourth highest in the G8 countries in 2025, instead of falling to last place.

Conclusions

1. The reliability of fuel supplies for electricity generation in G8 countries has been calculated for 2004 to 2024 using data bases for Business Risk and Political Risk Insurance Premiums.

2. The forecasts agree numerically with historic data for the reliability of oil supplies.

3. It is forecast that the likelihood of fuel shortages leading to major electricity blackouts is currently least for the UK, compared with the other seven G8 nations.

4. This is because the UK is currently completely self-sufficient in fuels.

5. However by 2025 the situation is reversed, and the UK is more likely to suffer major blackouts than any other G8 nation.

6. This is because the UK will, by then, be amongst the least self sufficient in fuels.

7. Historically, the UK's Gross Domestic Product has been reduced by an amount equal to the magnitude of each of the major, politically-inspired blackouts that have occurred. The same thing has happened in Japan and other countries.

8. The magnitudes of the Blackouts forecast to occur when the UK is reliant on imported fuels are much greater than those that have occurred in the past.

9. Such blackouts would, on past experience, lead to such large losses of GDP that the UK could not reasonably be expected subsequently to recover its position in the Global economy.

10. If instead of importing so much gas from outside the EU, the UK builds nuclear power stations to replace the present ones, which are near the end of life and makes more use of the renewables then the Security of Supply can be preserved. One way of doing this, without Government Subsidies, would be to introduce Security of Supply Obligation Certificates, SOSOC's, similar in principle to the present Renewable Obligations Certificates, ROC's.

25 August 2005

Memorandum submitted by the Green Party of England and Wales

Introduction

Perhaps a better title for this Inquiry might have been "Learning to turn the lights off when they're not needed". This may seen trivial, but behind the comment lays the serious point that a major culture change is needed, that continuing wasteful energy use is unsustainable, and that energy reduction and efficiencies have a vitally important part to play in reducing carbon emissions and combating global warming.

This memorandum is in three parts. Part One is a general overview with key material considerations for the committee's consideration. Part Two directs itself toward the Inquiry issues, whilst Part Three contains reports, public-domain source material and notes.

This submission argues that now is the time to recognise both the challenges of global warming and the dangers inherent in the UK's continuing reliance on oil, the supply of which is vulnerable in political and military terms. Now is the time for an environmental leadership that sees these circumstances as an opportunity for a sea change to sustainable, local and renewable low carbon energy systems that do not leave a hazardous nuclear legacy for future generations.

Fossil fuels are not the only thing in finite supply. So is cash. The astronomical costs of a new nuclear power programme would divert money away from creating a low-carbon economy, the real solution to global warming.

Part One—Overview

Economic concerns

1.1 Nuclear power is expensive in comparison to other forms of generation, once the state subsidies have been removed.

1.2 The construction, reprocessing and decommissioning costs of nuclear power stations are enormous. The same resources invested in renewable energy generation will generate equivalent power without creating nuclear waste that no one knows how to dispose of.

1.3 The AP1000 reactor has never been built; no first-hand operating experience exists. This would inevitably lead to unforeseen and unquantified "learning-costs".

1.4 There are historic construction cost overruns in previous nuclear power station projects.

1.5 The extended design and build phase means that new power stations would not be operational for 10–15 years from commissioning.

1.6 The high risk of nuclear power generation is evidenced by no commercial insurer being able to provide affordable cover, leading to government needing to underwrite power stations.

1.7 The government subsidises nuclear power creating a false competitive advantage at the expense of alternative methods of generation.

Power demand and handling

1.8 Greater emphasis needs to be placed on reducing demand for power. Projected energy growth assumptions of 3% per annum would mean a doubling of production and consumption every 25 years. This is not sustainable, either in terms of resource use or climate change.

1.9 In considering new reactors serious note should be taken of the power losses during transmission. Far better to have smaller generating sources serving local communities.

Regeneration opportunities offered by renewable energy over nuclear

1.10 By focusing resources on a small number of new power stations there is a lost opportunity to invest and invigorate the renewable energy sector. Proactive government measures could attract investment and create employment in product development/manufacture/installation. Both social and employment regeneration as well as export market potential exists in UK.

1.11 Government should use taxation and a proactive regulatory framework to enable development and encourage business to invest in renewable energy research, development and production.

Environmental concerns

> "At least three million children in Belarus, Ukraine and the Russian Federation require physical treatment [due to the Chernobyl accident]. Not until 2016 at the earliest will we know the full number of those likely to develop serious medical conditions." Kofi Annan, UN Secretary General, July 2004.

1.12 There is no agreed, proven or demonstrably safe storage method for radioactive materials. Creation of nuclear waste bequeaths an expensive and dangerous legacy that future generations have to deal with.

1.13 Nuclear production carries with it unacceptable accident risk. Chernobyl, Three Mile Island, Thorp and Drigg have all been sites of accidents and/or leakage.

1.14 Many UK nuclear power stations are sited in coastal areas, some in acknowledged high flood risk areas. As global warming takes effect, coastal power stations become more vulnerable.

1.15 Commissioning, operation and decommissioning of nuclear power stations carries inherent long term environmental risks and major expense. Set against renewable power generation the nuclear option equals high capital costs and major long term irreversible impacts, versus low impact sustainable regeneration, the effects of which are reversible.

1.16 Identifying sites and securing planning permission for new nuclear power stations will be politically damaging and difficult.

1.17 There are finite reserves of uranium.

1.18 Electricity produced by nuclear power is not carbon free.

1.19 In using renewables we're living off income, not capital.

Health

1.20 Routine discharges from nuclear power stations carry adverse health impacts, as well evidenced by cancer and leukaemia clusters around reactors. (see note 1). Additionally there are major health risks from accidents and spillage.

Security

1.21 Expansion of "breeder" technology would create large amounts of plutonium that can be used in nuclear weapons. With increased quantities of plutonium, there is an increased risk of nuclear weapon proliferation.

1.22 Nuclear power stations, and the transit and storage of nuclear materials are a target for terrorist attack.

1.23 In the medium term, the effects of Peak Oil and Peak Gas will serve to increase energy prices. This will increase the potential for political, commercial and possible military conflicts over the control of those resources and means of distribution. By remaining largely reliant on foreign fossil fuels, over the supply of which we have no direct control, the UK runs the risk of becoming a "hostage to fortune". A prudent government would move to identify and develop local energy supplies under UK ownership and control.

Part Two—Inquiry Issues

A. The Extent of the "Generation Gap"

2.1 (Inquiry question 1) *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

Electricity demand is increasing by 1% per annum on average (700 MW per annum). When all 12 UK nuclear stations close down, 12,000 MW of generation out of 74,000 MW will be lost. In the next 10 years, 19,000 MW will have to be found at current consumption projections, or 12,000 MW if electricity demand can be kept flat.

However in fixing estimates of demand, insufficient account is taken of the effect of rising fossil fuel costs, including "Peak Oil/Gas" effects. Additionally as the resultant electricity prices rise and with the increasing needs to reduce carbon emissions, there will be added incentives for low carbon energy generation. An important part of national strategy must concentrate on demand management and reduction. The regulatory framework should be employed to require and enable energy efficiency measures, rather than for government to merely champion them.

The Performance & Innovation Unit (PIU) (later renamed the Cabinet Office Strategy Unit) report for the 2001 energy review (see note 2) confirmed that energy efficiency measures have either negative or low costs because of significant resource savings.

B. Financial Costs and Investment Consideration

2.2 (Inquiry question 2) *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

A construction programme of eight AP1000 stations would be in the order of £8 billion, and each one would produce 1,100 MW. An additional £300 million per year is required for fuel re-processing costs, and decommissioning could well top £100 billion.

By comparison the latest solar thermal or micro wind turbine installations cost in the region of £2,000 with each one generating a (conservative) 1kW. To match the 8,000 MW anticipated power output of eight AP1000 reactors, fitting either of the two renewable options to 8.8m UK homes would cost £17.6 billion (if economies of scale are totally ignored).

That would be the same level of power generation with no fuel re-processing required and no nuclear decommissioning required.

It is as economically plausible to give away, at the taxpayer's expense, a renewable energy installation to half the homes in the country, and let them keep the free electricity, as it is to build nuclear power stations to a new design that has never been tested in production. It is probably more popular as well.

The bottom line of all this is that even setting aside its accident risks, proliferation dangers and waste problems, nuclear power is just plain too expensive and in all likelihood always will be.

"Because it's so expensive, investing in nuclear power makes climate change worse, and because capital is finite; sinking it into an expensive solution means it's not available for cheaper ones. In the United States, each dollar invested in electric efficiency displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power—without any nasty side effects".

(*Source:* Rocky Mountain Institute—see note 3).

2.3 (Inquiry question 2—Bullet 1) *What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?*

Construction and on-going operating costs of different large-scale technologies should not be the only major considerations. Regeneration, export and employment potentials exist through developing and operating renewable energy systems. On the negative side the long lasting risk and expense of nuclear waste storage together with the risk of terrorism, weapons proliferation or accident are difficult to quantify in purely economic terms.

Comparative costs and timescales

	Construction £/kW	*Estimated p/kWh*	*Timescale*
Nuclear new build	500–3,000 PSIRU	3.4–8.3 NEF	10–15 years
CCGT	280	2.3 PSIRU	1–2 years
On shore wind	650–850 BWEA	1.5–2.5 NEF	6–12 months
Off shore wind	1,000–1,200 BWEA	3–4 NEF	6–12 months

PSIRU—Public Services International Research Unit
BWEA—British Wind Energy Association
NEF—New Economics Foundation

The conclusion that may be drawn from looking at these comparative costs is that wind turbines, both on and off shore offer economic savings within a short timescale. CCGT produces an economically viable supply, and can be regarded as a lower carbon emitter but still depends on finite resource raw materials, and therefore subject to supply and price uncertainties. CCGT would be an acceptable short-term measure, certainly in comparison to new nuclear generation.

An additional attraction of developing wind turbine generation is UK experience in offshore engineering. Added to new employment and social regeneration an expansion of this sector would bring, there is a thriving potential to export technology and expertise.

2.4 (Inquiry question 2—Bullet 2) *With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?*

According to the PIU report, (see note 2) the final cost of Sizewell B power station was twice the original budget. Such cost overruns are not unusual, as estimates for other projects have proved to be notoriously inaccurate. Construction costs are crucial in determining the final cost of generated power because capital repayments have to be factored in as an operating expense.

An additional important factor to consider is that an AP1000 reactor has never been built, and the estimated construction and operating costs are not robust, in the view of the Public Services Institute Research Unit report. (See note 4)

Currently The Vienna Treaty 1963 (amended 1997) imposes a limit on nuclear operators' liabilities and in the UK, the Energy Act 1983 set a limit of liability for particular installations. In 1994 this limit was increased to £140 million for each major installation, so that the operator is liable for claims up to this amount and must insure accordingly. UK government underwrites risks in excess of £140 million.

Considering the Chernobyl disaster, where the costs may be in the order of hundreds of £ billion, conventional cover would probably not be available, and where it was offered may not be credible as a major accident would bankrupt the insurance companies.

There is much uncertainty about the true cost of decommissioning and the treatment of waste. In fact, regarding the storage, handling and disposal of waste the only apparent certainty is that there is no agreement whatever on identifying safe solutions.

Another certainty is that it will ultimately be government that has to step in to safeguard communities in the event of the commercial failure or underprovision in funding for decommissioning or waste handling. The question of waste and decommissioning funding is too important to be left to the vagaries of politics and the market. As an example the government subsidy 1990–96 described by Michael Heseltine as "to decommission old, unsafe nuclear plants" was in fact spent as cashflow by the company owning the generating plant.

Considering the serious risks and uncertainties that surround nuclear power, there is an overwhelming case against a new nuclear programme.

2.5 (Inquiry question 2—Bullet 3) *Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?*

At this time annual electricity generation from onshore wind power is 1,100 MW, with 300 MW being added during the last year under the current minimal government intervention programme. According to the British Wind Energy Association, (See note 5) offshore wind has huge generating capacity potential; they state that wind power has the potential to generate 590,000 MW, or eight times the UKs electricity needs.

Taken with the generative potential of micro-wind generation, domestic solar heating, domestic PV electricity, low carbon local CHP generators etc, there is no doubt that renewables can deliver the scale of generation required.

Realising this renewable energy supply will require political will and a supportive regulatory framework. Tax incentives can be used to create and stimulate investment opportunities, which will lead to increased employment. Embedding renewable energy generation requirements in Planning Policy Guidelines and development control protocols will help deliver the required "culture change" in the business sector and at the public level.

2.6 (Inquiry question 2—Bullet 4) *What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?*

A major relative efficiency of micro-generation over grid-supplied power is a saving on distribution losses. Grid distribution loses electricity as heat, noise, or as theft on distribution networks as it is transported through the grid. In UK this accounts for approximately 6.5% of electricity (valued at around £900 million). (see note 6)

Mention is made of the intermittent nature of some renewable energy generators, and the PIU report (see note 2) considered this. It concluded "the design and operation of the electricity network can be modified to accommodate increasing levels of intermittent power". There is no inherent obstacle to variable output generators, but there are two significant components that have to be addressed as renewable outputs increase—the ability of the system to balance variable supply and demand, and the allocation of costs to achieve the equivalence of "firm" power.

With an evaluation of how our energy needs are to be met, and bearing in mind the strictures imposed by the need to reduce carbon emissions there is an opportunity to move toward a more flexible, decentralised model of energy generation, as envisaged by the Energy White Paper (note 7).

There is little consensus on the costs of new nuclear power with estimates of between 1-6p/kWh.

Best estimates in the Green Alliance (note 8) report put costs for renewables at 4.6-7p/kWh for micro wind.

For Solar PV, the PIU forecast a sustained cost reduction from the present high of 70p/kWh to 10-16p kWh within a twenty-year time frame.

Micro CHP (mCHP) boilers can be installed in homes instead of conventional boilers. They cost about £500 more than a standard boiler and provide electricity as well as heat. The PIU report estimates mCHP costs at 3.5p/kWh, perhaps falling to 2.5p/kWh as the market grows. Although gas fired, and therefore not renewable, they can be regarded as low carbon in view of their efficiency. Every year 1.3 million boilers are replaced—if at least some of these could be mCHP there would be a steady decrease in grid power requirement and carbon emissions.

An Alternative Scenario for Energy Creation

Taken that 8 AP100 reactors would cost £8.8 billion plus fuel processing costs of £300 million per annum and generate 8,800 MW, an alternative scenario could be;

mCHP—If half the 1.3 million boilers replaced annually (650,000 units) were mCHP there would be a cost of £325 million, or £6.5 billion for 13 million units over 20 years. Assuming a capacity of 1kW per unit this results in 13GW capacity (ie 13,000Mw).

Solar PV—A £3 billion investment at £6,000 per kW capacity would yield a further 500 MW. In practice solar PV operates at a fraction of this capacity.

Micro wind—£3.25 billion invested in 2.17 million micro wind turbines would provide over 2GW capacity. Although as for solar PV, micro wind operates at a fraction of this capacity.

It can be demonstrated therefore that an investment of £12.75 billion over 20 years could yield up to 15.5GW of renewable energy, compared to an £8.8 billion construction cost plus £6.4 billion fuel processing charges totalling £15.2 billion producing 8.8GW of nuclear power.

2.7 (Inquiry question 3) *What is the attitude of financial institutions to investment in different forms of generation?*

No Response

2.8 (Inquiry question 3—Bullet 1) *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?*

Financial institutions are risk averse, and unlikely to offer significant investment without comprehensive underwriting and indemnities from government, particularly relating to issues around waste and accidents. Where the regulatory framework leads, the market will follow. An example of this is the way in which the CCGT sector has improved after government signposted it offered the prospects of an improved rate of return on investment.

2.9 (Inquiry question 3—Bullet 2) *How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

NO RESPONSE

2.10 (Inquiry question 3—Bullet 3) *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

The astronomical costs of a new nuclear power programme would divert money away from the real, long-term solutions to global warming. Conservation measures are far more efficient on a monetary basis than nuclear power investment. Renewable energy sources can be exploited—wind, tides, geothermal heat and solar influx will not run out, unlike uranium.

If government directs investment toward the nuclear industry, the willingness of the private sector to invest in efficiency or renewables will be diminished. Investment (or government subsidy) in nuclear power will distort the energy market by artificially depressing electricity prices whilst increasing the financial burden on the taxpayer.

C. Strategic Benefits

2.11 (Inquiry question 4) *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

Any attempts to justify a new build programme will ultimately fail, both in terms of short-term energy security or longer-term strategic objectives.

2.12 (Inquiry question 4—Bullet 1) *To what extent and over what timeframe would nuclear new build reduce carbon emissions?*

Contrary to popular belief, electricity produced by nuclear power is not CO_2 free. Construction of the station itself would be a major carbon emitter and to keep it running requires the burning of fossil fuels in mining and refining the ore, with extra emissions from operating the station, and reprocessing and storage activities.

Carbon emissions from mining and refining will increase as the uranium ore quality diminishes. A report by Jan-Willem Storm van Leeuwen and Philip Smith (see note 9) concludes "The use of nuclear power causes, at the end of the road and under the most favourable conditions, approximately one-third as much CO_2-emission as gas-fired electricity production. The rich uranium ores required to achieve this reduction are however so limited that if the entire present world electricity demand were to be provided by nuclear power, these ores would be exhausted within three years. Use of the remaining poorer ores in nuclear reactors would produce more CO_2 emission than burning fossil fuels directly."

2.13 (Inquiry question 4—Bullet 2) *To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?*

Amongst the main considerations in fuel security is the sensitivity and potential vulnerability of existing oil and gas supplies to the UK. To enhance and protect national security, we need to reduce our dependence on finite resources and foreign resources.

Further we need to commit to transferring clean technology to developing countries free of charge. By doing so we will play an important part in shifting the global economy toward low-carbon power generation.

2.14 (Inquiry question 4—Bullet 3) *Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?*

UK security should be based on securing continuing, stable and sustainable local energy supplies. In striving to achieve this, priority should be given to ensuring the methods of generation which are as benign as possible. Further, those measures should not create or increase vulnerability to terrorist attack.

Since conventional nuclear fission can make only a short lived and minor contribution to world energy supply, advocates of nuclear energy look to "breeder" technology as the solution. Some of the vast amounts of plutonium—the material for nuclear weapons—that would be created in a breeder programme would inevitably leak into the hands of terrorists. In a plutonium breeder economy, the hope of curtailing the proliferation of nuclear weapons would be gone forever.

2.15 (Inquiry question 5) *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

Government endorsement and investment in a nuclear new build programme will undermine progress in developing the renewable energy sector. As such, a decision to endorse the nuclear option would be contrary to the aspirations and vision of the Energy White Paper.

Extracts of the White Paper's vision for the energy system of 2020 include:

- That the backbone of the electricity system will still be a market-based grid, balancing the supply of large power stations. But some of those large power stations will be offshore marine plants, including wave, tidal and windfarms. Generally smaller onshore windfarms will also be generating. The market will need to be able to handle intermittent generation by using backup capacity when weather conditions reduce or cut off these sources.
- There will be much more local generation, in part from medium to small local/community power plants, fuelled by locally grown biomass, from locally generated waste, from local wind sources, or possibly from local wave and tidal generators. These will feed local distributed networks, which can sell excess capacity into the grid. Plant will also increasingly generate heat for local use.

— There will be much more micro-generation, for example from CHP plant, fuel cells in buildings, or photovoltaics. This will also generate excess capacity from time to time, which will be sold back into the local distributed network.

— Energy efficiency improvements will reduce demand overall, despite new demand for electricity, for example as homes move to digital television and as computers further penetrate the domestic market. Air conditioning may become more widespread.

— New homes will be designed to need very little energy and will perhaps even achieve zero carbon emissions . The existing building stock will increasingly adopt energy efficiency measures. Many buildings will have the capacity at least to reduce their demand on the grid, for example by using solar heating systems to provide some of their water heating needs, if not to generate electricity to sell back into the local network.

— Gas will form a large part of the energy mix as the savings from more efficient boiler technologies are offset by demand for gas for CHP (which in turn displaces electricity demand).

— Coal fired generation will either play a smaller part than today in the energy mix or be linked to CO_2 capture and storage (if that proves technically, environmentally and economically feasible).

— The existing fleet of nuclear power stations will almost all have reached the end of their working lives. If new nuclear power plant is needed to help meet the UKs carbon aims, this will be subject to later decision.

— Fuel cells will be playing a greater part in the economy, initially in static form in industry or as a means of storing energy, for example to back up intermittent renewables, but increasingly in transport. The hydrogen will be generated primarily by non-carbon electricity.

— In transport, hybrid (internal combustion) vehicles will be commonplace in the car and light goods sectors, delivering significant efficiency savings. There will be substantial and increasing use of low carbon biofuels. Hydrogen will be increasingly fuelling the public service vehicle fleet (for example buses) and utility vehicles. It could also be breaking into the car market.

— Nuclear fusion will be at an advanced stage of research and development.

— People generally will be much more aware of the challenge of climate change and of the part they can play in reducing carbon emissions. Carbon content will increasingly become a commercial differentiator as the cost of carbon is reflected in prices and people choose lower carbon options.

This vision of energy in 2020 paints a picture of a range of diverse options for generation. We would argue that in this diversity lies security.

Further it should be noted that currently research is being conducted by Southampton University to investigate the feasibility of "microgrids" (a collection of small generators for close proximity users) to provide peer-to-peer energy. The lead researcher, Dr Tom Markvart concludes that microgrids could make substantial efficiency savings and cuts to carbon emissions of 20–30% without major changes to lifestyles. (see note 10)

D. Other Issues

2.16 (Inquiry question 6) *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

Nuclear power is responsible for considerable carbon emissions from every stage of its production, apart from fission itself. Carbon emissions from construction will be on a par with other major projects, and there will be an increasing amount of carbon emitted in mining the necessary raw materials.

This is because nuclear power depends on a supply of uranium ores from scarce, rich deposits, which face a depletion problem every bit as serious as that of oil and gas. That rich ore will soon no longer be available. The poorer grades of ore that would then have to be used take more energy to process than they yield.

As uranium-rich ores reduce (see note 10), extractors will have to use raw materials with lower uranium content and be reduced to milling soft ores (sandstone) with a uranium oxide content of just 0.01% —10,000 tonnes of ore to be mined, milled and disposed of for every tonne of uranium oxide extracted. It is with ores at these grades that nuclear power hits its limits; this is where the energy balance turns against it. Therefore carbon emissions will increase (by virtue of the fossil fuel energy required for extraction) as uranium richness decreases. If ores any poorer than this were to be used, while at the same time maintaining proper standards of waste control in all operations, nuclear power production would go into energy deficit: it would be putting more energy into the process than it could extract from it.

2.17 (Inquiry question 7) *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

Yes. The amount of radioactive waste currently in the UK is enough to fill one of the Great Pyramids at Giza in Egypt—2.3 million cubic metres (see note 11). A new generation of power stations as being envisaged will double the amount of waste. No publicly acceptable way of dealing with this waste has been found as yet, and it would be an act of gross irresponsibility to proceed with a new programme in the anticipation that an acceptable storage method will be developed at some point in the future.

PART THREE—NOTES AND SUPPORTING INFORMATION

Notes

1. The Low Level Radiation Campaign http://www.llrc.org/index.html

2. Performance and Innovation Unit (Cabinet Office Strategy Unit) http://strategy.go.v.uk/2002/energy/workingpapers.shtml

3. Rocky Mountain Institute http://www.rmi.org/sitepages/pid642.php

4. Public Services International Research Unit www.psiru.org

5. British Wind Energy Association http://www.bwea.com/

6. Offgem http://www.ofgem.gov.uk/ofgem/microsites/microtemplate1.jsp?toplevel = /microsites/edist00&assortment = /microsites/edist00/edist08

7. The Energy White Paper http://www.dti.gov.uk/energy/whitepaper/wp—text.pdf

8. Green Alliance http://www.green-alliance.org.uk/publications/PubSmallOrAtomic/

9. Jan-Willem Storm van Leeuwen and Philip Smith report http://www.oprit.rug.nl/deenen/

9. World Nuclear Association http://www.world-nuclear.org/info/inf11.htm

10. Royal Academy of Engineering's Ingenia magazine http://news.bbc.co.uk/1/hi/sci/tech/4245584.stm

11. 2001 National Inventory—Nirex Report N3/99/01.

Supporting information

1. World Nuclear Industry Status Report 2004 (M Schneider and A Frogatt. Commissioned by the European Parliament's Greens EFA Group) http://www.greens-efa.org/pdf/documents/greensefa—documents—106—en.pdf

Plus public-domain reports

2. The Economics of nuclear power: an analysis of recent studies (S Thomas. Public Services International Research Unit) www.psiru.org

3. Nuclear Power: Economics and climate-protection potential (A Lovins. Rocky Mountain Institute) www.rmi.org/sitepages/pid171.php@EO5-08

4. Is nuclear energy needed? (Green Alliance briefing) http://www.green-alliance.org.uk/publications/PubIsNuclearEnergyNeeded/

5. Small or Atomic? Comparing the finances of nuclear and micro-generated energy (R Willis. Green Alliance briefing) http://www.green-alliance.org.uk/publications/PubSmallOrAtomic/

6. Green Party's Alternative Energy Review (D Toke & D Olivier. Green Party of England & Wales) http://www.greenparty.org.uk/files/reports/2003/aer—2003.pdf

27 September 2005

Memorandum submitted by Greenpeace

Greenpeace thanks the Environmental Audit Committee (EAC) for this opportunity to submit its views to this timely inquiry examining the options for investment in meeting the nation's future electricity needs. It welcomes the attention of the EAC on the area of electricity within the broader energy debate.

However, Greenpeace notes that the EAC's terms of reference (TOR) for this inquiry, while rightly seeking to explore the options for investment in meeting future electricity capacity requirements, restricts its attention to the relative costs and likely contribution of predominantly large scale generating technologies.

Greenpeace believes the Committee needs to recognise the critical role of delivery infrastructure options in electricity generation and how network considerations transform the economics of renewables (and cogeneration). The Committee's focus should therefore not be only on electricity generation options but on the energy system model required to support low-carbon technologies in order to meet the challenges of the 21st century.

It is Greenpeace's view that an analysis of the relative merits and disadvantages of technologies will only be useful if the centralised energy system within which they will operate is also brought in to the inquiry.

We therefore urge the Committee to apply great caution in its examination of the costs of technology options that will be submitted to the inquiry. Many cost analyses take the centralised delivery infrastructure as a given and therefore do not include the extremely high costs of centralised infrastructure. A whole-system approach to costs is needed which includes the costs of delivery infrastructure options and, indeed, energy efficiency. What matters ultimately to consumers is their energy bill. The committee therefore needs to examine not only generation costs, but delivery infrastructure costs and the negative costs of demand reduction.

We have sought to briefly answer your questions as set out in the inquiry, but hope you will accept our position that these are not the right questions that need to be asked at this stage. While Greenpeace's submission explains why the continued pursuit of nuclear power as a proposed option in reducing CO_2 emissions and in helping to achieve security of supply would be a costly, dangerous and unpopular endeavour, it also explains how nuclear power does not have a place in a demonstrably workable decentralised energy solution—available today using tried and tested technologies

The other stated objective of the inquiry is to consider to what extent investment in the various technology options will help deliver two key objectives set in the Government's Energy White Paper: to promote a step change in renewable energy deployment and energy efficiency savings.

Again, while Greenpeace accepts that in the interim pursuing a large scale programme of investing in renewable energy is important, in the longer term the objective of a secure and environmentally sound electricity supply can only be met through a radical overhaul of the entire electricity system, where perverse market rules an economic drivers currently govern the networks, favouring grid expansion and centralised fossil fuel technologies. This can not be done just through appraising individual technology options which produce electricity, but through looking at electricity as part of a system that combines renewable energy (both large scale, but with greater emphasis on decentralised projects) along with demand side management. It is this that will lead the UK towards a genuinely sustainable energy mix.

Investment aimed at meeting the White Paper objectives will only be successful if it is concentrated on supporting a three-pronged approach

Spearheaded by the priority implementation of a decentralised energy model and flanked by far reaching energy performance measures (energy efficiency that will deliver demand side management) and a portfolio of renewable technologies. The great beauty of this approach is that the model inherently stimulates and delivers the two flanking requirements. They are not left outside of the system core decentralised model and thus dependent on ever increasing government intervention.

Within this context, Greenpeace welcomes this opportunity to present its view of where the real solutions lie. Greenpeace would welcome the opportunity to present in person our view of a decentralised energy future to the Committee should the Committee feel that this would be helpful in informing it understanding of the issues raised in this submission.

This inquiry represents a golden opportunity for the Committtee to reframe the debate on energy. Greenpeace hopes the Committee will grasp this opportunity and make a real impact on the future of energy policy in the UK.

Part 1

Summary

1. There are significant uncertainties over construction and costs and timelines which are influenced by many variable and interdependent factors, such as the extent of government subsidies, licensing processes and planning inquiries. It is most likely a new reactor would not be operating in the UK until 2018–20—and that's if the go-ahead is given next year.

2. Even if the Government gives in-principle agreement to new build, it would not necessarily mean private investors would be willing to fund the enterprise. Uncertainty over costs is a significant factor in private sector reluctance to invest in new build. It is highly unlikely that the financial sector would provide capital for new build unless construction costs and liabilities are extensively underwritten by the firm guarantees of public finance. Government subsidies of the order needed to kick start new build, and provide for liabilities, would not be compatible with liberalised energy markets. Moves by the Government to finance new build would be challenged under European Competition law.

3. The amount of time taken to build reactors impacts on the time it takes to realise a return on capital. Companies will put investor and shareholder expectations on returns and dividends before properly financing segregated funds for liabilities.

4. Due to the lack of legally binding requirements for segregated funds there is absolutely no obligation on the industry to adequately invest in ring-fenced funds for waste and decommissioning costs for nuclear new build—unless segregated funds are made a legal requirement. Because of this, the risk to the public purse of having to bailout future private nuclear operators for liabilities is significant.

5. The amount of Government financial support that would be required to facilitate private sector investment in nuclear new build would be massive. It would be a major gamble with public money on a large, centralised energy system which may not provide returns on the investment—and which could rapidly become a liability through accidents or technical failures.

6. Nuclear programmes take a huge amount of money and resources. There is only so much money the Government has to spend and if it opts for new build it is likely, based on past experience, that cleaner, safer energy systems will lose out. There are however significant risks that a series of ten reactors, of an untried and untested design, will not work to expectations. That would mean many years of opportunity to implement workable and clean renewable technologies and energy savings measures instead of nuclear power would be lost. Greenpeace believes that investing a nuclear programme which has many risks attached to it would actually undermine security of supply—not enhance it.

7. Estimates for new build, drawn from actual costs of past reactor projects indicate prices will be far higher than the industry's figures for new reactors. The costs for waste (including decommissioning, clean-up, storage and disposal) for new build are not quantifiable. Estimates remain estimates.

8. Indeed, the cost for decommissioning and clean-up of existing sites is rising, with no final figure available for long term management or disposal of all wastes. New build will only exacerbate the problem of nuclear waste in the UK. The amount of the most long-lived and hazardous nuclear material produced by nuclear reactors, spent nuclear fuel, will increase 400% under a new build programme.

9. Insurance back-up by the Government is also "unquantifiable". Financial compensation arrangements following a major accident or terrorist attack on a nuclear installation would have to stretch decades into the future and no reasonable estimates can be given for the financial costs of such an eventuality. Little is known about the full scope of security measures and cost associated with the nuclear industry.

10. A new build programme in the UK, if in place between 2020–30, would only offset CO_2 emissions by about 4–5% (based on an estimate of the energy mix at the time). A new build programme is not a timely response to the immediate need to act on implementing the energy systems required to reduce CO_2 emissions well before a new build programme would "take effect" ie 2025–30. Unless there is a huge expansion in nuclear power, it will have little or no impact on the Government's targets for CO_2 reductions beyond 2020.

11. Embarking on a new build programme in the UK would send a signal across the globe that nuclear power is an appropriate response to tackling climate change. Yet the majority of materials and technology used in nuclear power programmes are dual-use—that is they can be used in civil and military programmes. Quite simply, spreading nuclear power spreads the wherewithal for nuclear weapons proliferation.

12. A global increase in the use of weapons usable nuclear materials would serve to further increase the chances of these materials falling into the hands of terrorists. More nuclear reactors here and the attendant spent fuel stores, means more terrorist targets—which could, over time, increase the likelihood of a successful attack on such an installation.

13. Nuclear power is not a major source of CO_2 emissions, but the nuclear fuel chain does give rise to CO_2 emissions. Studies have shown that overall the use of nuclear power produces more CO_2 emissions than renewable energy sources such as wind. The CO_2 emissions associated with nuclear power will increase as companies are forced to use lower grade uranium ores as more accessible, higher-grade uranium reserves are used up.

14. Nuclear new build is conditional on the development of acceptable solutions to the problems of managing nuclear waste. Greenpeace believes there is no "solution" to the nuclear waste problem—only "least worst" options. The public will be even more determined in its opposition to new build once it realises the extent of the additional nuclear wastes which will be produced by this form of electricity generation.

Recommendation

15. For all of these reasons, Greenpeace asks that the Committee recommend against any new build programme.

Construction Costs, Operating Costs and Timelines

TOR 2.1

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?[76]

Construction costs—not a stand alone matter

> "The key issue with new nuclear's valuation: It depends on many (and fairly volatile) assumptions. Building a new nuclear plant is largely a 60-year bet on interest rates—think of a number . . ."
>
> UBS Investment Research:—Q-Series, The Future of Nuclear, March 2005

16. There are complex links between the construction costs and the time it takes to build a reactor, licensing arrangements, security and terrorism, the politics of waste disposal, the willingness of Government to subsidise or support front or back end costs and the willingness—or otherwise—of financial institutions or utilities to support new build.

17. Pay-back time on capital and the size of dividends have to be set against the need to ensure that sufficient liability funds are set aside—and at the right time—to safeguard against the taxpayer having to fund liabilities.

18. In determining costs it is not possible to separate out the industry's hopes regarding Government assistance (eg low interest loans) and come up with purely theoretical costs as these issues are so interdependent.

19. At present there is very much a stand off situation, where the Government has indicated it is not willing to move new build forward unless the industry, financial institutions and utilities express a real interest in new reactors. Government, investors and industry are all cautious because of the level of public opposition to new build and/or waste disposal plans (see page 38–41 for discussion on the publics' views on new build and nuclear waste).

20. Because of the linkages outlined above, Greenpeace cannot respond to the Terms of Reference in the order as set out by the Committee but will instead respond in the order which best explains the issues from the organisation's perspective.

Problems with establishing construction costs for new nuclear power stations: The AP1000—an example

21. A number of the reactor designs proposed for new build programmes have not yet been built. In the main they are modified designs of existing reactor types and some have had significant design modifications made primarily for cost savings. The Westinghouse AP 1000 began life as the AP 600 (a 600MW reactor as opposed to the 1000MW–1GW—that is now being proposed).

22. However, after getting a licence agreement to build the AP 600 Westinghouse found that utilities were not interested, primarily because of the cost. Therefore, Westinghouse increased the power output by 80% with apparently only a 20% increase in construction costs. As both designs only exist on paper the economics are purely theoretical.

23. Any reactor proposed design will also have to undergo licensing to allow it to be built and operated in the UK (see pages 10–12 for discussion on licensing issues).

24. Because industry costings are theoretical, it is not possible to provide firm figures for construction, operation and decommissioning costs for the reactors "on offer".

25. Some figures for construction alone are in the public domain. Reports have given costs of US$2.2–2.7 billion for two reactors of 1GW,[77] with others quoting Westinghouse as having given a figure of US$1.5 billion per 1GW reactor.[78] This would mean construction costs at approximately £0.6 billion–£0.8 billion per reactor. More recently, in comments made during a presentation to the International Nuclear Congress this year, BNFL's Richard Mayson said a 1GW AP1000 reactor would cost £1.3 billion[79] but with reductions over a series of reactors.

26. The US Congressional Budget Office (CBO) has said it believes the industry's projected costs for reactors of approximately 1GW, to be overly optimistic and estimates that construction costs would most likely be much higher than industry estimates at between US$2.1 billion-$3 billion (£1.16 billion–£1.66

76 Greenpeace will respond on the issues concerning non-nuclear energy and energy demand in a separate section of this submission.

77 *Westinghouse expects to receive NRC certification for its AP1000* Platts Nuclear News Flashes 3 September 2004. It is assumed these are purely construction costs.

78 The International Herald Tribune, (2 September 2004) *"China looks abroad for nuclear help"*.

79 *Fuel for Thought* conference, British Nuclear Energy Society, Newport Wales, 6–7 July 2004

billion) each. It uses US$2.5 billion (£1.38 billion) as a working figure.[80] The CBO also says that it believes the risk of default on Government loans towards capital for these "first of a kind" reactors is so high that the US Government should not make such loans available. In its paper in June 2005, Oxera gives an estimate of £1.6 billion for the first reactor (including development costs), reducing to £1.15 billion for subsequent reactors.

27. Ten reactors: BNFL/Westinghouse claims that costs will fall over a 10 reactor programme and by the time of construction of the fifth reactor, the cost would be significantly less than for the first.[81]

28. Using the figure £1.3 billion given by BNFL, and CBO's figures (but allowing for the possible cost reductions claimed by the nuclear industry) the costs could be £9.8 billion–£12.6 billion for 10 1GW plants.[82]

29. If however there are no cost savings 10 new reactors could cost £13 billion (BNFL) or £16.7 billion (CBO's highest figure).[83] Cost reductions for programmes undertaken overseas certainly cannot be taken as a given for what might happen in the UK due to the different regulatory and inquiry processes (BNFL/Westinghouse based their costs reductions on a reactor programme in South Korea). Changes in exchanges rates markedly influence prices (as either a positive or a negative for the buyer or seller) if components are being bought from overseas.

30. It is this level of uncertainty which makes the market very wary of investing in nuclear power.

Ten plants have to be built—a massive upfront investment

31. In order to achieve lower costs across a new build programme, to get nuclear costs on a par with the costs of wind energy, a commitment would have to be given to build 10 plants. Economy of scale is absolutely essential for the industry to keep its costs low.[84]

32. A 10-reactor programme would entail a massive upfront commitment from industry, the Government/taxpayer and electricity consumers for an untried and untested reactor design. It would probably also entail having a number of sites "lined up" and ready to accept new build—delays for inquiries at each site would significantly risk increasing costs. To set up a series of sites to host the reactors would probably mean major—and unwelcome changes—to planning inquiry processes. In addition, the industry needs a workforce which is capable of building and operating 10 plants. This may not be not available over the 60 years of planned life of the reactors.

Financing New Build—Analysis of Reports

TOR 3.1

What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?[85]

> "One rule of thumb is to double the stated costs of nuclear stations to arrive at the genuine figure, and this reflects the broad experience in the UK"
>
> Simon Skilling, Head of Regulation, EON UK, June 2005, London[86]

33. There have been a number of reports concerning the financing of new nuclear reactor build in recent years as debate on new build has increased in the UK and the US.

34. All have pointed towards the same problems and risks to a greater or lesser degree that will deter investment in new nuclear: They also all conclude that some form of State support in the form of grants, loan guarantees etc would probably be required if new nuclear power plants are to be built. Other factors that could jumpstart a nuclear renaissance, by making it more financially attractive, are reducing the cost of construction and the time required, which may involve regulatory changes.

35. Some of the studies of the economics of nuclear power over the past three to four years include:

Canadian Energy Research Institute[87]

[80] Congressional Budget Office Cost Estimate 7 May 2003 s14 Energy Policy Act of 2003 as introduced on April 30, 2003. The CBO puts the cost of the first reactor at US$2.1–£3 billion. http://www.cbo.gov/showdoc.cfm?index=4206&sequence=0

[81] BNFL/Westinghouse AP1000 . . . *the reactor technology ready now.* Presented to the Energy Review in 2002.

[82] In BNFL/Westinghouse's claims the initial cost will include regulatory costs associated with licensing and associated site engineering works and financing costs. It is not clear if the costs of the subsequent reactors includes these costs. Richard Mayson did not explain exactly what costs would be included in the £1.3 billion figure, but it is assumed that licensing would be part of the cost. Based on BNFL/Westinghouse claim costs for reactors reduce to 86% for the 2nd plant, 78% for the 3rd, 77% for the 4th and 69% for the 5th–10th.

[83] Also important to note is that these figures are based on an average exchange rate of US$1.80=£1.

[84] Whilst the Committee has said "nuclear new build" is used to refer to a programme of building at least eight AP1000 reactors (or equivalent) this submission is based on a new build programme of 10 1GW plants, based on industry proposals. Others—including CoRWM in assessing the radioactive waste impact of new build—have also assumed a 10 reactor programme.

[85] Discussion on the cost of renewables and CCGT is dealt with in Part 2 of Greenpeace's submission.

[86] http://www.westminsterenergy.org/events_archive/downloads/june24/WEF_Nuclear_Investment_Policy_Issues_Exec_Summary.pdf

[87] Canadian Energy Research Institute, August 2004, *Levelised Unit Electricity Cost Comparison. Ontario.*

University of Chicago[88]

International Energy Agency/Nuclear Energy Agency[89]

Lappeenranta University of Technology[90]

OXERA[91]

MIT[92]

Performance and Innovation Unit[93]

The Royal Academy of Engineering[94]

USB[95]

36. The table summarises the major conclusions of these studies. Although there is some variation between the economic assessments of the different studies what is more notable is the difference between the paper studies and the actual data provided by the construction of Sizewell B. The actual construction costs are more than double any of the forecasts put forward in these analyses. Furthermore, the length of construction at 86 months is longer than any single figure put forward while the capacity factor of Sizewell is considerably lower than the forecasts put forward.

37. The Sizewell B figures, although far higher than recent forecasts are not an exception. Analysis of the costs of constructing the Advanced Boiling Water Reactor in Japan gives similar delays and costs over-runs. General Electric estimated that its 1300MW Advanced Boiling Water Reactor could be constructed in 48 months and at a cost of $1,528 per kilowatt. However, when finally built in Japan for the Tokyo Electric Power Company, it had taken approximately 60 months to build and the first unit cost $3,236 per kW, the second $2,800 per kW[96] (these equate to £2,006/kW and £1,736/kW at 1997 conversion rates).

In addition to the financial issues the reports referred to, the reports also highlighted other problems for new build, namely:

- what to do with the nuclear waste created;
- the costs of decommissioning; and
- issues of health, safety and the environment.

38. Significant attention must be placed on the financing mechanisms, and not just costs estimates, considering the economics. A report prepared for the US Congressional Budget Office (CBO) looked at the proposals for legislation on federal loans to support new build in the US.[97]

39. The proposals for Loan Guarantees for Nuclear Power Plants Energy Law (s 14) would have authorised the US Department of Energy (DOE) to provide loan guarantees for up to 50% of the construction costs of new nuclear power plants and would have authorised the DOE to enter into long-term contracts for the purchase of power from those plants.

40. The report notes that no new nuclear plants have been ordered in the US in the last 25 years, and the last was completed in 1996. Based on information from the DOE about preliminary construction plans at three sites, the CBO stated it expected the department would provide credit assistance for six nuclear power plants over the next 20 years. The comments—provided below in full—show that the CBO thinks:

- the risk of default by the owners of the reactors would be greater than 50%—and therefore should not go ahead;
- that even if the reactor is completed and monies recovered through electricity sales, the overall subsidy cost would be 30% of the project; and
- that taking a long-term purchase agreement would be even more expensive than a construction subsidy.

41. CBO text:

Estimates of the cost for such a plant range from $2.1 billion to almost $3 billion, including engineering, procurement, and construction, as well as costs associated with construction delays, and first-of-a-kind engineering costs.

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[88] University of Chicago, August 2004, *The Economic Future of Nuclear Power*.

[89] OECD/IEA NEA 2005, *Projected Costs of Generating Electricity*—update, 2005.

[90] *Nuclear Power: Least-Cost Option for Baseload Electricity in Finland* Risto Tarjanne & Sauli Rissanen, Uranium Institute, 2000.

[91] *Financing the nuclear option: modelling the costs of new build,* Oxera Agenda, August 2005.

[92] *"The Future of Nuclear Power: An Interdisciplinary MIT study"* available at http://www.mit.edu/afs/athena/org/n/nuclearpower/

[93] The Energy Review, Performance and Innovation Unit, February 2002.

[94] Royal Academy of Engineering 2004, *The costs of generating electricity.*

[95] *"More a question of politics than economics"*, Q Series: The Future of Nuclear, UBS Investment Research, March 2005.

[96] Congressional Research Service, CRS Report for Congress. *Nuclear Power: Prospects of New Commercial Reactors* 27 July 2001.

[97] March 2003—Congressional Budget Office (CBO) Cost Estimate 7 May 2003 S. 14 Energy Policy Act of 2003. As introduced on 30 April 2003.

42. "For this estimate, CBO assumes that the first nuclear plant built using a federal loan guarantee would have a capacity of 1,100 megawatts and have associated project costs of $2.5 billion. We expect that such a plant would be located at the site of an existing nuclear plant and would employ a reactor design certified by the NRC prior to construction. This plant would be the first to be licensed under the NRC's new licensing procedures, which have been extensively revised over the past decade.

43. Based on current industry practices, CBO expects that any new nuclear construction project would be financed with 50% equity and 50% debt. The high equity participation reflects the current practice of purchasing energy assets using high equity stakes, 100% in some cases, used by companies likely to undertake a new nuclear construction project. Thus, we assume that the government loan guarantee would cover half the construction cost of a new plant, or $1.25 billion in 2011. CBO considers the risk of default on such a loan guarantee to be very high—well above 50%. The key factor accounting for this risk is that we expect that the plant would be uneconomic to operate because of its high construction costs, relative to other electricity generation sources. In addition, this project would have significant technical risk because it would be the first of a new generation of nuclear plants, as well as project delay and interruption risk due to licensing and regulatory proceedings.

44. In its 2003 Annual Energy Outlook, the Energy Information Administration (EIA) projects that production from new nuclear power plants would not be cost-competitive with other power sources until after 2025. EIA also reports that current construction costs for a typical electricity plant range from $536 per kilowatt of capacity for natural-gas-powered combined-cycle technology to $1,367 per kilowatt of capacity for coal-steam technology. Although construction costs could diminish significantly as a new generation of nuclear plants are built, a new nuclear power plant starting construction in 2011 would have a construction cost of about $2,300 per kilowatt of capacity. By 2011, that cost would result in capital costs that are 40% to 250% above the cost of capital for electricity plants using gas and coal. Because the cost of power from the first of the next generation of new nuclear power plants would likely be significantly above prevailing market rates, we would expect that the plant operators would default on the borrowing that financed its capital costs.

45. Assuming the nuclear plant is completed, we expect it would financially default soon after beginning operations, however, we expect that the plant would continue to operate and sell power at competitive market rates. Thus, over the plant's expected operating lifetime, its creditors (which could be the federal government) could expect to recover a significant portion of the plant's construction loan. The ability to recover a significant portion of the value of the initial construction loan would offset the high subsidy cost of a federal loan guarantee. Under the Federal Credit Reform Act, funds must be appropriated in advance to cover the subsidy cost of such loan guarantees, measured on a present-value basis. CBO estimates that the net present value of amounts recovered by the government on its loan guarantee from continued plant operations following a default and the project's technical and regulatory risk would result in a subsidy cost of 30% or about $375 million over the 2011–2013 period. Based on information from DOE, we expect other loan guarantees would not be issued for nuclear power plants until after 2013.

46. Alternatively, under the bill, DOE could choose to forgo the loan guarantee and enter into a long-term purchase agreement to buy some or all of a nuclear plant's production instead. Under this option, the full value of funds committed by the government to purchase power from a nuclear plant over many years would need to be appropriated in advance, prior to construction, to assure a private lender that future cash flows would be adequate to cover debt-service costs. CBO estimates that this option for financial assistance would cost more than a federal loan guarantee and that DOE would probably not use this alternative.

COMPARISON OF ASSUMPTIONS IN RECENT FORECASTS OF GENERATION COSTS FROM NUCLEAR POWER PLANTS[98]

Forecast	*Construction cost (£/kW)*	*Construction time (months)*	*Cost of capital (% real)*	*Load factor (%)*	*Non-fuel O&M (p/kWh)*	*Fuel cost (p/kWh)*	*Operating life (years)*	*Decommissioning scheme*	*Generating cost (p/kWh)*
Sizewell B	2,250 3,000	86	—	84	1.15	0.7	40	Part segregated, part cash flow	—
Lappeenranta Univ	~ 1,300		5	91	0.5	0.2	60		1.6
Performance & Innovation Unit	< 840	—	8 8 15	> 80			30 15 15		2.31 2.83 3.79
Massachusetts Institute of Technology	1,111	60	11.5	85 75	0.83	–	40 25		3.7 4.4
Royal Academy of Engineers	1,150	60	7.5	90	0.45	0.4	40	Included in construction cost	2.3
Chicago University	555 833 1,000	84	12.5	85	0.56	0.3	40	£195m	2.9 3.4 3.9
Canadian Nuclear Ass	1,067	72	10	90	0.49	0.25	30	Fund. 0.03p/kWh	3.3

[98] Table taken from *The Economics of Nuclear Power—Analysis of Recent Studies*, by Steve Thomas, Public Sector International Research Unit, Greenwich University, July 2005, Funded by The Environment Agency.

Forecast	Construction cost (£/kW)	Construction time (months)	Cost of capital (% real)	Load factor (%)	Non-fuel O&M (p/kWh)	Fuel cost (p/kWh)	Operating life (years)	Decommissioning scheme	Generating cost (p/kWh)
IEA/NEA	1,100–2,500	60–120	5 10	85	0.38–0.90	0.15–0.65	40	Included in construction cost	1.2-2.7 1.8-3.8
OXERA	1,625 first plant 1,150 later unit			95	0.35	0.3	40	£500m in fund after 40 years life	

Notes:
1. Sizewell B operating costs are the average for all eight of British Energy's plants including seven AGRs as well as the Sizewell B PWR.
2. The MIT O&M cost includes fuel.

Licensing/Timeline for new build

47. To install a total of 10 1,000MWes units at a rate to replace closure of most of the largest Advanced Gas-cooled Reactors (AGR) would require a new build programme to be complete by 2025—and entail installing new capacity at an average of 770MWe/year from 2010 or commissioning onto the grid a new AP1000 nuclear reactor every one and a half years from 2010 until 2025; an extremely ambitious target given the nuclear industry's past construction record.

48. As part of its case for more reactors, the nuclear industry provided estimates for construction time for new build to the Government's energy review in 2002. BNFL/Westinghouse claimed each new reactor would take 33–40 months to construct—an optimistic estimate compared with the 86 months it took to construct the UK's last nuclear reactor Sizewell B. As can be seen from the reports chart, most other commentators believe new plants would take longer than the BNFL/Westinghouse time for construction.

49. Most independent industry analysts acknowledge that the first reactor of any new build programme probably wouldn't come on line until 2018–20.[99] The points below give an indication of what a timeline for new build might look like and what processes would have to be gone through:

50. An Energy Review takes place—in 2006? If that review gave the policy green-light to new build it would be substantially earlier than the "promised" five years for renewables to be allowed to be developed—it might therefore be challenged by companies investing in major renewable projects.

51. Late 2006–07—If nuclear power is given the go-ahead as part of a future energy mix under an Energy Review this will then be followed by consultation on a White Paper on new build (unless the Government combined the Energy Review and White Paper process).

52. If nuclear was still given the go-ahead, all designs proposed for construction in the UK would have to be licensed by the Nuclear Installations Inspectorate (NII). All reactors are untested in the UK and would be subject to lengthy licensing processes before a licence could be granted. It is expected this process could take five years. The NII is significantly understaffed and may not have the available staff to oversee this process.

53. Many significant question marks hang over how the NII will deal with licensing a new reactor design for the UK.

54. Will it accept a reactor that has been licensed overseas—with minimal input from the Inspectorate to ensure it meets UK regulations?

55. Will it accept a "one size" fits all licence across all sites once a reactor has met the UK licensing conditions eg if a reactor is ok to be built at Hinkley, then it can be built anywhere on existing sites because they already have reactors and are "fit" sites for nuclear power plants?

56. Will there be proposals to really streamline the inquiry process eg one inquiry into one reactor design which then fits all sites? How will the NII and other regulators deal with multiple reactor design licensing and tendering?

57. If the Government does give the green light to new build, will several companies then have to tender to build different designs which then go through the licensing process? This would add to the uncertainty of the final cost of the design chosen, and raises the possibility of the NII refusing to award a licence.

58. Alternately, will all those wishing to build in the UK have to put their designs through the NII licensing process before tendering? This could lead to a huge unmanageable work load at the NII.

59. All tenders to build would probably be subject to competition under EC regulations to ensure there are no illegal state aid subsidies attached to the tenders.

60. In the US the Nuclear Regulatory Commission has indicated it is not willing to go through the full licensing unless companies had a firm intent to build and to show that they had to have a domestic utility interested in the design.[100] Will up-front investor and/or utility interest in new build in the UK form part of the NII's process for how it deals with licensing?

[99] *Nuclear Power and the Characteristics of "Ordinariness"—the case of UK energy policy,* Gordon MacKerron, NERA Economic Consultants, September 2004.

[100] *AP1000 certification rulemaking entering public comment phase,* Nucleonics Week, 17 March 2005.

61. Also, who pays for licensing? Can the NII cope with all of this at the same time as overseeing a massive decommissioning programme—at a time when it has not got enough staff (or just enough) for current inspections/oversight? Who will pay for extra staff for the regulatory process to oversee reactor design licensing and planning inquiries? Will the taxpayer be expected to cover this?

62. Depending on the reactor design approved, additional time, possibly two to three years, might still have to be spent on siting and planning issues. Attempts to circumvent inquiry processes, through curtailing local government input or removing the ability of the public to challenge certain aspects, will probably face legal challenges themselves.

63. Around the same time as the licensing process for reactors might begin, the renewed search for a national nuclear waste dump could get underway following CoRWM's recommendations to the Government on long term options on radioactive waste management. This will undoubtedly focus public attention on where waste is coming from.

64. Construction could take three years (best case industry estimates) or five to seven years (independent commentators/experience-based construction times). Depending on events both at UK overseas reactors there could be legal challenges or regulatory changes during construction—the industry is keen to change legislation to prevent this happening.

Licensing—AP1000

65. Industry plans for multi-reactor programmes—based on exactly the same design—does nothing to assuage concerns over safety. As experience in Japan and France has shown such programmes raise the risk of generic faults in each reactor disabling all the plants. There is particular concern over the AP1000 as it has significantly less safety features than the currently operating reactors.

66. Safety and costs are inextricably linked and none more so than in the case of the untried and untested AP1000 design—an attempt at cost cutting which omits safety features which are regarded by the NII as essential for a PWR. Here is the background to that design:

67. The last time that the British nuclear industry applied for a license for a PWR was in 1981. The Westinghouse SNUPPS design, (a generation II reactor) which already had several years operating experience, was submitted for construction at Sizewell.

68. Design changes required by the NII in order for that design to meet British safety standards resulted in Sizewell B having 13% more large pipework and 22% more cabling than SNUPPS (as well as 75% more structural concrete).[101] The last surviving US order for a Westinghouse reactor was made over 30 years ago. In the US the Westinghouse AP600 design dating from the mid 1980s has been licensed but no-one has invested in it, so it has never been put to the test.

69. The AP1000 increases output from the same reactor pressure vessel by packing it with more fuel and pumping through more water, thus defeating the lower power density safety principles of the AP600.

70. The AP1000 "simplification" involved stripping 50% of the valves, 83% of the pipes, 87% of the control cables, and 35% of the pumps from a similar sized PWR. Richard Mayson of BNFL has stated:[102]

71. "In broad terms, it's roughly half the concrete and steel and therefore it doesn't take a genius to work out that's roughly half the capital cost of what Sizewell should have cost."

72. There are doubts the AP1000 can fulfil British safety standards with far less pipework and cabling than the original SNUPPS design. The public and Parliament will be understandably wary about the cost-cutting motives behind the "simplification" of PWR designs (such as the AP1000) while prospective investors are unlikely to be impressed by design innovation that does nothing, of itself, to prevent accidents that—in a very short time—could convert a huge investment into a huge liability.

73. It is also important to remember that the AGRs now operating in the UK (a number of which are experiencing shutdowns because of technical problems) were heralded by the industry as cutting-edge technology. Many of the same organisations that promoted those reactors are the same as those promoting today's designs.

Operational issues

> "The abiding lesson that TMI taught Wall Street was that a group of NRC-licensed reactor operators, as good as any others, could turn a $2 billion asset into a $1 billion clean up in about 20 minutes"
>
> Peter Bradford, former member US NRC (quoted *New York Times,* 4 May 2005)

74. As reactors get older, age related problems occur—resulting in lower safety margins. In a number of cases the problems have been compounded by lack of sufficient regulatory oversight. As we know from the

[101] Sizewell B Inquiry, CEGB proof 8 App 5, Fig 6.

[102] Speaking at an Institute of Physics Symposium as quoted in *Nucleonics Week*/Volume 45/Number 19/6 May 2004.

problems BE is experiencing at a number of its reactors, economic pressures have led to reduced safety and maintenance, which in turn have led to unplanned outages. Reduced employment levels also impact on plant safety and operations.

75. The plans by BNFL/Westinghouse are to have reactors operate for 60 years; other companies propose an operating life of 40 years.[103] This has implications not only because of what is known about the problems of ageing in reactors, but it also has cost implications for investors waiting to see capital refunds and dividend payments. Operational life is also a crucial factor in deciding when decommissioning funds should start to be put aside (for Greenpeace's view on this Appendix 1 and discussion on page 42).

76. The life time of a reactor also has a significant impact in terms of the amount of highly radioactive spent nuclear fuel produced—which also has to be provided for (and stored somewhere). This is discussed further on pages 24–28.

77. As part of this submission, Greenpeace has attached a major report undertaken on the hazards of different reactors and technical problems associated with them [not printed]. The report *Nuclear reactor Hazards—Ongoing Dangers of Operating Nuclear Technology in the 21st Century,* published on 25 April 2005, explains the many problems which exist with today's reactors and which could well occur in the next generation of reactors.[104] Greenpeace hopes it will help the Committee in appreciating the scale of the problem of current designs and what problems might arise in the future.

78. Greenpeace is not alone in its concerns. At the recent International Nuclear Congress, the Chief Inspector of the NII told an industry audience that sustained excellence is needed for industry operations. As his presentation showed however, the industry was only achieving an average performance.[105] It is important to note that the NII is itself understaffed.[106] Significant resources would have to be put in place to increase and extend staffing at the inspectorate to deal with a new build programme.

79. In recent years the World Association of Nuclear Operators (WANO) has publicly stated it has major concerns over safety standards. In a speech in 2003, WANO's listed of a number of "severe incidents" that have occurred over the past few years. These include:

- reactor pressure vessel head seal leakage at Sizewell-B;
- incorrect boron concentration at Philippsburg;
- unprecedented fuel damage at Cattenom;
- a pipe break in reactor head spray system at Brunsbuettel;
- reactor pressure vessel head corrosion at Davis-Besse;
- extensive ex-core fuel damage at Paks; and
- data falsification at both Sellafield and Tepco.[107]

80. Some of these accidents have had massive financial impacts. The closure of the Davis-Besse plant in 2003 cost the owner $298 million for replacement power, operation and maintenance, and capital in 2002, and as of August 2003, replacement power and O&M costs for the year totalled $205 million.[108]

81. It is because of the problems experienced with current reactors, potential problems with "new" designs, construction costs, liability funding (see pages 28–30 and Appendix 1) and potential licensing delays, the industry has lobbied Governments to either change licensing (and siting processes) and provide financial assistance for construction and liabilities.

82. This submission could not go acknowledging the massive health, social and financial costs of the Chernobyl disaster. The impacts of that reactor accident are still being felt today—and indeed will be for many generations to come. Greenpeace has not gone into the financial impacts—or devastating health and social impacts of the Chernobyl disaster in this submission. However, some of the impacts of Chernobyl are discussed in the attached report from Greenpeace International [not printed].

83. This leads to discussion of TOR 3.2 on the likelihood of Government subsidy.

Support Mechanisms—Financial and Legal

TOR 3.2

How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

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[103] For information on industry plans for 60 year life for reactors see—CORWM: http://www.corwm.org.uk/PDF/1277%20-%20Task%20088%20Study%20Report%20Final%20Draft.pdf

[104] Greenpeace International Reactor Hazards Report http://www.greenpeace.org/international/press/reports/nuclearreactorhazards

[105] NII presentation to International Nuclear Congress http://www.fuelforthought.org.uk/MikeWeightman.ppt

[106] National nuclear inspectorate short of staff, *Sunday Herald* 6 February 2005 http://www.sundayherald.com/47583

[107] *Nucleonics Week*—Volume 44/Issue 42, 16 October 2003. Complacency, negligence threaten nuclear industry, WANO warns.

[108] *ibid.*

Differing views

> "I am pretty confident that if we have future nuclear reactors in the UK there'll be no question of subsidies"
>
> Steve Kidd, World Nuclear Association,
> Open University Seminar, Nuclear or Not, 15 March 2005

> "Oxera's modelling analysis shows that the nuclear option is by no means closed, although economic investment is likely to require government support"
>
> Oxera, *Financing the nuclear option: modelling the costs of new build* June 2005

84. In a number of seminars the industry has said it believes the Government should provide support for new build, although some industry commentators have claimed that no such support is necessary. Certainly the level and extent of support expected by the industry is not compatible with liberalised markets. The already massive Government aid given to nuclear power already corrupts and distorts the whole electricity sector in the EU.

85. With regard to this issue, attached is a report on EU's subsidies to dirty energy industries (including the nuclear sector)—*Invest in a Clean Energy Future* from Greenpeace International—as part of this submission [not printed].

86. As noted earlier, the commercial sector and utilities have been reluctant to invest in new build because of technical hitches, long licensing procedures, legal challenges—and concerns that they won't get a good rate of return and/or dividends. It is unlikely therefore that a significant number of new reactors would be ordered without further direct or indirect subsidies and support mechanisms being made available to the utilities.

87. The nuclear industry has pointed to the subsidies and arrangements used to help stimulate the renewables industry to justify its demands for yet more subsidies. Examples of past, and continuing, subsidies include:

- Funding liabilities.
- Funding R&D.
- Funding R&D via International/regional treaties under the International Atomic Energy Agency (IAEA) and Euratom.
- Underwriting insurance under the liability treaty.

88. The extent and nature of additional financial support for new build would most certainly be subject to scrutiny by the European Competition Commission. (More detailed information on current subsidies and state aid issue for the UK industry is included under TOR 2.2 on pages 22–30.)

89. The general public and Parliament rightly have concerns over state aid. For any industry receiving state aid, Parliament might legitimately ask: Who controls it and does the taxpayer get a good/any return on investment?

90. If however the Government did choose to support the development of new nuclear power it could do so using a variety of mechanisms. These are included below. The impacts that these would have and the costs vary considerably: as some would have "upfront" cost implications (capital grants) while in other cases the charges would be passed directly onto the consumer eg nuclear obligation.

State aid Issues

Capital Grants

91. The Government could award capital grants for new construction. In France, the new EPR project at Flamanville is expected to receive around €500 million in capital grants from the Government. Similarly, in the US, the Government is offering specific funds for the construction of the first few reactors. As can be seen from the comments by the Congressional Budget Office in 2003, there are very real risks in loan default on these projects and in the Government recovering only part of its capital grants from new build.

Government loan guarantees

92. US proposals this year to give Westinghouse a $5 billion loan guarantee created controversy—not only because this is the largest loan guarantee ever put forward by the US Export-Import Bank—but also because it was (ironically) seen as a subsidy to the UK Government as Westinghouse is owned by BNFL.[109] If Westinghouse is not sold[110] there is a possibility it could apply to the UK Government—via BNFL—for loans for future reactor building projects either here or overseas. As noted in the DTI's document on the strategic review of BNFL[111]:

[109] *Platts Nuclear News Flashes,* 18 February 2005, Westinghouse received US Export-Import Bank backing for nearly $5 billion.

[110] The original loan guarantee for Westinghouse was for reactor building in China. This has now been blocked in the US because of concerns over technology transfer. If Westinghouse doesn't have any reactor sales on its order books it may not reach the asking price of £1 billion—and the sale may be deferred until it can reach a better price.

[111] Conclusions of BNFL Strategy Review: Explanatory Note, November 2004. http://www.dti.gov.uk/nuclearcleanup/ach/explanatorynote.doc

93. "The review has concluded that only limited synergies exist between Westinghouse and other BNFL business units, including those concerned with UK clean-up. Westinghouse does, however, rely heavily on its parent for guarantees and other balance sheet support in relation to both its site clean-up obligations and some contracts with its customers." (emphasis added)

94. Similar arrangements for Government loan guarantees exist across the nuclear sector internationally. Any future application for new build in the UK—either by a UK or foreign company—would have to be carefully examined to ensure that state aid funding is not distorting the market.

Cost over-run guarantees

95. Utilities may seek Government assurances that they will be compensated for any time or cost over-runs resulting from extended licensing processes. In the US it has been suggested that the Government could pay interest on any capital as a result of construction over runs due to unforeseen legal challenges.

Tax breaks

96. The nuclear industry could become tax exempt, deferred or have reduced rates. This could be at a local level, through adjusted business rates—as has already occurred on occasions—or nationally. Tax breaks might also be given on construction capital.

Public Private Partnership

97. Public part-ownership of future stations could be introduced. This would reduce the upfront capital expenditure of the utilities, but may not be considered attractive for either the utilities or Government.

98. Public/private partnerships involving Government loans have been recommended against by the CBO in the US for "first of a kind reactor" as the CBO believes the risk of default on the loan is too high.

Waste fund

99. The Government has established a Nuclear Decommissioning Authority (NDA) which is responsible for historic nuclear waste. The UK Energy Act 2004 allows for the Secretary of State to use discretionary powers to direct the NDA to fund the liabilities of private nuclear operators. During debate on the Act in the House of Lords it was conceded that it was precisely because of the problems with BE that these powers had been put in the Energy Act (for further details see Appendix 1 on Segregated Funds).

Nuclear obligation

100. Currently some countries, mainly the UK, have requirements for utilities to produce a specific proportion of their electricity from renewable sources. If the utility does not produce any or sufficient renewable electricity it may purchase a Renewable Obligation Certificate (ROC) to meet its target. A similar scheme could be introduced for nuclear however, this could raise a number of problems, including:

- Compared to renewable energy it is more difficult for utilities to become nuclear electricity producers and thus they will have to purchase their "NOC" from only a limited number of producers.
- Adding a NO (nuclear obligation) would affectively ring fence another significant share of the market.
- Some see this as creating too great a distortion of the market.

Feed-in Tariffs

101. Another mechanism to support renewable energy is the use of feed-in tariffs. This guarantees investors a fixed price for the electricity produced. A similar scheme could be used to support nuclear construction. As noted earlier, the CBO has warned the US DOE that using such a scheme to support new build would probably be more costly even than direct capital grants as the money for this scheme would have to be set aside up front—in order to assure investors the electricity would be bought at a fixed price.

102. The fifth reactor in Finland is effectively being built on the basis of feed-in tariffs, whereby the heavy electricity users are tied to fixed price contracts from the future reactor. That reactor project is the subject of a complaint to the European Competition Commission because of state aid given to help finance construction.

Licensing/siting/planning

103. The nuclear industry would like to see a streamlining of the licensing and planning inquiry processes. In the US licensed streamlining is being undertaken and is also being looked at in other countries.

104. Keith Parker, chief executive of the Nuclear Industry Association, has said "There have to be some enabling measures to give the right signal to investors. For example, there is no way investors are going to be interested when it takes six years to get planning permission for a new plant, so reform of planning law would be a good start."

105. Quite what "reform" means in terms of reducing public input at inquiries, and local government say over planning matters, has not been spelt out by the industry.

Grid availability

106. The incumbent nuclear generators have access to and control of the high voltage transmission wires connecting their facilities to the grid. These were constructed prior to market liberalisation. As nuclear power stations are retired then these grids connections could be made available for any other uses, such as replacement nuclear capacity or gas stations or offshore wind. The allocation of these grid connections could have a significant impact on the economics of new generation capacity.

107. One suggestion put forward by the US industry is that it should be allowed to earmark sites for future nuclear reactors now. It is not clear if this would be involved in a generic licensing arrangement covering reactors ie once a design is approved at Federal level it can be built at any site.

108. The industry has indicated it will probably apply to build on existing sites. Thus, if the US proposal was followed through in the UK, this could mean that even if a new reactor might be 20 years off, the site would be kept for nuclear use. Taking up sites for possible new build years into the future would effectively block access to the grid and could prove to be a major impediment to renewables developments needing to use those grid connections.

109. In addition, many nuclear communities expect to see their nuclear sites returned to "greenfield" status or at least see total decommissioning and hazard reduction. They may not be willing to welcome a new reactor onto existing sites.

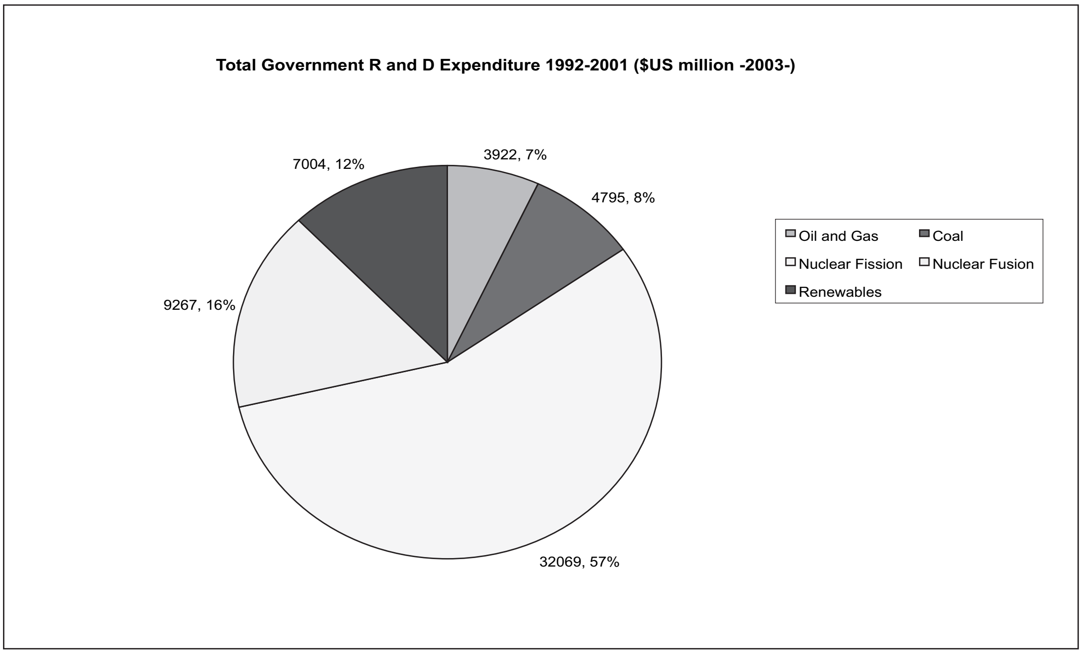
Indirect support mechanisms

110. Governments also have the opportunity to less directly support the development of nuclear power. These mechanisms can be extremely effective and have over the years given considerable assistance to nuclear power.

Research and development

111. For decades Governments have given research and development funds to the energy sector. These funds are supposed to be targeted towards the development of new technologies, but as can be seen in the figures below have mainly been for the further development of nuclear fission. In total over the last decade 75% of funding for the development of new energy sources has gone to nuclear power. Another example of R&D support includes funding university research programs. In the US $21 million was awarded last year to work related to nuclear energy development.[112]

[112] *Nuclear News Flashes,* 23 December 2004, 35 DOE nuclear research grants awarded to 25 universities.



Source: International Energy Agency 2005.

Examples of state aid in Europe

112. The industry has given the impression that new reactor programmes in Europe are being built without state aid. That is not the case.

113. The industry has also made much of the fifth reactor being built in Finland as a sign of the industry's renaissance. That reactor project is however the subject of a complaint to the European Competition Commission on possible illegal state aid funding from several countries.[113]

114. France's proposed new reactor is also receiving capital grants of €500 million, and probably other state aid subsidies will follow for liabilities.

Cost Overruns and Lack of Liability Funding

TOR 2.2

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

115. The short answer to this is no, the industry has not shown itself to be good at estimating construction costs and providing funding for decommissioning and waste liabilities.

How realistic and robust are cost estimates?

116. As seen from information provided in pages 3–12, cost estimates are just that—estimates. The actual price of a reactor may be far more than the original figure quoted. This is true for a number of UK nuclear projects.

Sizewell B

117. Capital costs increased from £1,691 million to £2,030 million (1987 prices) according to a paper produced by Brian George for a CEGB Board meeting on 7 June 1990. The revised figure did not allow for inflation, which if included would have meant a total for final payments of £2,621 million. Nor did the revised figure include interest payments, which would bring the figure up to between £3,501 million and £3,611 million. Finally, it did not include £199 million written off through "more prudent accounting policies", which covers delays in commencement arising from the public inquiry. If included this would bring the total to £3,700 million to £3,810 million.[114] Indeed the House of Commons Energy Select Committee said that "objectors at the Sizewell B Public Inquiry predicted the likely costs more accurately than the CEGB itself".Sizewell B opened on 31 January 1995 six to 12 months late.

[113] For full text see EREF complaint see: http://www.eref-europe.org/downloads/pdf/2004/EPR_Finland.pdf

[114] House of Commons Energy Select Committee Fourth Report, the Costs of Nuclear Power, June 1990.

Torness

118. It has been reported that sources in the Scottish Civil Service admitted in 1989 that the Torness nuclear power station, was "a £2,500 million mistake".[115] The station was originally projected to cost £742 million. The Scottish Office's admission that Torness should never have been built in the first place coincided with the announcement that the UK's nuclear stations would not be sold off with the rest of the electricity industry.

119. Construction of Torness began on Monday 13 November 1978. The first reactor went critical on 25 March 1988—a total of 11 years to build and start operation. The South of Scotland Electricity Board had said it was confident Torness could be built in six years, compared with a minimum of nine years for previous AGRs. It was plainly wrong.

Dungeness B

120. Dungeness B took 23 years to complete, instead of the five predicted and costs were 400% above the original projection.[116] One recent newspaper report notes that selecting and persisting with AGRs was, according to economist John Kay, "probably the worst economic decision ever made by a rich state".[117]

THORP

121. According to figures given at the 1977 public inquiry for the Thermal Oxide Reprocessing Plant (THORP) at Sellafield, the plant was expected to cost £300 million. It was originally due to start operating in 1987, but by its completion in 1992 costs had risen to £1.8 billion. With the additional costs of associated facilities, including new waste treatment buildings, the total bill reached £2.8 billion.[118]

122. The plant was expected to have a working life of 25 years, but is likely to close after less than 20. BNFL argued that its income from reprocessing 7,000 tonnes of spent nuclear waste fuel over THORP's first 10 years of operation would be sufficient to cover all capital costs, as well as operating and future decommissioning costs, and make a profit of £500 million. THORP eventually began operation in April 1994, but by April 2004 had still not completed its 7,000 tonnes of baseload contracts. By the time THORP was closed this April to due a massive internal leak caused by a fractured pipe, it was estimated to be around two years behind schedule in projected reprocessing throughput. Revenue losses from THORP's non-operation this year have been put at around £300 million—with the costs of repair yet to be added.

Sellafield MOX Plant

123. In November 1996, when BNFL applied to the Environment Agency for an authorisation to discharge radioactive waste from the Sellafield MOX Plant (SMP), construction was virtually complete and had cost £300 million. Subsequently the construction costs of the SMP were disregarded in any assessments of the economic case for SMP, because by the time of the application the costs had already been incurred and were, therefore, considered to be "sunk" costs. A further £170 million was spent between December 1997 and July 2001 on commissioning costs (and was therefore also considered to be a sunk cost). Arthur D Little produced an assessment of the economic benefit of operating the plant in July 2001, which concluded that operating the plant would produce a net present value of £159 million compared with a loss of £58 million if the plant did not operate.

124. ADL concluded that the key threat to achieving its predicted outcome was if SMP failed to meet the timetable for the first deliveries because of a delay to commissioning, or a delay to the start of Japanese deliveries.[119]

125. The first MOX fuel assemblies did not leave the plant until 28 May 2005. Technical problems since the first plutonium test material was introduced into the plant 42 months earlier prevented the plant from fully operating until early 2005. BNFL has spent an additional £100–200 million over the past three years in an effort to sort out all the technical hitches. It has had to subcontract MOX fabrication orders from Swiss and German customers to its European competitors Cogema and Belgonucleaire.[120]

126. Consequently it appears that the two main threats to SMP's profitability (assuming sunk costs are ignored) have both come to pass.

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[115] Alf Young, 10 November 1989, "Torness plant was "a £2,500 million mistake" *Glasgow Herald.*

[116] New Economics Foundation, *"Mirage and Oasis—energy choices in an age of global warming"* http://www.neweconomics.org/gen/uploads/sewyo355prhbgunpscr51d2w29062005080838.pdf.

[117] Over-reaction 12 August 2005, *Telegraph.* http://www.telegraph.co.uk/opinion/main.jhtml?xml=/opinion/2005/08/12/dl1202.xml.

[118] Aubrey, C, THORP: *The Whitehall Nightmare,* Carpenter 1993.

[119] DEFRA, DoH (July 2001) *Assessment of BNFL's Business Case for the Sellafield MOX Plant.*

[120] BNFL to miss target for producing first fuel at Sellafield MOX plant Pearl Marshall, Nuclear Fuel, Vol 30 No 5 28 February 2005.

127. We have included information on THORP and SMP because although they are "one off" projects the problems with cost and operations of these facilities are indicative of the many of the problems experienced across the nuclear field.

128. Future "one off" projects—such as a national nuclear dump—will probably also experience the same problems. If built and operated on a user-pays basis (as some have indicated should be the case) this could add significantly to the long-term liability costs of any new build operations. Alternately the costs of the dump may be borne purely by the taxpayer under Government's decommissioning and clean-up plans and future new build may enjoy a subsidised waste disposal option.

Insurance—hidden costs

129. Insurance for the nuclear industry—in terms of underwriting compensation for an accident or terrorist attack—constitutes a subsidy to the industry. Just how much that might be is not easy to say.

130. In the section of the DTI's Departmental Report for 2005 which discusses liabilities, it is noted (page 202):

131. In addition, the Government has had to provide temporary indemnity to British Nuclear Insurers to cover terrorism risks.[121]

132. It gives the figure for this as "unquantifiable". In short, if there is a terrorist attack and there are payouts no one knows what the full amount will be.

133. Arrangements for insurance by the Government are given on its website[122], where it notes that:

134. The Nuclear Installations Act of 1965 governs liability and compensation arrangements for nuclear damage for which a UK nuclear licensee is responsible. The Act requires compensation to be paid for damage to persons or property up to a limit of £140 million by the liable operator. This limit is kept under review. For 10 years after the incident causing damage, this obligation is met by the operator; between 10 and 30 years afterwards, the Government must meet the obligation. Under the Act, insurance arrangements for a nuclear site must be approved on behalf of the Secretary of State for Trade and Industry before a site licence is granted to the operator of a nuclear installation. The licensee requires £140 million of insurance or other financial security to cover his liability under the Act, including for transport of nuclear materials.

135. The impacts of a major nuclear accident or terrorist attack could be massive. In the short term, remedial action and compensation costs would in all likelihood cost far more than £140 million—which would mean the taxpayer would fund the difference. In the longer term contamination and the cancer and ill-health effects which would result decades after the event would see most of the burden fall on the Government.

136. On its website the Nuclear Industry Association insists that the industry arrangements between the Government and the industry do not represent a subsidy. However, as it notes: The Nuclear Installation Act stipulates that the plant operator cannot pay any compensation out of assets. There must be a separate financial mechanism in place to cover this.[123]

137. Why should the assets of a plant operator—shares, other companies, financial holdings—not be accessed to pay out compensation?

Security—hidden costs

138. Costs for security for the nuclear industry are not easy to come by. In its 2005 Annual report the DTI gives a figure of £6 million for the Civil Nuclear Police Authority (DTI Departmental Annual report, p 193). Costs for the Office of Civil Nuclear Security (2002–03) were £18 million. It is not known exactly how much is contributed by private companies such as British Energy or a Government owned commercial entity such as BNFL for security.

139. There will also be "hidden" costs for nuclear security as a range of authorities (police, military, emergency services, health and local authorities) all have to devote time and resources to planning for nuclear accidents and terrorist attacks. This would not apply to the renewables sector—or to a decentralised energy system.

[121] DTI department report 2005 p 202.
[122] http://www.dti.gov.uk/energy/nuclear/safety/liability.shtml.
[123] http://www.niauk.org/article_56.shtml.

How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy?

140. The Committee asked how a new build programme might impact on the current waste legacy. As with all things nuclear there is no easy answer to this. With regard to giving firm figures on the costs for waste and decommissioning for new build it is virtually impossible to answer this. There main problems in determining the cost of decommissioning, clean-up and waste/spent nuclear fuel liabilities is because these are dependent on:

- the scale of the new build programme proposed;
- the size of reactor eg 1GW or 1.3GW;
- reactor operational life;
- type of reactor;
- siting issues; and
- whether disposal of all types of waste will be a reality by the time the reactors are commissioned—which could mean major infrastructure costs like a national repository or store have already been financed by the taxpayer.

NDA—scale of current liabilities

141. Recently published estimates by the NDA indicate an expected £56 billion (an increase of £8 billion over the figure of £48 billion given last year) for decommissioning and clean-up of the nuclear installations it has taken charge of. These figures do not include British Energy's plants, which are covered under a separate arrangement. The DTI's annual report 2005 states that "various constructive obligations relating to the restructuring of British Energy" are estimated at £3.912 billion. If BE cannot fund its future liabilities under the new arrangements (see Appendix 1) then the taxpayer will have to fund this under clauses in the Energy Act (this would be done via the NDA).

142. The £56 billion may not be the final cost as, according to the NDA's strategy, future costs depend on many variables eg dumping Intermediate Level Waste by 2025 is claimed to be cheaper than storage (and—it is claimed—will impact on the cost of Magnox decommissioning.

143. The NDA has also said that disposing of plutonium as a waste could add several billions to its costs. However, that cost would have to be set against the cost of constructing reactors and burning the plutonium in MOX fuel (see below) which would have significant environmental risks and impacts eg MOX spent fuel is more radioactive than "ordinary" uranium spent fuel. Burning MOX also has additional security measures (and therefore costs) associated with it.

144. The DTI cannot give a figure for nuclear liabilities it is responsible for, stating that these are "unquantifiable".[124] In the report under "statement on contingent or nominal liabilities (Nuclear)" it noted:

145. The Department has a range of civil nuclear liabilities arising through its association with UKAEA and BNFL as well as ensuring that HMG complies with its obligations under various nuclear international agreements and treaties. The amount and timing of this overarching liability is not quantifiable.

Nuclear Wastes from new build

146. The quantity of waste estimated to arise from a 10 AP1000 reactor power programme is estimated at:

- 100,000t depleted uranium;
- 31,900 m^3 (14,000t) spent fuel;
- 6,000 m^3 ILW; and
- 85,000 m^3 LLW.[125]

147. The quantities of ILW and LLW are less than 10% of the volume of waste reported in the 2001 UK Radioactive Waste Inventory—but the spent fuel produced would be a massive 400% extra above the estimates 8,150 m^3 from the current programme.

[124] DTI department report 2005 p 202.

[125] NIREX 7 July 2005, Volumes of radioactive waste predicated to arise from a programme of 10 AP1000 reactors.

Spent fuel—a case in point in problems of determining the current and future costs

148. We provide below an example of what's happening at present with spent nuclear fuel from BE and then consider the amounts of spent fuel that would be created through a new build programme.

Spent fuel costs

149. Greenpeace commissioned a paper for the European Competition Commission's investigation into the restructuring and state aid package for British Energy looking at the reduced-cost reprocessing contract BNFL and BE had negotiated.

150. That report explained that BNFL is only charging £150,000 per tonne for spent fuel services but that this was not a commercial deal as spent fuel services could cost between £330,000 to £533,000 per tonne. The lower price offered by BNFL therefore represents state aid from the government to British Energy.

151. The £150,000 BE pays to BNFL for it to manage each tonne of spent fuel is the only payment it makes for spent fuel services. BNFL assumes ownership of the spent fuel when it is delivered and BE has no further liability. BNFL will presumably have to find the money for the costs and risks of disposal—possibly an extra £220,000 per tonne (Harvard estimate) or £423,000 per tonne (Nirex estimate).[126] It is not clear at present however, if it is the NDA or BNFL which will now have to take over whatever additional costs there are in managing this fuel.

THORP shutdown—more problems?

152. The closure of the THORP plant at Sellafield, and how it might impact (or otherwise) on what BNFL and the NDA decide to do with spent fuel being received from BE plants is something that cannot yet be answered. A change from reprocessing to storage may not cost BE any more money—but could mean additional funds having to be found by the NDA (ie taxpayer) to fund storage facilities.

153. If THORP is reopened it might well be at considerable cost—another financial burden which will fall on the NDA as the plant's owner. It is estimated the closure of THORP will cost £300 million in lost revenue this year.

Plant life extension

154. BE has recently announced it will be extending the life of the Dungeness B plant by 10 years. The additional spent fuel created will be sent to Sellafield. Some funding to cover the costs for this additional spent fuel should come from BE under the restructuring agreement. However, as explained shown above the amount BE pays for BNFL/NDA to receive the spent fuel will not cover long-term storage and disposal costs.

Massive increase in spent fuel holdings under new build

155. It is vital to consider not just the volume of radioactive waste from a new build programme, but also the amount of radioactivity contained within the wastes.

156. Spent fuel is the most problematic waste from reactors because it is heat-generating (extremely hot in fact), is intensely radioactive and contains very long-lived radioactive elements.

157. The latest radioactive inventory from the Committee on Radioactive Waste Management (CoRWM) provides the most up-to-date estimates for the wastes arising from a programme of building and operating 10 new reactors (based on a 60 year operating life) as:[127]

— Spent fuel arising from current programme	8,150 m^3.
— Additional spent fuel arising from 10 new reactors	31,900 m^3.

158. This is a 400% increase over and above expected spent fuel arising from the existing plants (CoRWM also estimates a programme of plant life extension for all of BE's plants could result in an additional 1,520 m^3 of spent fuel—a 25% increase to the baseline inventory).

159. The industry has constantly put forward the figure of 10% in terms of new waste arisings from a new build programme—that figure relates only to the additional amount in terms of overall volume. The industry is seeking to avoid debate over the fact that there will be a huge increase in spent fuel—the most hazardous and long lived of radioactive wastes from reactors—if there is a new build programme.[128]

160. CoRWM is to be commended for putting together these more comprehensive reports on the potential for new build to impact on the UK's radioactive waste inventory.

[126] *Restructuring Aid for British Energy: Issues for the European Commission,* National Economic Research Associates (NERA). Gordon MacKerron, March 2004. http://www.nera.com/Publication.asp?p—ID = 2063.Response to Questions Raised Based on Reference 334004. Nirex Letter to RWMAC. November 2000. The Future of Nuclear Power: An Interdisciplinary MIT Study. Massachusetts Institute of Technology. July 2003. http://web.mit.edu/nuclearpower/. *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel.* Belfer Center for Science and International Affairs. M Bunn. Harvard University. December 2003. http://www.puaf.umd.edu/faculty/papers/fetter/2004-NT-repro.pdf.

[127] Summary of inventory: http://www.corwm.org.uk/pdf/1280%20-%20Task%20088%20CoRWM%20Inv%20July%202005%20Summary.pdf. Document explaining basis for assumption of 60 year reactor lifetime http://www.corwm.org.uk/PDF/1277%20-%20Task%20088%20Study%20Report%20Final%20Draft.pdf.

[128] High level liquid waste accounts for 3% of the volume of a spent fuel rod, but contains 97% of the radioactivity, arises from reprocessing.

How much additional radioactivity from new build?

As the latest inventory from CORWM notes:

161. "The only scenario that would change the baseline inventory radioactivity to any significant extent is that where there is a commitment to future nuclear energy with life extensions to existing AGR and PWR stations and a programme of new reactors. In this scenario the amount of radioactivity (and the quantity of spent fuel for long term management) could be up to a factor of five greater than the baseline."

162. The baseline line inventory for all nuclear wastes in the UK is estimated to contain 78,000,000 TeraBecquerels (TBq) of radioactivity (see CoRWM inventory).

163. The extra radioactivity coming from spent fuel from new build would be 130,000,000 TBq. This would increase the total amount of radioactivity in the inventory of UK nuclear wastes from 78,000,000 TBq to 208,000,000 TBq.

164. To "sell" a programme of new build that will create so much more highly radioactive and hazardous waste would be a massive issue in terms of public perception.

165. It's hard to see how the industry and Government will persuade people to accept a new build programme when they already have such major problems with gaining consensus over what to do with the current waste stockpile.

166. With regard to this, it's also worth noting that because of the costs, proliferation and environmental problems associated with reprocessing a "once-through" cycle is being proposed for new build spent fuel—no one is reckoning on reprocessing over the coming decades.

Disposal or storage of spent fuel?

167. Spent fuel is the most hazardous material produced by nuclear reactors.[129] There are no disposal options available for spent fuel, although the impression given by industry is that this matter has been resolved in other countries.

168. Finland is still very much in the exploratory stage of its national repository, the same for Sweden. Neither country has a working spent nuclear fuel or high-level waste repository. Only recently the US has run into problems—again—in constructing the Yucca Mountain high-level waste store (to the point that there are currently proposals in the US to ship spent fuel to France or the UK to help reduce stockpiling of spent fuel at US reactor sites).

169. NIREX has admitted that no final waste repository is likely to go ahead for the next 25–40 years. In its most recent strategy the NDA does not raise the issue of spent fuel disposal, whether this is because it believes this is not an issue which is relevant to the next five years to be covered by the strategy is not clear.

170. BNFL/Westinghouse has published a document which indicates that it believes storage at the reactor site to be the most likely management option for spent fuel at new reactors.[130] In discussing radioactive wastes produced by reactors it has stated:

171. "In addition spent fuel can be safely stored for at least a century on the reactor site making a new build programme independent of a long term solution. Effort and resources that are being devoted to addressing the waste 'legacy' from earlier national programmes must therefore be clearly distinguished from waste management activities for new commercial reactors".

172. This is interesting coming from a company (BNFL) which has hitherto always claimed reprocessing is the best option for spent fuel.

173. This proposal also shows how cynical the industry can be. On the one hand a number of industry commentators have claimed that direct disposal is the best option for spent fuel and have recently seized on the security risks to waste stores in order to push disposal (and also, coincidentally "solve" the political issue of radioactive waste at the same time).

174. But when it comes to having to explain what to do with the massive amounts of spent fuel that would be produced by a new build programme—and in order to dodge the thorny question of there been no spent fuel disposal programme—suddenly storage for 100 years is ok! Whether the residents living around potential new build sites would have quite the same view is another matter (more detailed points on public opinion on radioactive waste are made in discussion under TOR 7, page 38 of this submission).

175. Spent fuel stores are also important in the context of the security debate. Spent fuel stores can contain many times the amount of radioactivity of that released during the 1986 disaster at Chernobyl and an attack—or accident—at a store could lead to widespread contamination and could result in hundreds of thousands of deaths.[131]

[129] High level liquid waste is produced during reprocessing of spent fuel when the plutonium and unburnt uranium is separated out.

[130] BNFL (5 September 2002) "Nuclear Now for tomorrow's generation: BNFL Submission to the Consultation on UK Energy Policy" http://www.bnfl.com/library/upload/docs/001/222_1.pdf.

[131] Greenpeace International Reactor Hazards Report http://www.greenpeace.org/international/press/reports/nuclear reactorhazards.

How confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

Background and current situation

176. There is a long history of state aid to the industry to help with liabilities which continues to this day and will continue for some decades to come for existing nuclear companies such as BNFL and British Energy.

177. This has given rise to expectations within the industry that such support will be available in the future. In fact, the industry is actively lobbying for financial subsidies for reactor construction and liabilities. It will resist any changes to legislation to make segregated funds a legally binding requirement for nuclear liabilities.

178. The industry claims it prefers the "flexible" approach taken to date—which has invariably left the taxpayer funding a major part, or all of, the industry's liabilities. The actions of successive Governments (including the current one) have not been to ensure the public purse is protected. Instead, the industry has been bailed out time and time again, with no legislative changes made to prevent similar occurrences to BE's bailout happening in the future. In fact only last year the Government passed legislation which will allow for the bailout of future private nuclear operators if they too fail to sufficiently fund their liabilities.

British Energy

179. With regard to British Energy there is evidence of a major failing on the part of the DTI to monitor the company[132] and the Department has been criticised by the National Audit Office and the Public Accounts Committee for its lack of oversight of BE.[133] (See Appendix 1 on segregated funds).

180. Due to BE's failure to properly fund its liabilities, the state aid subsidy for this now stands at £3.9 billion (DTI Department report 2005). However, if BE fails to put aside sufficient funds for future waste costs it will—as Appendix 1explains—be bailed out yet again by the taxpayer via the NDA. Provisions included in the Energy Act 2004 allow for the Government to bail out any future nuclear private operator if they too fail to meet their liabilities (See Appendix 1).

181. Surprisingly though, the Energy Act allows for the Secretary of State to direct that wind plant decommissioning funds have to be paid up front for wind turbine projects, even though no such rule exists for nuclear power.

NDA and BNFL—state aid investigation—another example of bad prediction

182. Apart from the problems with monitoring and assessing the risk from BE's failure to properly fund its liabilities, the DTI also appears to have failed to fully appreciate the problems of the movement of assets and liabilities from BNFL to the NDA and whether or not this could simply pass as an unchallenged state aid measure.

183. In September of last year senior DTI officials (some of whom are now senior NDA officials) told Greenpeace and other NGOs there was no problem with the transfer of liabilities from BNFL to the NDA and that they were confident this matter would not be investigated by the European Competition Commission (DTI had notified the EC of the transfer).

184. A couple of months later the same officials were having to explain to Greenpeace and Friends of the Earth that the Competition Commission was indeed calling in the transfer of liabilities as part of a state aid investigation into the NDA.[134]

185. The initial attitude of officials to the legality of the BNFL liabilities transfer proposal seemed a little blasé given that Greenpeace had submitted an opinion to the Commission, from a leading state aid legal expert, that the legislation covering the NDA was illegal under state aid and competition rules. That there was no possibility of the transfer deal being questioned either exposes a lack of understanding of these issues by the DTI, or over-confidence on its part.

186. Either way, the NDA/BNFL state aid case investigation is yet another example of how senior departments may get it very wrong about how much money the nuclear industry can simply take from the taxpayer. Future provisions by Government to support the industry might also be challenged by the Commission—something the investment community will doubtless be aware of but which the Government may be badly advised on by overly optimistic advisers. The EC's investigation on the NDA and state aid is still ongoing. Its conclusions are expected any time between December and June 2006.

187. In the meantime the NDA has been unable to take over full ownership of Sellafield's liabilities from BNFL because of the ongoing European Commission (EC) investigation.[135]

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[132] NAO, 6/2/04 http://www.nao.gov.uk/publications/nao—reports/03-04/0304264.pdf and PAC http://www.publications.parliament.uk/pa/cm200304/cmselect/cmpubacc/354/35402.htm.

[133] NAO, 6/2/04 http://www.nao.gov.uk/publications/nao—reports/03-04/0304264.pdf and PAC http://www.publications.parliament.uk/pa/cm200304/cmselect/cmpubacc/354/35402.htm.

[134] Greenpeace's submission on this can be found at http://www.greenpeace.org.uk/contentlookup.cfm?CFID = 1230708&CFTOKEN = 91665436&ucidparam = 20050901122409&MenuPoint = D-E-F.

[135] *Nuclear Fuel* (Vol 30, No 8) 11 April 2005.

Ring fenced funds?

188. This is explained more fully in Appendix 1. In brief the views are as follows:

189. *Industry view:* It sees the need to repay capital and provide dividends to investors before putting sufficient money aside for decommissioning and waste. Its general views is that it is safe to put off greater funding for liabilities into later in the reactor's operational life and that it will have plenty of time to set aside money from profits made during that time. It doesn't want mandatory legislation on this issue, as it believes it would put investors off if they had to wait longer for a return on capital and accept lower dividends if larger amounts of funding are "diverted" earlier into liability accounts.

190. *Environment groups view:* From the moment a reactor is commissioned and starts operating it creates a large, contaminated building and produces spent fuel. Adequate funds should therefore be put aside from the very beginning to cover liabilities. Relying on the industry to put money away in later years assumes that the reactor will have all the later years necessary in which to produce profits (and not have any costs for repairs/technical changes), which may not be the case.

191. *Pension funds:* A simply analogy is that of an individual considering putting money aside for a pension. Do they spend money on holidays and paying off the mortgage in the early years of their working career, or contribute towards a pension over a longer period throughout their whole working life? As we know the Government encourages the latter and is actively promoting early provision for pensions. As with the individual, the nuclear industry just can't rely on a state pension (aka liability bailout) to get it out of trouble in its later years.

CO_2 Emissions and Nuclear Power

TOR 4.1

192. *To what extent and over what timeframe would nuclear new build reduce carbon emissions?*

193. The UK's fleet of 23 operating nuclear reactors currently provides 22% of the UK's electricity. But it has to be remembered that power stations are responsible for less than 30% of the UK's CO_2 emissions. Nevertheless without these reactors the UK's CO_2 emissions would rise by about 10% (around 6%–7% of total greenhouse gas emissions). All but five of the current generation of reactors are due to close by 2020. The nuclear industry's proposal to build 10 AP1000MW reactors[136] would effectively replace all the current reactors.

194. But building 10 new reactors would not make a big dent in the UK's CO_2 emissions and by 2020, because of the changing fuel mix and increasing energy efficiency, the CO_2 offset would be much less than 10%. Using DTI figures, Greenpeace estimates that a new 10,000MW nuclear power programme would reduce emissions by around 6–8 MtC depending on the output (ie around 1MtC per 10TWh of output).[137]

195. Putting this 6–8 MtC into perspective, it would represent around 4–5% of total carbon emissions in 2020 or around 3–4% of total UK greenhouse gas emissions (around half of the increase in emissions expected from the transport sector by 2020). Because of this, some commentators have proposed that instead of just a replacement programme, there should be a massive expansion in the amount of nuclear power in the UK. One senior government official has gone so far as to suggest a programme of 45 new reactors, which it is estimated could supply 50% of the UK's electricity. In theory this would reduce UK's CO_2 emissions by 60% by 2050[138] (this figure is dependent on projections for energy mix by 2050 and also on the capacity of reactors installed).

196. It has been reported that IAEA has stated it does not believe nuclear power could not grow fast enough over the next decades to slow climate change across the globe.[139] The IAEA report considered two scenarios.

1. Nuclear energy continues to decline, with no new stations built beyond those already planned. Its share of world electricity—and thus its relative contribution to fighting global warming—drops from its current 16% to 12% by 2030.
2. Nuclear power grows by 70% over the next 25 years but its overall contribution to electricity—and thus to reducing CO_2 emission is less under this scenario because the world would have to be so prosperous to afford the expansion that traditional ways of generating electricity from fossil fuels would have grown even faster.

[136] BNFL (5 September 2002) "Nuclear Now for tomorrow's generation: BNFL Submission to the Consultation on UK Energy Policy" http://www.bnfl.com/library/upload/docs/001/222—1.pdf.

[137] DTI (2000) Energy Paper 68: "Energy Projections for the UK" http://www.dti.gov.uk/energy/inform/energy_projections/index.shtml.

[138] Britain must go nuclear, energy chief tells ministers, Angela Jameson, Timesonline 14 September 2004. http://www.timesonline.co.uk/article/0,,2-1261215,00.html.

[139] Nuclear power "can't stop climate change" By Geoffrey Lean, Environment Editor 27 June 2004.

Security of Supply

TOR 4.2

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

197. Greenpeace does not believe nuclear power can form any part of the solution—indeed it is very much part of the problem. For Greenpeace's part, the question is not so much whether new build would contribute to security of supply, but that investing huge amounts of money into an unresponsive (timeline wise) and inflexible centralised system with inherent safety and security risks would actually undermine security of supply. In Part 2 of this submission the alternative route for securing electricity supply is discussed in more detail.

198. To use another financial investment analogy. If someone were to be advised to invest all their money into one high risk venture that might pay off decades into the future but which also had the potential for significant losses—in fact has the potential to accrue liabilities and risk a massive and sudden depreciation of capital—then that person would walk away from the investment adviser (in fact this is exactly why investors are not queuing up to fund new build).

199. Isn't it better to invest in a mixed portfolio which had assured returns (renewables), or undertake measures which offer longer-term cost reductions and savings (energy efficiency) than one big risky venture? The same is true of financial capital as energy capital.

200. We simply do not have the time and therefore cannot take the risk on a reactor programme that might not work decades after we've decided to place all our faith in it.

New Build: Proliferation, Terrorism and Security

TOR 4.3

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

201. The short answer is no. The security problems brought by the proliferation and terrorism risks certainly mitigate against nuclear power as a suitable energy source.

202. The Government should move to guard against the potential for proliferation problems brought about by encouraging and trading in dual use civil and military nuclear technologies through developing and promoting renewable energy and decentralised energy systems worldwide. It should set an example by closing nuclear facilities here as soon as possible—which would also serve to reduce the risk of a terrorist attack by decreasing the number of targets.

Proliferation

203. As part of this submission Greenpeace has attached a briefing on proliferation which explains in broad terms the difficulties in the promotion and trade of dual-use civil and military nuclear technologies and materials [not printed].[140] In particular it explains the complex and often contradictory nature of the remit of the International Atomic Energy Agency and the objectives of the Non-Proliferation Treaty and explains the many challenges to the international non-proliferation regime. Adding to these through the massive export of nuclear technologies and materials by encouraging all countries to "enjoy the benefits" of nuclear power would create many, many more problems than it would solve

204. Certainly, changes could be made to tighten up in many areas of the current regime eg putting all technology transfer under a legal system similar to the (flawed) system of plutonium and uranium sales between NPT states. Unfortunately, whatever changes are made will not resolve or eliminate the proliferation risks of nuclear power.

205. We also attach some articles which highlight some of the political problems related to the spread of nuclear technology, how it can lead to the risks of proliferation and the problems in "reining" in the nuclear threat [not printed].[141] We do not agree with all the views expressed in the articles eg that nuclear fuel facilities under international control would be more effective than under national control in terms of reducing proliferation. The information will serve to give the Committee some idea of the complexity of the proliferation aspects of nuclear power.

206. Most telling perhaps is the view of the International Panel on Climate change on this issue. In discussing the idea that nuclear power might be necessary to tackle global warming, the IPCC has warned: "The security threat . . . would be colossal"

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[140] Greenpeace briefing: Proliferation: where civil and military nuclear ambitions form a critical mass. http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7217.pdf.

[141] US hopes for nuclear energy face resistance, *FT*, 19 September 2005 03:00. Nuclear Weapons in Iran: Ploughshare or Sword? 25 May 2004 *New York Times* by William J Broad. Nuclear double standards Why should some nations but not others be allowed nuclear weapons, asks Mohamed ElBaradei, director general of the International Atomic Energy Agency *New Scientist,* p 17, 10 July 2004.

207. Another worrying area in terms of the spread of nuclear power is that it would require significant amounts of fuel if many countries opted for this form of electricity generation. It is believed there are insufficient supplies of uranium to fuel a massive expansion of nuclear power (or even a replacement programme for all current reactors—see following discussion on uranium). If this proved to the case it might mean that countries would opt for reprocessing programmes to extract the plutonium for use in reactors. This would add even more to proliferation concerns and the potential for terrorism if safeguards failed to keep secure materials which could be used in "dirty" bombs or nuclear weapons.

208. Finally, proliferation is not just about nuclear technology and materials. As the Greenpeace briefing explains, the failure of the nuclear weapons states to honour the legally binding disarmament obligations under the Non Proliferation Treaty have, and are being, used as both a justification and incitement by other countries to gain nuclear weapons.

Terrorism

209. It is extremely difficult to give a definitive answer on whether new build would result in more terrorists attacks aimed at nuclear installations. After 9/11 the nuclear industry finally, publicly, acknowledged that nuclear power plants, nuclear waste and spent fuel transports, and waste facilities should all be regarded as terrorist targets.

210. It appears there is increasing concern over the risk of a terrorist attack on a nuclear installation. Reports from governments around the world indicate this is high on the political agenda.[142] Hardly a day goes by in recent months that a story concerning either the risks of terrorism to nuclear plants.[143]

211. Late last year the IAEA appealed for money to update its computer system so it can more effectively track nuclear materials, admitting that the current system is outdated and is not modern enough for effective inspections.[144] The UK's Office of Civil Nuclear Security has recently decided to post armed police around all the nuclear reactor sites in the UK—so significant is the security threat to these sites.[145]

212. Speaking at a conference in Ireland earlier this year, US nuclear specialist Dr Gordon Thompson explained how terrorists could attack a nuclear installation as a "pre-deployed nuclear weapons" and discussed the potential impact of such an attack.[146]

213. Having more nuclear facilities or keeping existing facilities open longer would increase the likelihood of any attack and of the perpetrators being more successful eg more time and more targets available to attack.

214. We also refer the Committee to the Parliamentary Office of Science and Technology report: Assessing the risk of terrorist attacks on nuclear facilities.[147] Greenpeace presented evidence to this on the risk of aircraft being used to crash into nuclear facilities, as well as the risk of land-based attacks.

215. The impacts of any attack would, of course, be dependent on how much radioactive material was released and the plant's situation (facilities near large centres of population would mean more people would be at risk). Recent studies in the US put the health impacts of an attack on a reactor at 44,000 immediate fatalities with 500,000 long-term health impacts, including cancers.[148]

216. Nuclear facilities and transports also provide targets for terrorists wanting steal nuclear materials to use in a low-grade nuclear bomb or a "dirty bomb". Equally likely is that terrorists could use rockets or bazookas to attack a spent fuel transport or ship carrying nuclear materials. Such an attack could result in widespread long-term contamination; harm to the health of the population around the damaged transport—as well as serious social disruption to the affected communities.

CO_2 emissions and the nuclear chain

TOR 6

How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?

Uranium and CO_2

217. Nuclear power is a low-CO_2 emitter, not a CO_2-free source of electricity. This is because the nuclear fuel chain uses energy to mine, mill, enrich and fabricate fuel, to build reactors and associated waste and spent fuel stores and (if applicable) to reprocess and store/manage wastes and nuclear materials from reprocessing.

142 Annan: Nuclear terror a real risk. BBC news, 10 March 2005.

143 eg Are these towers safe? Why America's nuclear power plants are still vulnerable to terrorist attack—and how to make them safer. *Time Magazine* 20 June 2005.

144 IAEA says nuclear security fund healthy but constrained by donors, *Independent on Sunday,* 20 October 2004.

145 UK upgrading nuclear security by posting armed police at sites, *Nucleonics Week* 27 January 2005.

146 http://www.nuclearpolicy.info/Latest—News/Pr05/050307.htm.

147 POST Report 222, July 2004 http://www.parliament.uk/documents/upload/POSTpr222.pdf.

148 Nuclear News Flashes—Wednesday, 8 September 2004—A terrorist attacks on Indian Point could result in as many as 44,000 fatalities immediately and more than 500,000 long-term cancers.

218. Some research on the CO_2 emissions from the nuclear fuel chain has been carried out. Research carried out for the European Union concluded that overall the nuclear power life cycle, produces around 50% more greenhouse gas emissions than the wind power life cycle.[149] Although this does not mean nuclear power a major source of CO_2 emissions, it does serve to highlight that it does not come "CO_2 free" as the nuclear industry would like people to believe.

219. For many years the nuclear industry has given the impression that there is an endless supply of uranium for new nuclear reactors. This is not correct, as with fossil fuels there is a limited supply of readily accessible uranium—at the right ore concentration.

220. Increasingly questions are being asked about how much uranium would be available if the industry experienced a massive expansion.

221. Last year a report by the International Atomic Energy Agency[150] on the future of nuclear power included discussion on uranium supply. The basic conclusion is that if all current plants were replaced with new reactors (operating on a 60 year life) the easily accessible, cheap reserves would be used up within 60 years.

Uranium—decreased supply, lower grades, more CO_2 emissions

222. In a global setting CO_2 emissions from the nuclear life cycle are therefore likely to rise in future as the industry is forced to use increasingly poor grades of uranium—which take a massive amount of energy to extract from the ground and "enrich" to reactor grade.

223. Using lower-grade ores leads to increased CO_2 emissions through enrichment processes and accessing remote ore bodies leads to increased costs and operational problems.

224. The CO_2 contribution to from nuclear power is in addition to the already substantial risks of accident, terrorism and radioactive waste that nuclear power presents.

Proliferation implications from plutonium use if uranium is scarce

225. The amount of uranium available also has terrorist/proliferation implications if countries opted to use mixed uranium-plutonium fuel (MOX) instead of just uranium fuel. As the IAEA mooted in its report, limitations on uranium supply may mean that countries extend the energy of uranium through reprocessing and extracting plutonium for use in fast breeder reactors (a very hazardous technology rejected by most nuclear states) or MOX fuel.

226. Thus in the UK the amount and type of uranium and therefore the energy used in making fuel, may be complicated by proposals that future nuclear power plants use of MOX instead of fuel made solely from uranium.

227. Until a reactor proposal is on the table and information provided on whether or not MOX fuel would be used it is not possible to say how much CO_2 might be used to provide the fuel to run a reactor. However, MOX fuel is dependent on:

— reprocessing plants to separate out the plutonium from spent fuel (which entails a whole panoply of associated facilities which also use energy);

— a MOX fabrication plant (which, as we have seen from earlier discussion) is a costly endeavour; and

— transports from the reprocessing site to the reactor in question—which will require significant security.

228. Reliance on MOX fuel would, therefore, need more energy and create many more environmental and security concerns than the use of uranium fuel.

229. Within the UK context expanding and prolonging the nuclear industry—if in competition with other countries doing the same (or setting up major nuclear programmes) would necessitate the move towards more reprocessing and the use of fuels which have proliferation concerns as well as higher environmental risks (in reactor use) than "ordinary" uranium fuel.

Uranium mining and waste

230. It is little known that in general 80% of the radioactivity in a uranium ore body remains behind in the waste tailings at a uranium mine. Uranium mining and milling is not an efficient way of maximising extraction of U-238 and U-235. In terms of overall volume uranium mining leads to the largest amount of radioactive waste in the whole nuclear fuel chain.

231. To appreciate the problems with uranium mining we refer you to a recently published report from a coalition of environment groups in Australia which explains some of the problems experienced in uranium mining, even in a developed country.[151]

[149] *AEA Technology* (1998) "Power Generation and the Environment". A UK perspective. Vol 1. http://externe.jrc.es/uk.pdf.

[150] http://www.iaea.org/NewsCenter/PressReleases/2004/prn200405.html.

[151] Nuclear Power: No solution to climate change, Australian Conservation Foundation and other groups, September 2005 http://www.acfonline.org.au/uploads/res_NukesReportfull.pdf.

Nuclear Waste—Public Concern and Mistrust

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Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?

232. We don't know whether or not and when the public would be prepared to say that an acceptable solution has been found. It is quite possible that CoRWM's recommendations will resolve the issue of nuclear waste—but then they may not. Added to that, we don't know if a resolution of current waste problems would make new build acceptable, as although this is a major factor in public acceptance, it is not the only factor.

233. The Government's Energy White Paper said there are "important issues of nuclear waste to be resolved" before new build could proceed. Research carried out for the Department of Trade and Industry to inform the preparation of the Energy White Paper concluded that:[152]

> "Waste Management was a dominant issue for all shades of opinion on nuclear power . . . "

234. But it is not clear what the public might consider to be a "solution" to the long-term management of radioactive wastes, or when it might consider that policy implementation has proceeded far enough. This could, for example, be when (and if) a political consensus has been reached on a nuclear waste management option, or alternatively might need to wait until host communities have been found and planning consent for new facilities has been secured, or even construction of the facility, or a period of successful operation has taken place before they decide this matter is resolved.

235. Alternatively, it may be that the prevailing public viewpoint is that the nuclear waste management option, selected by the Government, is only acceptable on condition that no further nuclear waste is produced. Some evidence for this view was provided by the Ministry of Defence's consultation on the disposal of nuclear submarines—Project Isolus—which recommended that:

> *"The appropriate bodies should be informed of the strength of feeling against building further nuclear powered submarines, especially in relation to the absence of a final disposal route for the radioactive wastes."*

236. There is also evidence from Sweden that the public acceptability of waste management proposals can be increased by setting a limit on the amount of nuclear waste which can be produced in future. For example, the 1980 referendum in Sweden, which resulted in the adoption of a policy to end nuclear power generation by 2010, created the context in which better progress could be made in establishing disposal facilities. This suggests that any future waste management proposals should be combined with a well-defined nuclear closure programme so that an unambiguous picture of the type and scale of waste arisings can be presented to the public. Setting a "boundary" around wastes arising also means there is a limit in terms of cost and defines the size of any chosen facility—which in turn would be an issue for any community asked to host a national storage or dump.

237. Greenpeace's view is that there is no "solution" to the nuclear waste problem, only "least worst" options. As a consequence we should stop producing further nuclear waste as soon as possible.[153]

238. It is also important to remember that CoRWM will not make recommendations about selection of a site or sites, only on which management option or combination of options it recommends. There will then have to be further public consultation on the proposed option and how it should be implemented, which could take a further two or three years. Public consensus might never be reached, which would leave the Government making a contentious decision to impose a solution.

239. Whichever management option is ultimately selected by the Government, it is likely to be some considerable time before any facility becomes available. So the nuclear waste problem, which the White Paper said needs to be resolved, will not even approach resolution until the Government decides on the best management option, say around 2008–09. It is highly likely that the public will require to see, at the very least, waste being placed in an actual facility, perhaps between 2020 and 2040, before it considers the waste problem to be anywhere near resolution. That does not fit in with the industry's timeline for new build proposals.

Public Mistrust of Industry Plans

240. It has been acknowledged by the industry that "solving" the nuclear waste problem is a major issue for it. On current timelines the Government could be proposing a programme of new build—with subsidies for both construction and back-end decommissioning and waste costs—at the same time the industry is looking to site a nuclear waste dump somewhere in the UK.

[152] DTI (Sept 2002) "Integrated Public and Stakeholder Consultation to Inform the Energy White Paper: Summary Report", IPPR, UKCEED, NEF and Dialogue by Design on behalf of the DTI.

[153] Greenpeace's responses to Round One of the CORWM consultation process can be found at: http://www.greenpeace.org.uk/contentlookup.cfm?ucidparam=20050901143916&MenuPoint=D-E-F, and to Round 2 consultation process at: http://www.greenpeace.org.uk/contentlookup.cfm?ucidparam=20050901145240&MenuPoint=D-E-F

241. The public will be well aware that finding a solution—or giving the impression that a solution has been found (as opposed to what might prove to be a recommendation for disposal some time in the distant future)—will be no more than a cynical ploy by the industry and pro-nuclear advocates in the Government so that new build can go ahead.

242. This clash of timing will, unfortunately, undermine much of the valuable work CoRWM has done in canvassing the range of options on nuclear waste (although it should be said that it is too soon to say whether Greenpeace will agree with the recommendations proposed by CoRWM, at least it acknowledges the efforts made by the Committee).

243. Given that the industry's push to get rid of waste has, in the main, been predicated on disposal allowing it to build more reactors—and thus create more waste—the public's mistrust is clearly well founded. This is partly do to with how the industry has handled past disposal proposals via organisation's like NIREX—an organisation which is unlikely to enjoy public support or that of the environment movement if involved in future disposal plans because of the organisation's past activities (that NIREX has moved from being an industry funded body to being a government funded body has not changed this perception).

244. It will also be the responsibility of the Government and industry to explain why taxpayers should pay for disposal costs and possibly invest more money into an industry which produces hazardous wastes; which can be a target for terrorists; which creates weapons-usable materials; which operates plants which can have catastrophic accidents etc. As the sample of opinion polls given below indicates, the Government and industry have a long haul ahead of them on this issue.

Eurobarometer Latest on Public Views on Nuclear Power and Nuclear Waste:

- More than half the EU's citizens oppose the use of nuclear power, according to a new Eurobarometer survey.
- A majority would instead support it if radioactive waste management issues could be solved.
- Of 25,000 EU citizens questioned this spring, 55% said they were "totally" or "fairly" opposed to nuclear power, while 37% were totally or fairly in favour.
- Support for nuclear would increase if the sector's waste problems were tackled, the survey found. Of those initially declaring opposition to nuclear energy, 38% said they would support it "if the issue of nuclear waste were resolved".
- Non-governmental organisations and independent scientists remain the most trusted sources of information on nuclear questions, and the nuclear industry itself the least trusted, but trust in governments and the media has also plummeted.[154]

Eurobarometer survey:

http://europa.eu.int/comm/energy/nuclear/waste/doc/2005_06_nucelar_waste_en.Pdf

and summary

http://europa.eu.int/comm/energy/nuclear/waste/doc/2005_06_nucelar_waste_resume_en.pdf.

Only 1 in 4 support new nuclear reactors in the UK

245. Only 25% of the British public support the building of new nuclear power stations according to a survey carried out by the Institution of Civil Engineers.

ICE Press Release 11 March 2005

http://www.ice.org.uk/news_events/newsdetail_ice.asp?PressID = 272&NewsType = Press

Poll Shows Nuclear Waste as Key Environmental Issue for the Public

246. A MORI poll for the nuclear waste agency, NIREX, shows that a key issue in the nuclear debate is the disposal of radioactive waste.

247. The public rates environmental factors as the most important to take account of in the decision of what energy sources to use—cost is secondary.

248. Radioactive waste does not come first in terms of overall concerns for the public: only 3% mention it spontaneously as an environmental issue that concerns them.

249. When prompted with a list of six major environmental and scientific issues, the public places the management of radioactive waste at the top of the list, alongside controlling pollution.

[154] Most EU citizens "opposed to nuclear power" Environment Daily 1944, 20/09/05.

250. When asked how reliable and honest they expect a number of organisations to be in relation to giving information on radioactive waste, the public places the nuclear industry near the bottom; only the British Government is less trusted. The environmental campaign groups are the preferred option, followed by university/academic scientists.

MORI 2nd December 2004 http://www.mori.com/pubinfo/rk/what-do-the-polls-tell-us.shtml

The establishment of the Nuclear Decommissioning Authority (NDA) on 1st April 2005 has had little impact on public awareness

A new MORI public opinion survey shows that building public confidence in the nuclear industry is still very much a live issue, and a challenge to the success of the NDA. Only four in 10 (38%) are very or fairly confident that the right decisions will be made regarding the future of the industry.

MORI 11th April 2005

http://www.mori.com/polls/2005/nda.shtml

73% of Scots support building more wind farms and only 17% the nuclear option

According to a BBC poll. FoE Scotland Press Release 11 April 2005

http://www.foe-scotland.org.uk/press/pr20050405.html

BBC 11 April 2005 http://news.bbc.co.uk/1/hi/uk_politics/vote_2005/scotland/4430659.stm

More than half of UK public opposed to new nuclear stations

Just over half of people were opposed to the Government considering nuclear power as a future energy source, according to a poll of 1,000 people for BBC 2's Newsnight. Only 39% were in favour.

BBC 16 May 2005: http://news.bbc.co.uk/1/hi/uk/4552051.stm

59% say it would be irresponsible to build more nuclear power stations while problems remain in disposing of nuclear waste.

The public is sceptical about the case for building new nuclear power stations. Hostility to nuclear power is matched by a belief that renewable sources of energy such as wind farms could fill the gap in energy needs in the next 20 years. A Populus survey also found that politicians are not trusted to tell the truth about nuclear safety. The poll found that 59% of those questioned believe that it would be irresponsible to build more nuclear power stations while problems remain in disposing of nuclear waste. Half of respondents go so far as to say that they believe nuclear power to be unsafe.

Times 8 August 2005

http://www.timesonline.co.uk/article/0,,2-1726141,00.html

Part 2

Summary

1. The Government's Energy White Paper (EWP) set out key objectives of developing renewable energy and energy efficiency measures in response to the threat of climate change and the need to secure future energy supply. Progress to date aimed at meeting these objectives however has been either slow or non-existent.

2. It is the view of Greenpeace that these two key objectives can only be met through comprehensive reform of the whole regulatory and fiscal system that currently stifles their progress. Greenpeace proposes a three pronged approach with decentralisation of the electricity system at its heart, providing the framework that will genuinely facilitate the speedy development of the other two prongs, renewable energy and energy efficiency. Greenpeace sets out in detail its vision of a decentralised energy system in the attached report Decentralising Power, [not printed] but the following summary in tabular form is designed to illustrate how a decentralised model is preferable in delivering all of the EWP objectives when compared to a centralised model.

Summary of Decentralised Energy vs Centralised Energy in meeting Energy White Paper (EWP) policy objectives, and summary of further considerations/indirect costs

EWP Objective	*Centralised pathway*	*Decentralised pathway*
Promoting a step change in energy efficiency	Current centralised regime rewards network expansion and demand increase. Remote energy remains irrelevant to the individual. Therefore personal energy efficiency has to be driven by ever increasing number of initiatives. Such as: EEC—remains a square peg in a round hole. Sat with energy suppliers it will forever remain contrary to their core business of increasing profit from energy sales. Has no way of dealing with massive resource wastage through heat loss during combustion process.	Decentralised regime rewards demand reduction and network contraction. Tackles supply-side energy inefficiency head on through more efficient system model. Individual/ESCO ownership of generating technologies offers tangible economic benefits for efficiency and drives energy awareness. Proven effect on reducing energy demand. Captures heat loss from combustion processes thus delivering a highly efficient energy infrastructure.
Deployment of renewables	Centralised grid is extension of fossil-fuel and nuclear technologies since fossil-fuels globally concentrated. Centralised grid designed for large scale generation away from point of demand. Remains unsuited to majority of dispersed renewable energy sources which are often intermittent. Only allows in RE technologies that are centralised (even then penalised)—ie focused on areas of concentrated RE such as wind on hills/out at sea and marine. Renewables investment decisions in hands of global multinationals pursuing short-term profit.	Reflects reduced network needs of highly dispersed RE resources. Transforms economics of RE by mitigating network costs. Delivers active local networks able to cope with intermittency. Highly complementary to renewable heat. Supports a much wider range of renewable energy technologies in many more locations. Empowers many new actors to invest in renewables capacity and challenge existing sector inertia.
Security of supply	Massive inherent system inefficiency demands excessive primary energy inputs weakening national energy security. Dependence on a few energy sources (most of which (fossil fuels and nuclear) will remain a serious environmental threat) brings with it security of supply risks: (a) Failures and shut downs on nuclear power takes out significant proportions of generating capacity. (b) Limited storage of gas and increasing reliance on import bring obvious risks; Small incidents can cause major impacts on a centralised grid leading to major and costly interruptions of supply. Dependence on fossil fuels leaves system open to massive price increases. Dependence on few global suppliers presents security risk (eg of bankruptcy eg Enron, BE) Increasing vulnerability to climate change impacts, eg pylons, nuclear power stations on coastlines etc.	Highly efficient model reduces primary energy inputs enhancing security. Diverse and embedded renewable technologies spread the risk widely Each property has some form of security Impact of system failures can be locally contained and have limited impact and have options from grid/neighboring networks for supply. Impact on district heat networks and private wire systems are therefore limited and short lived Diversified ownership increases security of supply. Reduced exposure to climate change impacts, reduce consequences of climate change impacts.

EWP Objective	*Centralised pathway*	*Decentralised pathway*
Tackling Fuel Poverty	Focus on cheap kWh on grid is poor policy mechanism as households not protected when fossil-fuel prices increase. Failure of suppliers under EEC to meet poor households targets.	Close relationship with energy efficiency insulates householders from effect of price rises. Removal from fossil-fuel market volatility through renewables increases energy security at household level. DE networks suited to council/ association owned estates/tower blocks and already used to reduce bills.
Carbon reduction (see energy efficiency and renewables above)	Remains incredibly wasteful. Centralised thermal combustion will always waste associated heat. Centralised grid will continue to waste significant amounts (of even renewable) electricity through losses in transmission. Supports business demands of global fossil-fuel industry.	Widespread adoption of renewable (low/ no carbon technologies) is demanded. Emissions are therefore minimised Maximum efficiency of technologies is achieved Supports business demands of low-carbon technologies.
Other matters		
Global dissemination	Continued adherence to appalling and outdated energy model undermines bid for international leadership on climate change. Would replicated two-thirds wastage of energy world-wide Would build in reliance on fossil fuels and/or nuclear (and do so for a generation) Raises the question of whether nuclear is suited across the globe—clearly not given uranium rare resource and obvious security problems.	Incubation of low-carbon model offers genuine international leadership. Promotes renewables energy sources which are readily available across the globe Technology is ideal for transfer for international development Releases vulnerable societies from fossil-fuel industry dependency and political manipulation.
Security	Large scale infrastructure open to major attack and disruption Dependence on imported fuel fundamentally changes interaction with foreign policy Nuclear remains very risky	Widespread and distributed so resistant to any form of interference (scale of impact very limited) Limited dependence on imported fuels Reduced fossil-fuel dependency fosters wholesome international relations.
Adaptability to changes in circumstances	Big capital investments require long term returns—thus the investment community leads energy policy Large generating plants can't be readily altered to developing circumstances Reliance on diminishing fossil fuels leaves system open to massive price increases	Allows for more adaptability to technology changes—switching gas CHP to biomass CHP etc. Can adapt to the varying renewable energy sources
Cost	High grid investment Locks in investments to big generating plant. Increases investment risks. Fosters technological timidity. Offloads huge social and environmental costs locally and globally.	Avoids the need for massive investment in centralised grid. Investments made in smaller chunks over a longer period of time—reduces market risk. Therefore fosters technology innovation. Mainstream uptake drives cost reductions in RE technologies.
Technology issues		
Technological progress	Rules and regulations and infrastructure rewards old technologies and suppresses technological progress Drives vulnerable grant-dependency for low-carbon technologies ill-suited to centralised model.	DE model and regulatory regime captures the benefit of technological progress through mainstream market access and incentivises innovation.

EWP Objective	*Centralised pathway*	*Decentralised pathway*
Fossil fuels	Is wasteful of the energy within the fuel Large capital investment delivers dependence (addiction) on to a single fuel type. Fossil fuels will seek public money to address emissions eg "clean coal" to prolong fossil-fuel economy.	Can readily accept fossil fuel powered generation—very efficient CHP—but level of investment allows for changes to be made as future markets and technologies develop. Moves away from supporting economic logic of fossil-fuels.
Nuclear	Is the only system in to which nuclear can fit. If nuclear is considered an answer to CO_2 emissions then it dictates a wasteful; centralised system should be built across the globe. Demands huge public subsidy to address emissions.	Simply doesn't allow for it (and it is basically unnecessary/irrelevant) Many DE technologies can reduce emissions without public subsidy under this model.
Micro generation and decentralised energy	Has to work incredibly hard to be allowed on to the centralised system. The two technologies are largely incompatible. Microgen/DE need the grid to be remodeled.	Provided the ideal platform to delivgher large amounts of micro generation and larger decentralised energy plant.

1. The Extent of the Generation Gap

What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?

3. The DTI's "Updated Emissions Projections" (November 2004)[155] compiled to inform the forthcoming Climate Programme Review indicate that gross electricity supplied to the grid in 2005 is expected to be 361 TWh. Of this, nuclear will contribute 22% and coal 32%.

4. By 2020 all but three of our nuclear plants are due to close, with only Sizewell B expected to be operating beyond 2030. By 2020, these three stations will represent around 7% of overall capacity.

5. The European Large Combustion Plant Directive (LCPD), due to come in to force in 2008, is having a significant impact on the investment decisions of utilities with coal capacity. To adhere to the requirements of the LCPD, expensive flue gas desulphurisation equipment will need to be fitted. Utilities that choose not to fit the equipment can opt out of complying with the Directive, leaving them a maximum of 20 thousand hours of operating time before the plants must close for good. The utilities are free to choose when they run the plants, but they cannot exceed the 20 thousand hour limit.

6. The exact number of stations that will be refitted in line with LCPD regulations is not yet clear. According to Government figures[156], however, it looks likely that of the 19 coal plants currently operating, contributing a combined capacity of 28.6GW, five plants have either already fitted or are currently fitting desulphurisation equipment with a further three strong or reasonable candidates. Together, they represent 14.5GW of which 10GW will certainly be available after the 2008 deadline.

7. So we can deduce that roughly half of the UK's current coal capacity will be committed to closure by 2015.

8. The loss of half the UK's coal capacity along with the large majority of our nuclear plants will result in the loss of around 30–35% of current generating capacity by around 2025, but exactly how this affects the scale and nature of the likely "energy gap" is unclear. What size and form that gap takes depends on many factors that are difficult to predict, such as the progress of renewable energy development, installation of future gas capacity, effectiveness of long term demand reduction measures and the extent of the UK's connection to the EU electricity grid as part of the liberalised European market.

9. The DTI's Updated Emissions Projections suggest that the shortfall in capacity expected by 2020 will be met through a combination of increased gas capacity and the fulfilment of the current RO obligation of 15% by 2015, leading to total output generation in 2020 of 381 TWh. This does not account for any increase in renewable capacity that might result from an extension of the RO beyond 2015.

[155] DTI *Updated Emissions Projections—November 2004, Addendum Projections beyond 2010* See: http://www.dti.gov.uk/energy/sepn/uep_addendum.pdf

[156] Mott Macdonald *UK Coal Production Outlook: 2004–16*, March 2004 see: http://www.dti.gov.uk/energy/coal/invest—aid/lcpd—report.pdf

10. There is little doubt however that we have enough practicable renewable energy potential to fill this gap, however large. According to estimates from the DTI[157], the combined practicable renewable potential by 2025 in the UK is at least 230 TWh/year. DTI projections for electricity output in 2020 stand at 381 TWh, indicating that even with a highly conservative estimate of what is possible, there is still enough practicable renewable energy available to fill almost twice the gap left by the closure of most nuclear and some coal capacity (forecast for energy demand?).

11. More importantly though, the prospect of an energy gap simply reinforces how urgently we need to see effective energy efficiency and renewable energy policies that will stabilise the overall energy demand and make this practicable renewable potential a reality. It is therefore imperative in our opinion that we select a unified energy model that is flexible and resilient enough to deal with this challenge.

12. A current centralised model leaves us poorly equipped to respond to such challenges because:

— It makes highly inefficient use of the primary energy inputted, thereby unnecessarily driving up primary energy demand.

— It leaves us dependent on a few energy sources, most or which must be imported, that create security of supply risks:

— Small incidents have major impacts on a centralised grid leading to major and costly interruptions of supply.

— Dependence on fossil fuels leaves the system open to price fluctuations.

13. A decentralised energy grid provides the best model for overcoming such problems as it maximises the efficient use of the primary energy used to generate the power by capturing and using the waste heat, as well as unlocking the currently unexploited agency of the domestic consumer, giving them the opportunity to become suppliers. The easiest and cheapest way to address the possible energy gap remains to use less energy. The decentralised model provides a genuine economic incentive to use energy efficiently, as well as bringing an understanding of energy use directly in to their homes.

14. Greenpeace believes that the long term framework within which the energy gap can most effectively be closed is through a decentralised energy model that maximises the efficiency of the primary energy inputted and promotes conservation right through the chain from generation source to point of use.

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

15. Concentrating on the investment opportunities of different technologies, putting them in to direct competition with each other, is unhelpful. Greenpeace believes that a more holistic view of investment in the full generating cycle would be more useful. The following illustrates the economic benefits (and therefore investment return) of directing generation capacity down the pathway towards decentralisation represents the best value for money in achieving the objectives set out in the EWP. The varying abilities of each technology type to respond to the different challenges of decentralised generation will then determine their different costs and timescales. This approach allows the model of decentralisation—characterised by small-scale flexibility and reliability—to determine the success of the different technologies, rather than conventional technologies that currently dictate the model of centralisation.

16. Modelling from the World Association of Decentralised Energy (WADE) indicates that application of a DE pathway globally by 2020 would yield 25% reductions in electricity retail prices. In China, similar modelling found that a full commitment to meeting growth through DE rather than centralised power would yield savings of $400 billion.

17. Similar conclusions have been reached for the UK. Most recently, Mott Macdonald's analysis for OFGEM concluded that the cost of embedding DE capacity in local low-voltage electricity networks would be "considerably outweighed by the benefits". The same study estimates that embedding a quarter of UK peak demand capacity on local grids would deliver economic benefits of around £1.3 billion per year.

18. There's seems little doubt that investment in technology and infrastructure consistent with a decentralised grid as opposed to the wasteful and inefficient centralised grid we have at present represents excellent value for money.

2.1 *What are the likely construction and on-going operating costs of different large-scale technologies (eg, nuclear new build, CCGT, clean coal, onshore wind, offshore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh) Over what time scale could they become operational?*

19. Construction and operating costs for different technologies are notoriously difficult to accurately estimate, due to the myriad assumptions that must be made on future fuel prices, steel prices, differing levels of technological maturity and so on. Some attempts have been made to quantify these costs however, a recent example being the detailed assessment of renewable supply costs by Enviros as part of the

[157] DTI *Renewable Energy in the UK* DTI—1998.

Government's ongoing Renewable Obligation consultation (February 2005). Other relevant studies include Oxera's "Non-Market Value of Generation technologies" (2003) and the cost estimates of wind power in the Sustainable Development Commission's report, "Wind Power in the UK" (May 2005).

20. None though are comprehensive, with the most authoritative study of future generating costs still being those quantified by the Government's Performance and Innovation Unit as part their research to inform the EWP[158]. The PIU concluded that by 2020, onshore wind will offer the lowest generation costs, closely followed by energy crops, offshore wind and Combined Cycle Gas Turbines. Nuclear power and fossil fuels with carbon capture and sequestration internalised in to the cost price did not do so well.

2.3 *Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are there any policy changes required to enable it to do so?*

21. As previously stated, conservative DTI figures indicate the impressive scale of practicable potential from renewable generation in the UK. Regarding what scale of generation is required, that depends on which pathway we choose to go down in the future. Under a centralised system, even with complete exploitation of our renewables potential, the anticipated explosion in energy demand will severely undermine any efforts—renewable or otherwise—to decarbonise supply whilst ensuring security.

22. Greenpeace proposes a three pronged approach where policies and investment are focussed upon decentralising the entire electricity system, from generation to end use. A decentralised electricity network will enable more efficient use of the primary energy input (under the current centralised system, only 22% of the primary energy inputted is used in the home), reducing primary energy demand whilst creating an energy environment that is genuinely conducive to the development of dispersed, small scale technologies such as renewables.

23. Equally important, it would also create the correct environment for individuals to take responsibility for energy conservation by fostering greater understanding of the value of electricity, and providing economic incentives either as individuals or as part of community owned Energy Service Companies to conserve power and translate the three pronged savings in to tangible financial reward. Only through pursuit of this approach, with a shift towards decentralisation at its centre, will we be capable of meeting the four key objectives set out in the EWP of cost, security of supply, decarbonising the system and fuel poverty.

24. In terms of policy changes that are needed to achieve the overhaul outlined above, current policies are designed to deliver cheap electricity under a centralised system. There would therefore need to be a complete overhaul of the policy and regulatory system that facilitates rather than obstructs a transition towards decentralisation. Greenpeace proposes:

- A complete overhaul of energy regulation, with OFGEM transformed in to a sustainable energy regulator with its primary duty being to deliver substantial emissions reductions through the encouragement of DE.
- The use of tax incentives for householders and businesses that install DE technologies, such as reduced stamp duty or business rates.
- All new buildings to be required to incorporate DE technologies.
- Removal of current limits on the development of private wires in order to encourage localised sustainable electricity systems.
- Regional statutory CO_2 reduction targets to engage local Government in implementing the transition to DE.
- Legislation requiring all electricity suppliers to purchase power from domestic generators.
- Tightening of the NAP allocations as part of EU ETS in order to accurately reflect the social and environmental cost per KWh of fossil fuel generated electricity.
- No new fossil fuel generation to be permitted unless it incorporates cogeneration.
- The publication of a Decentralised Energy White Paper.

2.4 *What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?*

25. Under a decentralised framework, micro generation would be set to contribute the mainstay of domestic consumption, which currently represents around a third of overall electricity consumption. As detailed above, a shift to a decentralised generation system of which micro-generation would be part would have a significant impact on current investment practices. It would enable many more energy actors to take part, diversifying the investment landscape away from merely the solely corporate investment in large scale projects and towards community ownership and management of complete energy service packages. Many barriers still exist however that currently impede the growth of microgeneration, with the recently

[158] [4] Performance and Innovation Unit *"The Energy Review"*—2002.

announced Building Regulations Part L from the Office of the Deputy Prime Minister constituting another missed opportunity to bolster the industry by failing to oblige new buildings to meet energy performance targets.

26. The lack of a user friendly retail package for microgenerators to gain reward for generating surplus power also remains a significant problem. The Distributed Generation Co-ordinating Group recommended that electricity supply companies should be obliged to publish terms for the buying of excess electricity from microgenerators and purchase surplus electricity under those terms. Greenpeace believes it is imperative that suppliers are obliged to engage with microgeneration industry in such a way as only then will they develop a commercial interest that expertise in resolving the currently outstanding obstacles to the growth of microgeneration.

27. See the Greenpeace report Decentralising Power for more details.

3. *What is the attitude of financial institutions to investment in different forms of generation?*

3.1 *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?*

28. One can assume that confidence in the nuclear market and the returns on investment has to be high in order for the billions of pounds to be offered by the financial institutions. The intervention of Government and the massive underwriting of the industry by the public purse is the only way in which this confidence and level of return can be provided. On the other hand investment in Greenpeace's three-pronged approach, requiring the same confidence and levels of return, can be secured without vast sums of public money being committed for many years in to the future.

29. The investment required is not in CCGT (although this will be required for the short term bridging period) but in the three prongs of decentralising the system, energy efficiency and a portfolio of renewable energies. When investment is looked at in this balanced way it is easy to envisage finance being made available.

30. The confidence that Government needs to provide is not entirely financial; it is principally regulatory. A complete overhaul of the regulatory system to support a decentralised model and the ensuing EE and RE would unlock the billions required to deliver. The simple basis for this is that energy is a multi trillion-dollar business.

- As an industry, in Europe, it is already planning to invest $648 billion dollars[159] in the centralised grid over the coming 30 years.
- The UK domestic electricity sales are valued in billions each year.
- As an economy we lose £12 billion worth of energy each year through its inefficient use[160].

31. Should the Government confidently set the decentralised framework then all three sources of investment can be readily accessed. Financial institutions, whose investment will be required, will respond to this clear signal. In addition a completely new set of investors can be brought to the table with, small and medium sized enterprises, industry, householders and communities making their own investments in energy performance and embedded generating technologies on the basis that this both saves and makes them money. An enthusiasm for personal financial investment along the same scale as for British Gas and British Telecomm can be envisaged with the difference being that the investment is in their own energy needs and financial interest.

32. A new fiscal framework is needed to drive investment by all these sectors in energy generation capacity. Please see Decentralising Power and earlier comments.

3.2 *How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

33. When considering a liberalised energy market we should first and foremost note that a truly liberalised electricity market simply does not exist in the UK or in Europe. Of the 25 European countries, 10 companies operate the majority of the total installed capacity and control over 60% of the overall electricity market. In addition it is also worth recognising that the only electricity that you can buy through any of these suppliers is expensive, inefficient and polluting centralised electricity. The entire system is tilted towards serving centralised power and actively discriminates against small scale and low-carbon technologies. This illiberal and unfair market place is supported by the current maze of regulation and fiscal incentives.

[159] World energy Investment Outlook 2003, International Energy Agency, 2003.
[160] The Energy review 2002, Performance and Innovation Unit, Annex 6.

34. Greenpeace's three-pronged solution can deliver a truly liberalised market. It seeks to remove the bias in the market, economic and sector regulation in favour of centralised power. It therefore introduces to the market place a whole new set of electricity products that are cheaper, more efficient and less polluting that can exploit the economic advantage of proximity to consumers. Consumers therefore have increased choice. It can also foster a much wider range of Energy Services Companies that can be backed by existing multinationals operating on a large scale down to community owned businesses and private individuals. It can allow other existing and successful sectors of the economy (such as retailers) to enter the energy market place encouraging new private sector businesses to grow and become important competitors in a truly liberalised market place.

35. If this route is adopted the level of Government investment would be restricted to supporting the introduction and adoption of emerging EE and RE technologies. The market place would deliver them to the mainstream and ensure all energy was efficient, more affordable and less polluting. The principle purpose of Government would be delivering appropriate regulatory and fiscal frameworks.

3.4 *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

36. In short, the impact would be disastrous. As demonstrated above, the scale of nuclear programme necessary to achieve anything like competitive economies of scale would require a colossal investment programme. Redirection of the finite investment funds available away from renewables towards nuclear would fatally undermine the still fledgling investor confidence currently being bred in the renewables industry, send out a signal internationally that renewables effectively has no future in the UK, and commit both private and public investment to another generation of nuclear for decades, with nuclear waste and clean up costs that would follow.

37. As Gordon Mackerron, one of the principle contributors to the PIU's Energy Review, noted in reference to the nuclear industry's proposal for 10GW of new build:

38. "The nuclear industry's proposal for a 10GW programme was almost the minimum needed to reduce costs to an acceptable level, and in practice a 10GW programme would have crowded out most other generating investment"[161]

39. Most significantly, however, a major programme of nuclear investment would stifle the opportunity that currently exists to decentralise the grid and facilitate the small-scale, dispersed, highly efficient portfolio of renewables necessary to meet the White Paper objectives.

40. Investment in nuclear would require grid reinforcement to accommodate the inflexible, baseload characteristics of nuclear power, rather than the needs of potential renewable developments. Regulatory changes would also have to be made to guarantee a long term price for nuclear, directly contradicting the Government's professed intention the liberalise the market and "let the market decide".

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

41. The principle at the heart of this question is whether investment in RE and EE is compatible with nuclear. The simple answer is no. The commitment of massive funds to a new nuclear programme has two basic negative effects:

42. The first is that it simply removes cash from the energy investment economy making less available to EE and RE. The result is that we will not gain any control over our growing energy demand because we cannot resource EE and that RE will never make it to the mainstream because it is starved of funds.

43. The second negative impact will be that the clear signal will be for a centralised energy pathway. Investments that will last 50 years will commit us to wasteful and expensive generating technologies and the opportunity for empowering a whole new energy industry will be lost. The imperative for regulatory and system reform to fairly support and incentivise RE and EE will be lost and the power balance will remain business-as-usual. The sad result of this is that our only genuinely sustainable opportunity for tackling climate change, keeping the lights on and offering meaningful international leadership will have been squandered.

44. The ONLY investment route that is compatible with the strategy set out in the energy white paper is a decentralised one. A simple options analysis shows that investment in a centralised energy pathway—whether it be fuelled by nuclear or fossil fuels—CANNOT provide long-term energy security, relatively affordable costs, tackle climate change and eradicate fuel poverty. Nor is any other investment model able to be disseminated around the globe.

[161] Gordon Mackerron *"Nuclear power and the characteristics of 'ordinariness'—the case of UK energy policy"*, Energy Policy issue 17 November 2004.

45. In terms of the strategy set out the Energy White Paper, Greenpeace maintains the government has failed to operationalise those objectives by retaining the singular primary remit of the regulator Ofgem. It is embarrassingly obvious that a regulator with a single remit cannot deliver on the four integrated Energy Policy Goals set out in the Energy White Paper. We do not believe there has been a serious attempt by government to pursue them. Further, continuing to bury its head in the sand plays in to the hands of the nuclear lobby. There is an alternative energy scenario that meets all the EWP objectives. It is cheaper, more reliable, more flexible, easily disseminated abroad and uses existing technologies. But it requires courage on the part of Government to look beyond the myopia of centralised generation model that assume demand can only grow and that fuel will always be available.

27 September 2005

Memorandum submitted by Professor Robin W Grimes and Professor William E Lee

Comments on Issue 7:

To understand the issue of nuclear waste it is first necessary to understand that it comes in three forms: Low Level Waste (LLW), Intermediate Level Waste (ILW) and High Level Waste (HLW). Usually when people talk about waste they are referring to high level waste but in fact, this is only a small part of the total, and all the UK's present HLW can be stored in one football-pitch sized final vault. Also a large portion of the UK's legacy waste is from military programmes and is nothing to do with the UK's nuclear power programme. The majority of waste is LLW which contains tiny amounts of radioactive material, often due to slight contamination on clothing and gloves (much of which comes from hospitals). It is safe to dispose of this by placing in metal drums or boxes packed into lorry-sized containers which can be buried at specific landfill sites such as Drigg in the UK.

ILW contains significant amounts of radioactive material but not enough that it generates heat. This includes the metal casings from nuclear fuel rods and radiation sources used by hospitals. It will include wastes from the clean up of existing nuclear sites. Such waste can be encapsulated in cement within metal containers for interim safe storage underground.

HLW is waste that generates heat as a result of its radioactivity. It is either the spent fuel as removed from the reactor or the waste arising from reprocessing the spent fuel to extract the uranium and plutonium which can be reused in fuel. Such waste needs to be kept away from the environment for a very long time, while the long-lived radioactive elements decay to safe levels. In the UK HLW arising from reprocessing is mixed with molten glass in which it dissolves to leave the waste in a glass form that effectively locks up the radioactive elements in the glass structure. The glass is poured into metal containers where it solidifies and the canisters are stored in air-cooled chambers.

A solution for the immobilisation of HLW therefore already exists. That is not the same as saying that all aspects of the nuclear waste cycle have been fully optimised. Thus scientists such as ourselves should continue to investigate the technological limits and boundaries of the present technological solution. Furthermore, as part of public acceptability it must be clear that as our scientific knowledge develops, the core technologies associated with HLW immobilisation are being re-tested and re-evaluated. This is not the same, however, as saying the present solution for HLW is being challenged in a negative context.

The key waste issue which needs to be faced in the next 20 years is not how to immobilise HLW but what to do with the immobilised waste canisters. We must decide on an option and then on where that option will be located! We are presently waiting for a decision from the Committee on Radioactive Waste Management on potential disposal options. The UK is far behind many countries (eg Sweden, Finland, Japan, USA, China) in making firm decisions in this area.

The good news is that modern pressurized water reactor (PWR) designs (such as the AP1000), which could be built in the next decade, to replace our current reactors, generate much less waste than older designs per unit of electricity generated and would therefore increase the total amount of HLW by only a small proportion. In the next 40 years, however, we need to consider likely wastes from future Generation IV reactors. The waste from these could be quite different and therefore require a different technological solution. The challenge is to design for the whole life cycle so that in future we are not faced with waste as an afterthought. There is an old American Indian saying that we do not inherit the earth from our ancestors but borrow it from our children; our long term aim should be not to leave them our mess to clean up.

22 September 2005

Memorandum submitted by Malcolm Grimston

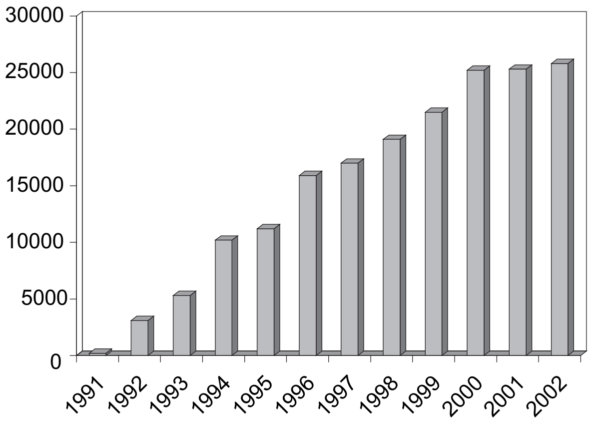
A. The Extent of the "Generation Gap"

It is important to distinguish between potential "power gaps" and "energy gaps" when considering generation of electricity.

The power gap refers to the possibility of electricity outages caused because of insufficient generating capacity being available to meet peak demand. The energy gap refers to a mismatch between the total electricity demand over a period of time, say a year, and the total amount of electricity generated over that period of time.

For most commodities, including many energy sources such as oil, gas and coal, the focus is generally on the latter, since it is possible to stockpile large amounts of the commodity. (This being said, there are growing concerns about the UK's storage capacity for natural gas as North Sea reserves become depleted.) This is not the case with electricity—the absence of a large-scale storage method means that secure supplies can be threatened not only by a chronic shortage of fuel or failure of the transmission system but also by insufficient capacity to cope with unexpectedly high demand and/or high levels of unscheduled plant outage.

While the UK has maintained a "capacity margin" of between 15 and 25% in recent years, the fall in investment in new plant since 2000 following the "dash for gas" suggests that this situation may not continue.



New installed capacity since 1991, UK (MW, cumulative)[162]

(Capacity margin, expressed as a percentage, is defined as:

Generation capacity—Average Cold Spell (ACS) demand

It is generally accepted that a capacity margin of between 12% and 20% is needed to ensure secure power supplies against unexpected events such as a surge in demand, perhaps because of extreme weather conditions, or the unexpected breakdown of a considerable number of generating plants. The precise size of the required margin depends on factors such as access to imports and the fuel mix used for electricity production.)

As it is, secure electricity supplies in the UK are already vulnerable in extreme circumstances. On 10 December, 2002, the UK faced its highest power demand then recorded, of 54,430 MW, some 5% higher than the previous maximum, as a result of a cold spell which developed over the previous four days. It occurred in the context of breakdown of some 3,500 MW of capacity over the previous week. In the morning of December 10 it seemed that the demand would be met comfortably but in the three hours before the hour of peak requirement a record amount of plant was withdrawn because of breakdown (about 2,400 MW). Plants with technical problems were called up or ordered to continue generating and all steam plant was instructed to operate at full stretch. Although outages were avoided it was close-run thing and the balancing price reached £10,250 for a single MWh tranche.[163]

Higher futures prices for the winter of 2003 led to companies returning capacity from mothballing: in 2005 Ofgem announced that energy supplies to domestic customers could be maintained even in a 1-in-50 winter and that the electricity capacity margin stood at over 20%.[164] However, bringing plant back from mothballing is a different matter from investing in new projects and it remains unclear whether enough investment is being made to deal with shortages in the medium term (say up to 2010).

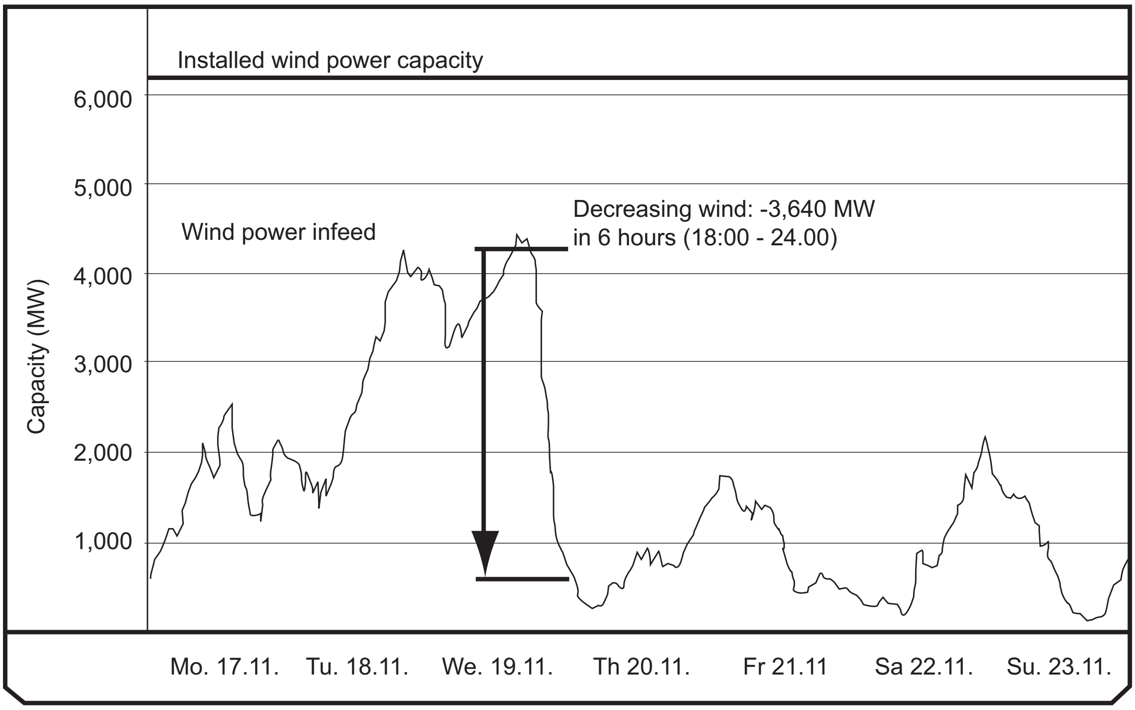
[162] http://www.nera.com/wwt/publications/5740.pdf, Shuttleworth G and MacKerron G, (2002), *Guidance and commitment: persuading the private sector to meet the aims of energy policy,* NERA: London.

[163] http://www.nationalgrid.com/uk/indinfo/balancing/pdfs/ DAY_IN_THE_LIFE_10_Dec_Issue_1_final_version_4_March_updated.pdf, Ball R. (2003), *A day in the life—an operator's view of Tuesday 10th December 2002.*

[164] http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/11583_r24_31may05.pdf, Ofgem (2005), *NGT publish consultation on possible winter energy supply scenarios, Ofgem Press Release (May 31, 2005).*

In the longer term, a combination of closure of most of the UK nuclear fleet by 2020 and of much of the UK's coal capacity in the same period (owing in part to the effects of the European Large Combustion Plant Directive which will severely restrict permitted emissions of sulphur dioxide) with ongoing growth in electricity demand suggests that considerable new investment in plant will be required simply to meet the potential gaps in both energy and power production. At the end of 2004 some 73,300 MW of capacity were registered in the UK by major power producers (with another 7,000 MW owned by auto-producers), of which 22,600 MW were coal-fired and 11,900 MW nuclear.[165] Assuming capacity requirements in 2020 of about 85,000 MW (a central estimate derived from various government publications, notably the supporting statistics to the 2003 Energy White Paper) it is likely that some 34,000 MW (40% of 2020 requirements) of new capacity will be required by that date. It follows that the battle is not between "nuclear or renewables", as it is sometimes portrayed—large amounts of plant will be needed and there is plenty space (and perhaps even need) for both.

It should be noted that, from a power gap point of view, some renewables, notably windpower, cannot be counted as a *pro rata* contribution towards overall capacity as their output is too dependent on weather conditions. Wind availability tends to be inversely correlated to electricity demand—anticyclones that bring cold winter nights and hot summer days tend also to bring low wind speeds. For example, in 2003 E.On Netz was taking output from over 6,000 MW of wind capacity in Germany. The output could fluctuate widely within relatively short periods of time.



Fluctuations in wind power feed in E.On Netz control area, November 2003[166]

How Do These Relate to Electricity Demand Forecasts and to the Effectiveness of Energy Efficiency Policies?

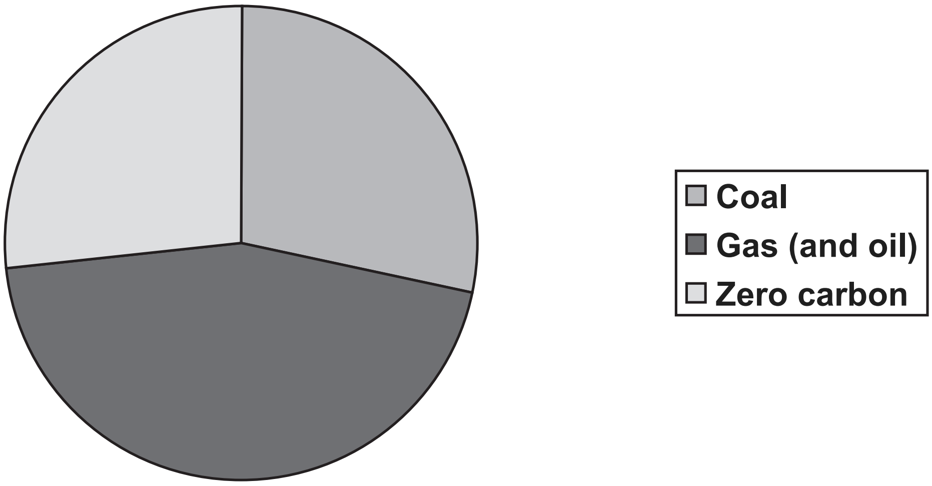
Taking the middle estimates from publications such as Energy Paper 68[167] and the supporting documents to the 2003 White Paper[168] it is possible to construct a plausible middle estimate of electricity demand and fuel mix for 2020, which appears as follows:

165 http://www.dti.gov.uk/energy/inform/energy_stats/electricity/dukes05_5_7.xls, DTI (2005), *Digest of UK energy statistics* Table 5.7.

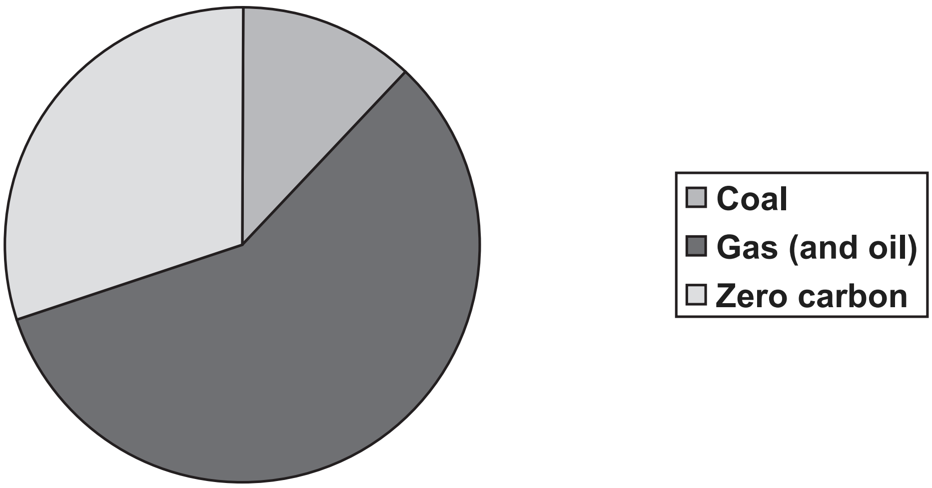
166 http://www.eon-netz.com/frameset_reloader_homepage.phtml?top = Ressources/frame_head_eng.jsp&bottom = frameset_english/energy_eng/ene_windenergy_eng/ene_win_windreport_eng/ene_win_windreport_eng.jsp, E.On Netz, *Wind Report 2004.*

167 http://www.dti.gov.uk/energy/inform/energy_projections/ep68_final.pdf, DTI (2000), *Energy projections for the UK.*

168 http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf, DTI (2003), *Our Energy Future—creating a low carbon economy.*



UK fuel mix 2000—demand 329 TWh



UK fuel mix 2020?—demand 381 TWh[169]

The 2020 figures assume that the aspiration for 20% of electricity to be generated by renewables is achieved but that no new nuclear plants are built, so that in effect new renewable build simply replaces nuclear stations with little net greenhouse gas emission benefit. It also assumes that electricity imported from France is zero-carbon (ie nuclear). If the renewables aspiration is not met then the shortfall is likely to be provided by gas; if it is then spare capacity (again, probably gas-fired) will need to be built to compensate for the intermittency of renewable sources.

The 2020 projection assumes considerable improvements in energy efficiency, as forecast in the source materials. Higher levels of technology-driven energy efficiency *per se* are unlikely to make much difference to the projections owing to "rebound" (Khazzoom-Brookes) effects.[170] However, if energy prices are increased significantly then overall energy use may be constrained further, although this would be in tension with government aims for "affordable" energy.

A. Financial Costs and Investment Considerations

The key point is that very large amounts of investment in new generation capacity—and, depending on its location (eg the wind resource offshore), on new grid connections and developments—will be required in any case. The comfort induced by the "dash for gas" of the 1990s has already proved temporary.

For fossil fuels, notably CCGT (Combined Cycle Gas Turbine), costs of generation are deeply affected by the costs of the fuel itself. If we are moving into an era of oil prices at $60 per barrel plus (or even above say $40), with gas and (to a lesser extent perhaps) coal prices following suit, then the economics of these sources of electricity will look much less positive than they have done since the collapse of the oil price in

[169] Grimston M (2003), *Defining the value and role of nuclear power in the UK energy mix*, IIR Conference Electricity Trading in the UK, London, September 30, 2003.

[170] See http://www.rpi.edu/dept/economics/www/workingpapers/rpi0410.pdf, Stern D and Cleveland C (2004), *Energy and economic growth*, Rensselaer Polytechnic Institute: New York.

the mid-1980s. Some renewables will indirectly be affected by high gas prices, since the back-up capacity necessary to underpin investment in windpower (against low or very high windspeeds reducing output) will in all likelihood be gas-fired.

The new generation of simplified nuclear plants look economically attractive on paper if costs are viewed on a whole-cycle basis (ie including the external costs associated with environmental damage and averaged over the 50 year lifetime of the plant)—see for example the recent Royal Academy of Engineering report.[171] There are however two caveats.

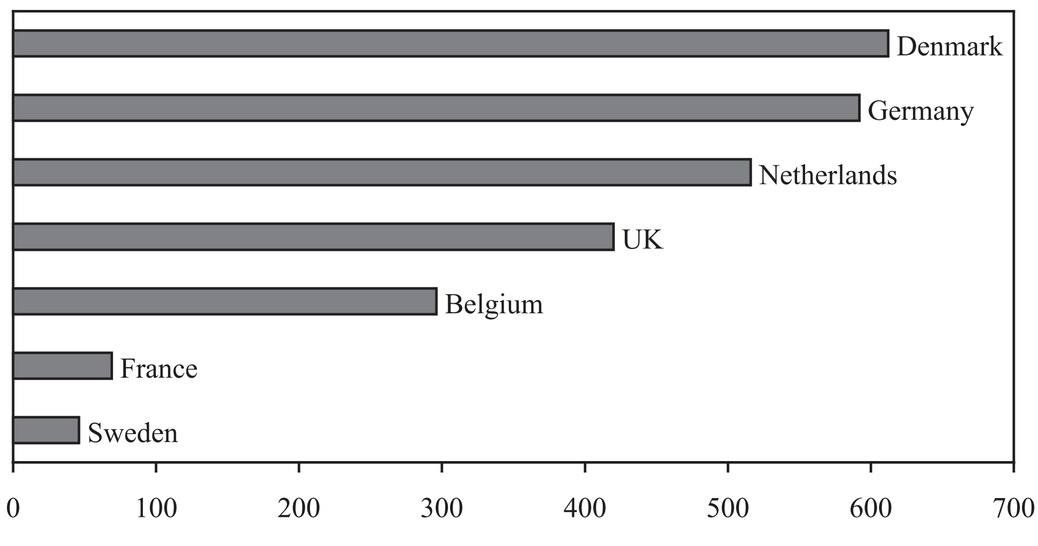
First, the new technologies have not yet been fully demonstrated, Potential investors would need to be confident that the "appraisal optimism" of the nuclear industry in the past, notably with respect to the British Advanced Gas-Cooled Reactors, will not be repeated. However, there is evidence that recent plants built in the Asia-Pacific region, which include many features of the new passive designs, are now being brought on line to time and cost. Furthermore, it is unlikely that the UK will follow a uniquely British design path in the future but will instead be able to take advantage of experience elsewhere.

Secondly, in a competitive market high-capital low-running cost technologies tend to be at a disadvantage given the essentially short-term nature of the wholesale power market, making full-cycle costing difficult and perhaps of limited relevance owing to different levels of economic risk. Funding of new build may therefore require some mechanism for providing long-term contracts, perhaps through consortia of major electricity users/suppliers (as has been the case with the IVO plant under construction in Finland) or protected market share as the kind implied by the government's renewables obligation.

B. Strategic Benefits/D. How Carbon-Free is Nuclear Energy?

The strategic benefits of nuclear energy are clear—a financial and resource hedge against fossil fuel prices and availability; and a near-zero carbon source at a time when UK greenhouse gas emissions are on a worrying increasing trend after the accidental benefits of the "dash-for-gas" and increasing nuclear output in the 1990s.

That a major programme of nuclear energy can deliver reduction in carbon dioxide emissions of the sort required by the Royal Commission on Environmental Pollution[172] is easily demonstrated by considering the emissions per unit of electricity generated in a range of countries.



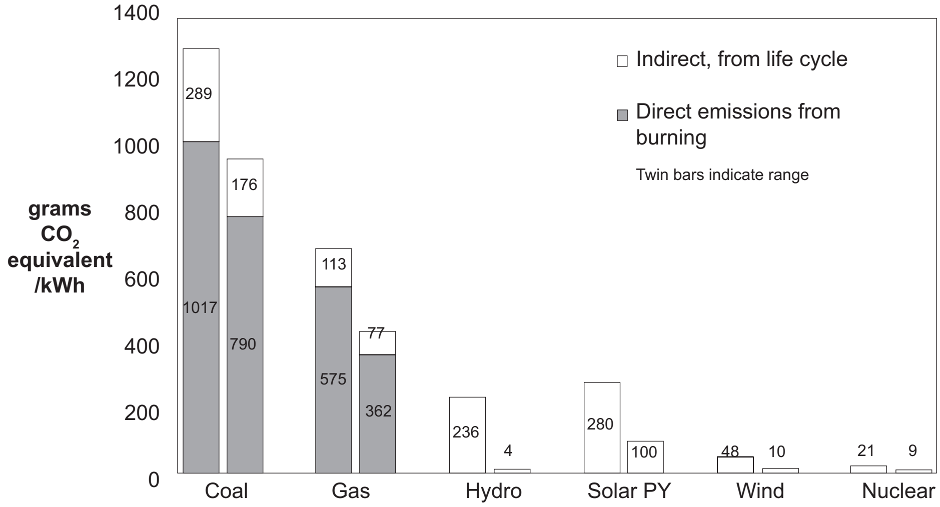
Carbon dioxide emissions per unit of electricity produced (g per kWh)

Those countries whose electricity production is dominated by coal (Germany, Denmark) have emissions roughly 10 times those which have major nuclear (France), hydro (Norway) or both (Sweden) programmes. Should the transportation sector be penetrated by electricity (either directly or through hydrogen produced by electrolysis, for example) these benefits could be increased considerably. The costs of reducing greenhouse gas emissions by large nuclear programmes has varied considerably, but in the best cases (eg France) it is very low and may even be negative (ie very low carbon nuclear energy may be advantageous over fossil fuels in cost terms even without pricing greenhouse gas emissions by a tradable permit system or pollution taxation).

[171] http://www.countryguardian.net/generation_costs_report.pdf, Royal Academy of Engineering (2004), *The costs of generating electricity*, RAE: London.

[172] http://www.rcep.org.uk/newenergy.htm, Royal Commission on Environmental Pollution (2000), *Energy—the changing climate*, The Stationery Office: London.

Emissions from various fuels vary as follows.



Greenhouse gas emissions from electricity production[173]

Assuming 90% availability, a 1,000 MW nuclear power station will produce some 7.9 TWh of electricity per year. If this were to be generated using coal (using mean life cycle figure of 1,136 grammes per kWh for coal and 15 g per kWh for nuclear) the emissions would be some 8.8 million tonnes of carbon dioxide (2.4 million tonnes carbon equivalent) higher; if generated by gas carbon dioxide emissions would be 4.3 million tonnes (1.2 million tonnes carbon equivalent) higher.

1 September 2005

Memorandum submitted by Nigel Hawkins

All the views expressed below are my personal opinions and they do not seek to reflect those held by any organisation for whom I have worked—or am working currently.

A. Extent of the Generation Gap

1. The National Grid's Seven Year Statement probably provides the best estimates of future electricity generation capacity requirements. However, the key factors are the extent to which nuclear plants will secure life extensions and whether any new Combined Cycle Gas Turbines (CCGTs) are built: high gas prices are a serious disincentive to invest in new gas-fired plant. Renewable energy projects will add a minimal amount to base-load generation capacity. Historically, electricity demand has grown at around two-thirds of GDP. Energy efficiency has—and probably will—continue to have a marginal impact on demand growth.

B. Financial Costs and Investment Considerations

2. It is new base-load—not mid-merit or peaking plant—that is needed. The two main options are new nuclear or new CCGTs: the latter would increase the UK's exposure to high gas prices. Renewable projects are generally unsuited to providing base-load capacity. The per KWh costs are very dependent upon the assumptions within the financial model, especially in terms of the gas price assumption—it accounts for c60%–70% of a CCGT's generating costs. However, a new CCGT plant could be constructed within two years prior to any planning delays.

In the presentation that I made to the nuclear conference held at Canary Wharf by the Westminster Energy Forum during the summer, I concluded that a new nuclear plant is capable—subject to certain financial and contractual obligations—of providing electricity at a price of between 2.3p and 2.8p per KWh over a 40 year period. My financial model assumes a 1,250 MW plant, whose capital costs were projected both from the data provided by vendors of nuclear plant and from other relevant figures. I also assumed that a new nuclear plant could be operational within four years of the first concrete being poured. Obviously, the lengthy planning process would involve a further lead time, although I believe that new nuclear-build should only be considered for existing nuclear plant sites.

I doubt whether any renewable project—except large-scale hydro—can deliver power consistently at below 4p per KWh, unless particularly favourable assumptions are made and they are financed by major international energy groups, such as E.On and RWE: both of the latter would command a low Weighted Average Cost of Capital (WACC).

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173 http://www.iaea.org/Publications/Magazines/Bulletin/Bull422/article4.pdf, Spider J, Langlois L and Hamilton B (2000), "Greenhouse gas emissions of electricity generation chains—assessing the difference", *IAEA Bulletin* 42 **2**.

I have not undertaken detailed comparative analysis, since the per KWh generation figures are almost entirely dependent upon the initial assumptions made. In any event, the UK needs a mixed portfolio of generation sources—and not just the cheapest option at a particular point in time. The Royal Academy of Engineering report, which was published in 2003, gives some comparative analysis, although the assumptions made are crucial, especially the 23p per therm gas price. The level of ROC payments is also very relevant for the financial viability of renewable projects.

In the case of offshore wind, wave and tidal, I find it improbable that major projects from these sources can be developed within the next decade either from a technical or financial aspect.

Past experience of new nuclear-build relates to the 1960s/1970s designs of AGRs—almost exclusively in the UK—and to the First-of-a-Kind (FOAK) PWR at Sizewell. Major engineering advances have been made in the interim. Hence, the experience of Asian new nuclear-build in recent years is more relevant. The construction performance has generally been good, although Japan continues to experience major problems—especially in PR terms—with its nuclear industry.

My nuclear financing model, which formed the basis of my presentation to the Westminster Energy Forum conference on nuclear power, allows for waste/decommissioning costs on a per KWh basis. The Net Present Value (NPV) costs of plant decommissioning are minimal due to the very extended plant lifetime. I don't believe that insurance is a serious problem, since nuclear insurance is a very lucrative business for the insurance sector: the largest potential pay-out, Chernobyl, was uninsured.

In terms of waste, I believe it should be buried at Sellafield, given the massive cost of cleaning up the site. It is accepted that a repository may be needed for HLW and MLW, most of which has been generated since the 1960s.

As part of its licence to operate, any new nuclear-build owners would be required to undertake nuclear waste disposal as specified. This obligation is unlikely to be a major concern given that E.On, RWE, EDF and BE are the most obvious investors—directly or otherwise.

In terms of physical and technical capacity—and omitting the difficulties of fund-raising—the two major constraints for renewables are planning, especially for onshore wind, and grid connections. In the case of the latter, it is still far from clear how National Grid's future regulated capex programme, which would be incorporated within its Regulatory Asset Value (RAV), should be boosted to allow for additional renewable capacity, especially of wind plant. It is also the case that, as renewables capacity grows, further back-up plant will be needed and some grid strengthening will be required: the experience of wind plant in the Schleswig-Holstein area of Germany is relevant in this respect.

The relative efficiencies of different generating technologies vary considerably, depending on various factors. Aside from nuclear, gas efficiency levels are now edging towards 60%, whilst most coal-fired plant should be between 35% and 40%. I am not convinced that micro CHP, micro-wind and PHV can make any meaningful contribution to meeting UK energy demands over the next decade.

3. Financial institutions will compare generation investment alongside other investment scenarios in other sectors, both in the UK and overseas. However, over the last decade, many investors have lost considerable sums of money, especially from the collapse of various Independent Power Projects (IPPs). The failure of British Energy, following the introduction of NETA, also did damage to the quality of UK generation investments. There is also real concern about the financing of new renewables projects, especially as a start-up exercise.

In my experience, financial institutions will study carefully any plans to build new nuclear plant. However, they will be disinclined to study too many hypothetical scenarios—they will look at the data when efforts are actually made to raise the finance. The quantum of funds should not pose a serious problem. Four new nuclear plants costing c£5 billion is relatively modest when set against Network Rail's £40 billion investment requirements. To be sure, the collapse of British Energy will not help the process but it does not mean it is insurmountable. Indeed, if big players, like E.On, RWE and EDF are involved, the financing should not be too onerous, providing a few key criteria are met—Government guarantees as per the Network Rail bonds and long-term Power Purchasing Arrangements (PPAs). CCGT investment would carry less risk, because of the smaller capex element. With the exception of a major tidal wave scheme, no renewables energy project is of the same scale as new nuclear-build.

In terms of funds from Government, I believe that new nuclear-build can take place without overt Government financial support. A Network Rail-type guarantee for the bonds and long-term PPAs—possibly being a supply licence requirement—may suffice to keep the WACC in the 7%–8% range, with 80% debt and 20% equity. The Government would also need to push through the planning process—if necessary by amending current legislation. The requirement for long-term PPAs would be little different from the requirements currently imposed on existing energy suppliers through the Renewables Obligation. In my view, there would be no incompatibility with existing energy liberalisation policy but more a recognition that new nuclear is needed for the long-term benefit of UK plc.

Given the small financing requirements for renewables projects, I do not think there would be a major impact if new nuclear-build were to take place. What would be more relevant is whether renewables could provide sufficient PPA comfort to convince lenders and whether the various infrastructure—such as grid connections—and economic issues can be overcome.

C. Strategic Benefit

4. I don't think new nuclear-build requires Government financial support, save the Network Rail-type bond guarantee. However, new nuclear-build would provide the UK with a genuinely mixed energy portfolio and far less exposure to international gas prices, notwithstanding balance of payments benefits. Such a scenario is especially valid for base-load plant. Nuclear is also a very good hedge against fossil fuels, both in terms of prices and emissions. Unlike most other commodities, such as tea, electricity is quite essential for any modern economy—and therefore demands Government involvement. Given the very differing time profiles of the main generating sources, it is arguable that nuclear's attractions are too-long term for many investment horizons. By way of example, each FTSE 100 company is likely to have had three different Chief Executives between planning investment in a new nuclear plant and getting electricity from one.

Carbon emission levels in the UK are principally a function of the output from coal and CCGT plants. The more power that is generated from other sources bar these two, the lower will be the level of carbon emissions. New nuclear-build would only have an impact on carbon emissions once it was actually in operation.

New nuclear-build would make a major contribution to energy security long-term, both in terms of minimising the chances of power cuts but also in lowering the price risk factor. In any security of supply scenario, a solid base-load generation performance is crucial. Nuclear is also divorced from the many risks attached to gas imports. Some security of supply risks, such as a grid failure, are outside the generation environment. It should also be noted that the impact of sustained power cuts in the IT-dominated era of 2005 is immensely more serious than in the early 1970s despite the contraction of UK manufacturing industry.

Clearly, the terrorist risk cannot be ignored for new nuclear-build, although it applies equally to current nuclear plant. However, if a nuclear replacement scenario were adopted, there should be no major difference from the status quo.

5. New nuclear-build is specifically aimed at producing large quantities of base-load electricity, something that renewables is simply unable to do. I don't believe that micro generation or any energy efficiency scheme—the latter has been tried for over 30 years—will produce the volume of additional power that is needed. After all, with all nuclear plants, except Sizewell, due to be decommissioned by 2023—subject to any life extensions—a considerable amount of new base-load capacity will be needed both to replace them and to sustain an economy growing at over 2% per year. I do not believe that renewables, with a few exceptions, can deliver a sufficient volume of power or can do so at economic prices.

D. Other Issues

6. As I understand it, the generation of nuclear power produces minimal carbon emissions: moreover, the construction of such a plant is unlikely to produce significant carbon emissions. I have no specific experience of uranium mining but I would expect that any carbon dioxide emissions would be minimal. Indeed, when set against carbon dioxide emissions in the US, China and India—none of whom have signed up to the Kyoto Treaty—any such emission levels from nuclear activities would be inconsequential. Of course, the totally unprecedented disaster at Chernobyl in 1986—a plant that would have failed Western Europe construction and operation practices—should be considered totally separately in terms of environmental damage.

7. I do not believe that the nuclear waste issue should be allowed to wield a veto over new nuclear-build. After all, nuclear plants have been operating in the UK for almost 50 years without a full resolution of this problem. I would argue that the UK would be taking a real risk by not building new nuclear plant—both in terms of security of supply risk and exposure to high gas prices. Whilst CoRWM's recommendations still have to be finalised, burying the waste at Sellafield still appears to be the obvious option.

20 September 2005

Memorandum submitted by Innovative Energy Solutions

1. We are most grateful for this opportunity to contribute our views on these critical issues to the EAC.

2. ResponsiveLoad Limited is a small private knowledge-based UK company pursuing innovative technologies to facilitate and enable lower carbon behaviours within the Electricity Supply Industry (ESI). We hold a UK patent. Several UK and European patent applications, with successful PCT searches, are in progress.

3. I, David Hirst, am the principal and inventor, and I am actively supported by the ResponsiveLoad Limited board. David Slater, ex Chief Regulator of Pollution for UK and Royal Academy of Engineering Professor of Sustainable Engineering at University of Manchester is non-exec Chairman. Robert Spears, chairman of the Utility Consumers Consortium is a non exec board member.

4. We are pleased to provide this evidence to the Environmental Audit Committee, as we believe our technologies, although not yet fully mature, enable a vision of a fully sustainable ESI, able to meet the challenges of Climate Change without compromising or risking current or future well-being.

5. This document represents the views of the company derived from internal debate. We have restricted our comments to the areas where ResponsiveLoad Limited has particular expertise.

6. We have no fundamental objections to nuclear power, but do not believe the envisaged "new nuclear build" programme will successfully address the critical issue facing us, but rather detract from more sustainable solutions that could.

7. The following paragraphs explain some of the issues that a nuclear power programme will need to address.

Nuclear Power is Inflexible

8. Nuclear plant is very limited in its ability to adjust its output—it is essentially baseload with emergency cut off. This is a fundamental constraint, as the cost of designing and implementing controls to adjust the reactor output is very high, and would compromise many current safety arrangements and certifications. This is because, with current control systems, modulation of the reactor output causes changes the balance of radio nucleotides in the reactor, and these poison the chain reaction. The poisoning decays quite rapidly (days), but impacts the capacity of the reactor to increase its output. In France, they are able to make limited reductions of power output for weekends, but this is only possible when the reactor has been recently refuelled.

9. If the power station is subject to an emergency shut down, then it is usually days before it can be restarted—due to the poisoning of the reactor by the shutdown process. So should there be a major or significant blackout in which one or more nuclear plants have to shut, then those plants become unable to contribute to the immediate recovery, and restoration will depend on other sources and nuclear power stations that have not shut down. As a consequence dependence on nuclear baseload will increase the impact of blackouts, or requires other investment to deal with this (rare, but feasible) contingency. After the US NE blackout of 2003, shortage of nuclear generation was an issue for some days.[174]

10. In the UK, the inflexibility of nuclear plant has largely driven the need to ensure adequate "off peak" load, with the extensive and expensive infrastructure of "white" meters and electricity storage heaters. The cost and losses associated with this inflexible infrastructure is rarely factored in to the costs of nuclear electricity generation.

11. In Europe, the inflexibility of French nuclear plant drives large overnight exports of electricity to countries where the generation portfolio includes more flexible generation that can be switched off. Often, the low cost enables pumped storage to be replenished and so contribute power during the day. The large overnight export from France to Italy may well have been a contributor to the major blackout of Italy in 2003.[175]

Nuclear Plant is Large Scale

12. The suggested nuclear plants are individually large scale—around 1GW.[176] This is at variance with the trend towards smaller plant, more amenable to series or mass manufacture. This smaller scale is evident in the high efficiency evolution of other power station technologies.[177]

13. The large scale also means that the transmission and distribution system will continue to need frequency response capable of coping with the unplanned loss of such plant. At present, the largest credible single loss of generation is considered to be the Sizewell plant (1.3GW), followed by the loss of half the link to France (1GW) (a link largely dedicated to exporting French nuclear generation to the UK). This need for frequency response is currently largely met by holding a "spinning reserve" of part loaded but flexible plant. This plant must be in a position to replace lost generation within a few seconds. This means it cannot be nuclear plant, and it tends to be older (and so less efficient) coal fired plant.

14. A continuing fleet of nuclear plant (or even just one large scale installation) will thus require the grid to maintain the same scale of spinning reserve that has become traditional. This will create an obstacle to more distributed, participatory forms of electricity market, such as that advocated by the Government (via, for example, the Distributed Generation Co-ordination Group[178]), by Greenpeace, in a recent report[179], and by ResponsiveLoad Limited in a recent submission to the DTI.[180]

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174 DOE, 2004 Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations U.S.-Canada Power System Outage Task Force. https://reports.energy.gov/

175 UCTE, 2004 Final Report of the Investigation Committee on 28 September 2003 Blackout in Italy, Union for the Coordination of the Transmission of Electricity www.ucte.org

176 1GW = 1,000MW. The peak demand for the whole UK is around 56GW.

177 Lovins, A B, *et al,* Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size. 2003 Earthscan Publications Ltd, 1881071073:

178 Distributed Generation Co-ordinating Group. DTI & Ofgem. http://www.distributed-generation.gov.uk/index.php.

179 Greenpeace, 2005 Decentralising Power. An Energy Revolution for the 21st Century, Greenpeace.

180 Hirst, D R, Microgeneration Strategy and Low Carbon Buildings Programme. ResponsiveLoad Consultation Response. 2005.

15. This ResponsiveLoad Limited submission to the DTI is attached to this letter [not printed], as it articulates a vision of how the ESI can evolve to participatory disturbed electricity markets, incorporating smart price sensitive appliances, large and small scale renewable generation, as well as low carbon domestic generation, such as Domestic Combined Heat and Power, wind and solar technologies. The opportunities to pursue these sustainable and low impact technologies would be damaged by pursuit of the "new nuclear build" programme.

16. Nuclear reactors create steam that is converted to electricity by steam turbines. Steam turbine generation (which is at best 40% thermally efficient) is inherently wasteful. If the power station is large and sited in a remote area, they will be unable to use more than a small proportion of the unused heat, which becomes wasted. This waste heat will have significant local thermal impacts. For example, during the drought summer of 2003 depleted French rivers were unable to meet the cooling needs, and, despite raising the permitted river temperatures, power stations had to be shut.

17. The skills needed to operate and keep safe a large scale infrastructure will be increasingly scarce. In an engineering world concentrating on large volume production of highly efficient small scale generating equipment, the skills and engineering infrastructure associated with large scale custom built equipment will inevitably decline.

Challenges to Nuclear

18. The problems raised here are soluble, but at a cost that will have to be carried by the rest of the ESI. They are not easily quantified, but are substantial.

19. Nuclear power could, at least in principle, address the issues by appropriate technology. Long series production of small scale and flexible generation units, capable of being safely and securely used in, for example, a district Combined Heat and Power plant, would fit well within the vision proposed. We would expect the costs of such systems to be reliably predictable and individual deployment to be quite rapid. Such systems could become "ordinary" and so fulfil criteria for public acceptability.[181] We hope that this is a challenge the nuclear industry will pursue.

20. Our resources in insufficient to provide meaningful analysis to address the specific questions raised in your enquiry brief, but we hope the evidence is sufficient to demonstrate that realistic alternatives to a new nuclear build are desirable and possible. We would be happy to address questions you wish to raise or provide further oral evidence.

21. We look forward to the results of your inquiry.

21 September 2005

Memorandum Submitted by the Institute of Directors (IoD)

Introduction

(i) This is the response of the Institute of Directors (IoD) to the Committee's inquiry into the options for investment in meeting future requirements for new electricity generating capacity—"Keeping the Lights on: Nuclear, Renewables, and Climate Change" (Environmental Audit Committee Press Release dated 21 July 2005).

(ii) The IoD is an individual membership organisation made up of some 54,000 directors of business and other important organisations worldwide, mainly in the United Kingdom. Members of the IoD are drawn from all sectors, and functions within organisations.

(iii) The IoD is also involved in scrutinising United Kingdom Government and European Union (EU) policies. This includes making responses to public consultations. The IoD gave written and oral evidence to the House of Commons on the UK's climate change policy, in 1999.[182] It also gave evidence to the House of Lords (on EU climate change policy) in 2004.[183] It has published policy papers on various environmental issues, including energy and climate change.[184] The IoD also advises its members on issues connected with energy use and environmental practices. One of the most recent was a guide to directors on issues connected with climate change.[185] This was produced with the support of the Carbon Trust.

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181 MacKerron, G, Nuclear Power and the Characteristics of "ordinariness"—the Case of UK Energy Policy. Energy Policy, 2004. 32: p 1957–1965.

182 Memorandum by the Institute of Directors (IoD) (CC8), *Environment, Transport and Regional Affairs Committee UK Climate Change Programme Memoranda relating to the inquiry submitted to the Committee,* House of Commons Session 1998–99, HC171-II, The Stationery Office (TSO), London, 20 January 1999, pp 21–25, and *Environment, Transport and Regional Affairs Committee UK Climate Change Programme Minutes of Evidence Wednesday 3 March 1999,* Session 1998–99, HC171-ii, TSO, London, 3 March 1999, pp 40–45.

183 Memorandum by Geraint Day, the Institute of Directors (IoD), *The EU and Climate Change Volume II: Evidence,* House of Lords European Union Committee, 30th Report of Session 2003–04, HL Paper 179-II, TSO, London, pp 248–252.

184 See, for example *Energy: the policy climate,* IoD Policy Paper, Geraint Day, IoD, London, 2004, and *Global Warming—Implications for Business,* IoD Research Paper, Geraint Day, IoD, London, June 1998. These and others may be found at www.iod.com/policy/papers under "Transport, Environment & Energy".

185 *Climate change how UK businesses can benefit by reducing carbon emissions,* IoD and the Carbon Trust, Director Publications, London, September 2005.

(iv) Aspects of several of the specific questions posed by the Committee are addressed in this response under the heading used in the Committee Press Release, as well as the principal questions posed by the Inquiry.

Inquiry Issues Posed by the Committee

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

(v) According to work by Cambridge Econometrics published on 16 September 2005 UK demand for all sources of energy taken as a whole over the years 2005–15 is likely to increase by between 0.25% and 0.75% per annum.[186] This was despite a forecast fall in industrial use. It was estimated that increases in transport, household and commercial use would offset industrial reduction.

(vi) The Department of Trade and Industry (DTI) has commented that the reduction in electricity supply from the planned phase out of existing nuclear power plant will be made up by an increase from gas-fired power stations and from renewable energy sources.[187]

(vii) There have been concerns about reliance on gas for reasons of concern about security of supply from some parts of the world. Notwithstanding carbon sequestration, for which to be sure there are plans, the fact of greater reliance on a source (ie gas-fired power plant) that generates greenhouse gases is worthy of note. Current UK Government policy means that this would be occurring at the same time that UK nuclear power would be being phased out. More seriously, if the Government is determined about meeting its own commitments on greenhouse gas emissions then energy mix as such should be put back on the policy agenda.[188] The IoD has urged previously that the Government should fulfil its commitment to initiate a debate about the need for nuclear power.[189]

(viii) Energy efficiency measures are key in themselves, yet they are already factored into many energy forecasts. As the DTI has stated previously a range of measures is required to tackle problems of energy policy and of atmospheric greenhouse gas emissions. No single measure can—or should be expected to—provide a guarantee in either policy area.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

(ix) In general a stable public policy environment is desirable for investment in new electricity generating capacity. It was stated in the 2003 Energy White Paper that "Government is not equipped to decide the composition of the fuel mix used to generate electricity".[190] Yet a policy strand deliberately underlying that White Paper is that of focusing on greenhouse gases and seeking more application of renewable energy technology. In this sense the Government has already intervened in the energy market (and there are instruments such as the renewables obligation that do just that).

(x) Returning to the topic of nuclear power, note that Sir Alec Broers, President of the Royal Academy of Engineering, stated in 2003 that renewable energy would neither prevent global warming nor power blackouts: "I think we need both [nuclear and renewable energy]".[191] The long lead time for construction of nuclear power plant is another reason for a decision sooner rather than later.[192, 193] The construction periods are a decade or more, most likely. For such investment timescales stability of public policy is certainly desirable.

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[186] Cambride Econometrics news release, 16 September 2005: www.camecon.com/whatsnew/releases/uke3/text.htm.

[187] www.camecon.com/services/samples/UKE3.pdf.

[188] See for example Memorandum by the Energy Intensive Users Group, *The EU and Climate Change Volume II: Evidence,* House of Lords European Union Committee, 30th Report of Session 2003–04, HL Paper 179-II, TSO, London, pp 257–260.

[189] *Energy: the policy climate,* IoD Policy Paper, Geraint Day, IoD, London, 2004.

[190] *Our energy future—creating a low carbon economy,* DTI, Department for Transport (DfT) and Department for Environment, Food and Rural Affairs (DEFRA), Cm 5761, TSO, February 2003, p 87, para 6.47.

[191] Mark Henderson, "Nuclear power is 'critical to Britain's future'", *The Times,* 18 August 2003, p 10. Professor Broers also said that "The view of wind power is over-optimistic—that we can get to 20% renewable energy by 2020 and that it will be as straightforward as that. Some forms are far more expensive than we think they are." The costs of having back-ups to wind power needed to be factored in, for example.

[192] "Come clean on your nuclear policy", *Financial Times,* 28 August 2003, p 16.

[193] The Energy White Paper also states that the expectations being placed on energy efficiency and renewables are not only extremely ambitious, they are also "uncertain": *Our energy future—creating a low carbon economy,* DTI, DfT and DEFRA, Cm 5761, TSO, February 2003, p 12, para 1.23.

(xi) Current Government policy, which relies heavily on targets for renewable energy, may or may not lead to real changes. Rather than relying too much on targets for renewables, economic policies that will encourage innovation seem more likely to lead to breakthroughs in the required technologies. One thing is for sure; at present there is no guarantee that any particular renewable energy source will ensure adequate supply of energy. It seems quite likely that renewables will come to play a much bigger role over time. Yet there are other issues to be considered. Apart from engineering considerations around efficiency and continuity of energy supply from a range of technologies, from wind to photovoltaics, there are issues such as land-use planning to think about. Expressions of public support for more wind (ie renewable) power are not found to be consistently acceptable when subject to some of the long delays of the planning process, at least when it comes to onshore wind power.

(xii) Other factors such as the availability of trained personnel to design, build and operate some of the new technologies come to the fore. Such concern for the supply of sufficiently educated and skilled people is not confined to the energy or environmental sectors, but it does appear to be a subset of a national concern over the availability of skills in science and technology in general. This relates to Government education and skills policy. The IoD has previously referred to this in the context of energy policy.[194]

3. *What is the attitude of financial institutions to investment in different forms of generation?*

(xiii) The Committee posed a supplementary question as to the impact of a major programme of investment in nuclear power on investment in renewables and energy efficiency. Of course, with a finite amount of investment, a focus on one technology would deny some resources to others. Yet it may ultimately prove to be the case that diversity of emphasis and of investment will be crucial. As referred to in paragraph viii above, a mix of approaches is needed. If one energy source is interrupted, we need to be able to rely upon another. Thus it is important to ensure that there is security of supply that we can control, and also to invest more in research and development on new technologies of various sorts.

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

(xiv) On the nuclear front the Government's Energy White Paper states that if innovation in low-carbon technologies did not make enough impact, then costs of cutting carbon emissions would be higher. It is of significance to note that it also that they would be higher if improved energy efficiency savings were not to be made, or if both new nuclear power capacity and carbon capture and storage did not materialise in the long term.[195] So the basis of deciding whether or not there were any need for financial support should lie around considerations of energy demand and of UK and international policy on the importance of greenhouse gas reductions. The public goods would include energy supply and security of energy supply.

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

(xv) The Government's energy White Paper of 2003 has sought to promote energy efficiency measures and renewable energy sources as the main means of reducing the UK's carbon dioxide emissions. Scepticism has been forthcoming, not only from environmental groups but also from some energy experts. For example, by rejecting nuclear power and not investing enough in renewable sources some have said that this will not do enough to move away from reliance on oil and gas.[196]

(xvi) The strategy set out in the Energy White Paper already involves potentially conflicting goals (reducing greenhouse gas emissions; maintaining reliable energy supplies; promoting competitive markets, raising sustainable economic growth and improving UK productivity, and ensuring all homes are adequately and affordably heated). Thus deciding upon the relative allocation of resources as between nuclear power and other energy technologies or measures is no different in this respect.

20 September 2005

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[194] *Energy: the policy climate,* IoD Policy Paper, Geraint Day, IoD, London, 2004, p 36.

[195] *Our energy future—creating a low carbon economy,* DTI, DfT and DEFRA, Cm 5761, TSO, February 2003, p 28, box.

[196] Natasha McDowell, "Experts cast doubt on Britain's green energy ambitions", *Nature,* Vol 421, 27 February 2003, p 879.

Memorandum submitted by the Institute of Physics

1. Introduction

Within an approximate five- to 10-year time frame there are likely to be significant reductions in both coal-fired and nuclear fission capacity. As a consequence, despite reductions in energy demand resulting from increased energy efficiency and an increase in renewables capacity, there will be a shortfall in generating capacity. This will also be impacted by the intermittent nature of the primary, near-term, renewable energy sources.

Over this timescale, the shortfall can only be addressed by the construction of additional capacity from existing technologies. Such capacity must, however, be consistent with the commitment for reduction in greenhouse gases emissions. Policy and regulatory regimes must also ensure that both sustainability and diversity of supply are assured and that the UK does not become overly dependent on imported oil or natural gas.

2. Climate Change

The objective of meeting climate change targets is fundamental, as the issue of stopping the growth (and preferably the reduction) of atmospheric carbon dioxide levels and other greenhouse gases is one of great importance. Realistically, emissions need to be reduced by about 60% to stop growth; however, that target at present appears to be unattainable.

The continuous use of fossil fuels will eventually result in carbon dioxide levels exceeding the recommended upper limit of 550 ppm which, as highlighted in the Royal Commission on Environmental Pollution's (RCEP) report, *Energy—The Changing Climate*, will probably lead to dangerous and destructive climate change.

The Institute has noted the Government's commitment to meet challenging environmental targets, such as a reduction in the emission of greenhouse gases of 12.5% by 2008–12 and of carbon dioxide by 20% by 2010. It is of concern to note that the RCEP report stated that the UK is poorly prepared to meet these long-term targets. Our concern is exacerbated by the fact that carbon dioxide emissions have risen during each of the past two years, and are now higher than at any time since 1997.

The Institute is of the view that, although a reduction in current levels of greenhouse gas emissions is achievable, this could be more than countered with large increases in emissions from developing countries like India and China, undergoing rapid industrialisation. Thus, the UK along with the rest of the EU, needs to continue to push for international progress in reducing emissions.

3. Natural Gas

Natural gas is expected to fuel the production of over two-thirds of the UK's electricity by 2020. Such a dependence on what will increasingly be an imported resource is a major concern. The Institute published a report last year, *Gas supplies to the UK—a review of the future*, which clearly highlights the risks associated with a dependence on importing natural gas, to meet the UK's need for energy.

The report stated that from 2006 the UK was forecast to become a net importer of gas. However, it is of concern to note that the UK actually became a net importer in 2004. This has implications for the UK's security of supply, in terms of:

- potential threats to supply arising from political instability in gas-producing nations;
- price disruptions arising from risks associated with the supply and demand of gas; and
- concerns relating to the transit of gas and the facilities through which it is delivered.

The report also stated that a greater demand across the EU for natural gas is forecast, with increased competition for the same gas resources as nations attempt to meet their own carbon and pollutant-reducing targets. Even though carbon dioxide emissions from gas-fired generating plants are significantly less than from previously dominant coal-fired plants, gas-fired electricity generation alone will struggle to help meet the UK's future climate change targets. Additionally, there are concerns over gas leakage during transit along long pipelines, which is of concern as natural gas (ie methane) is an even more potent greenhouse gas than carbon dioxide.

4. Nuclear Fission

(a) *What nuclear offers*

Nuclear fission has a major role to play in lowering carbon dioxide emissions, as it can meet base-load electricity demands and is practically a zero carbon dioxide emitter. Given that most EU nations are poorly prepared to meet their respective Kyoto Protocol emissions targets, the Institute believes that new nuclear power plants need to be commissioned to replace current plants as they reach the end of their lives. If new nuclear power plants are not constructed, then by 2020 there will be a power void which will most probably have to be filled by fossil fuel electricity generation resulting in more, not less, carbon dioxide emissions.

The Institute has in recent years welcomed both the UK Government's and the Scottish Executive's various initiatives to tackle carbon dioxide emissions such as the renewables obligation and the climate change levy. However, the Institute feels that the nuclear industry has been severely disadvantaged by not being exempted from the climate change levy, since nuclear power does not contribute to carbon dioxide emissions.

The Institute wholeheartedly agrees with the views of the UK Government's Chief Scientific Advisor, Professor Sir David King, that in order for the UK to meet its international targets to reduce carbon dioxide emissions, it must inevitably revive its nuclear power plant building programme.

Unless there is new nuclear build, the reliance on fossil fuel energy generation will be unabated. The decommissioning of nuclear plants in Scotland, for instance, will result in the loss of approximately 55% of its current electricity generating capacity by around 2023. New nuclear plants are required in order to maintain and improve not just the UK's, but the EU's current diversity, security and environmental balance of electricity supply.

On the critical path of ensuring an extant option for nuclear power is the technical assessment or "licensing" required by the regulatory authorities. This is a three-year process which does not pressure implementation but would ensure an option to move forward while nuclear is kept open.

(b) *Novel reactor designs*

While the popular perception in Europe and North America is that nuclear power is an industry in decline, the reality worldwide is the reverse. Over recent years there has been a wave of new nuclear plant construction in the Far East, most notably in China. In addition, Finland and France are constructing new nuclear plant.

The Institute's technical report, *The future of fission power—evolution or revolution?*, published in April 2004, highlights the technical advances that are being made in reactor designs worldwide. New modular reactors are being developed, which have lower capital costs, are more efficient, safer to operate, produce significantly less radioactive waste and generate electricity at a lower cost unit than the current fleet of reactors.

The report reviews both evolutionary and revolutionary reactor designs. Evolutionary designs capitalise on existing technology and introduce system simplifications that improve safety while, at the same time, reducing costs. For example, the AP1000 design, a pressurised light water reactor from Westinghouse, already licensed in the US, and the European Pressurised Water Reactor, which is the design adopted by both Finland and France, are both ready to seek licensing in the UK. A key feature of the evolutionary designs, following 9/11, is that they meet ever more demanding safety and security requirements. A study sponsored by the Electric Power Research Institute, in the US, determined that current reactor structures are robust and protect the fuel from impacts by large commercial aircraft.

Revolutionary designs reviewed in the report include the development of High Temperature Gas Reactors and Pebble Bed Modular Reactors, which represent the first of a class of "revolutionary" systems. These revolutionary designs will be inherently even safer and more efficient than the evolutionary class. The Pebble Bed Modular Reactor (PBMR) is being developed in South Africa by an international consortium. Key benefits of PBMR include the fuel's ability to withstand very high temperatures, and the fact that the concept is of a simple modular construction with consequential low capital cost of units, which may be produced in substantial numbers ensuring economy of scale. These systems also have the potential for duality of mission, ie electricity and hydrogen production, desalination, symbiotic process heat for energy intensive chemical processes.

The report concluded that both types are needed. The evolutionary designs are needed to plug the gap left by the retirement of current nuclear and fossil fuel plants, and to avoid the sizable increase in carbon dioxide emissions in the near future. Revolutionary designs could then follow, delivering safe, long-term competitive and sustainable energy.

One of the key problems of ensuring fission's future in the UK could be the lack of a skilled work force. The nuclear industry, at present, plays a key role in the UK economy, employing 40,000 directly and supporting many additional jobs—new build would offer opportunities to maintain and grow the work force, while keeping alive the knowledge and expertise that has been built up. New build would also benefit the UK in terms of GDP. The benefit in GDP terms of a programme to replace the current nuclear fleet has been assessed in a recent independent study[197] at around £4 billion per year once the stations are all operational.

[197] Macroeconomic Analysis of Nuclear Plant Replacement, Oxford Economic Forecasting; Match 2005.

The Institute's report also makes reference to work that is jointly being carried out cooperatively by a number of countries on the US Department of Energy's Generation IV programme. This activity is aimed at developing advanced reactor systems and fuel cycles for deployment circa 2030. International collaborative work has selected candidate systems to be developed that further improve the economics, safety, environmental impact and security in order to meet the stringent challenges of sustainable development energy generation in the 21st century.

(c) *Legacy waste and new build*

In considering the issues relating to managing radioactive waste, it is fundamental to separate those dealing with pre-existing radioactive waste from issues involved in the construction of new nuclear plants. Even if a decision were made not to construct new nuclear plants, the need to manage nuclear waste produced as a consequence of past and current electricity generation and plant decommissioning will remain. The new nuclear plants, highlighted in the previous paragraphs, will generate significantly lower amounts of waste. A fleet of 10 new reactors would be enough to maintain the UK's share of nuclear electricity at around 25% and such a fleet, operated for their full design lifetime of 60 years, would add less than 10% to the volume of waste which already exists. The new waste would also be easier to deal with than much of the legacy waste. The UK should not use the challenge of dealing with some of the more difficult legacy wastes as a basis to delay the decision for a new nuclear build programme.

5. Nuclear Fusion

Nuclear fusion has long been hailed as the ultimate energy source, mimicking on Earth the processes which take place deep inside the Sun and other stars, where light elements are fused to form heavier ones, releasing huge amounts of energy.

Harnessing this energy on Earth would provide a virtually inexhaustible energy source with no greenhouse gas emissions.

The Institute is of the view that nuclear fusion potentially has an important role to play in low carbon energy generation in the long-term future. Despite the fact that commercial electricity generation from nuclear fusion is not likely before 2040, its benefits as an energy source for the long-term future are significant.

Fusion research is finally coming of age. Results from large machines like the Joint European Torus (JET), the world's largest magnetically confined fusion facility, mean that physicists have a deep understanding of the processes that will make fusion a reliable system for large-scale base-load electricity generation. The UK Government and their international partner Governments commitment to the International Thermonuclear Experimental Reactor (ITER), which it was recently announced is to be built in Cadarache, France, will hopefully lead to a demonstration of fusion energy production on a 20–30 year timescale.

6. Renewables

(a) *The challenge for renewables*

The Institute wholeheartedly supports RD&D into new renewable energy technologies which potentially, may eventually reduce the UK's dependence on fossil fuel electricity generation. Renewables are an essential part of the future energy mix, but there is a need for increased research and innovation in the relevant RD&D sectors, in order for the UK to be in a position to respond to the challenges of the medium to long-term future.

The Institute notes that the 2003 Energy White Paper, *Our energy future*—creating a low carbon economy, aspires by 2020 to double the UK's renewables' share of electricity from the 2010 target of 10%. The equivalent targets for Scotland are 18% by 2010 and 40% by 2020. These targets represent a significant challenge given that, in the UK, only 3.6% of electricity was generated from renewable energy in 2004, coupled with the fact that renewables presently suffer from various barriers to exploitation, which in themselves demand greater RD&D.

(b) *Barriers to the deployment of renewables*

Realising the large potential benefits that renewables and other advanced technologies, such as fuel cells, could make to a low carbon economy requires a number of technical, economic, institutional and social constraints to be overcome. Overcoming the technical and economic barriers requires substantial RD&D to improve performance and reliability, bring down costs, and resolve issues of grid integration. These measures need to go hand-in-hand with policy support to remove institutional and social barriers.

Maturity

The maturity of renewables varies considerably. While a number are commercially proven, others are still at a pre-commercial stage, and some still require quite fundamental R&D.

Cost

In the UK, at current gas prices and under current market structures, mature technologies are not yet competitive with existing gas fired Combined Cycle Gas Turbine plant without subsidy, although in the medium term (2020) some technologies (eg on- and off-shore wind) could be. Technologies such as solar photovoltaics are unlikely to be cost-competitive with centralised generation unless a step change in cost-effectiveness is achieved by the new types of photovoltaic cells currently under development. They may, however, become competitive in remote off-grid locations, where the cost of other stand-alone systems, such as diesel generators, is high. It is also worth noting that as Governments seek to reduce carbon dioxide emissions, the emissions will acquire an economic "cost". For example, the EU Emissions Trading Scheme which is now operational will determine a monetary value per tonne of carbon dioxide for the trade of carbon dioxide emissions. If this additional cost of emitting carbon dioxide from fossil fuel based power sources is taken into account in the future, then the competitiveness of renewables will improve.

Intermittency

Many of the technologies, for example, wind power, are intermittent and thus require energy storage or backup generating capacity to be available on the electricity network.

Distributed nature

Current renewable energy plants are generally small in scale—from a few kilowatts for individual PV installations to tens of megawatts for biomass plant—compared to conventional power stations (typically a gigawatt or so). The small scale nature of renewables has advantages for use in some situations, for example, for stand-alone applications, but in a country like the UK where the transmission grid is designed for distribution of power from a small number of large power stations, the incorporation of small, distributed sources raises some technical issues. The bulk of renewable energy resources may also occur in locations which are remote from regions with large energy consumptions (eg remote parts of Scotland), and where grid infrastructure to transport the power is limited or non-existent.

Social and institutional constraints

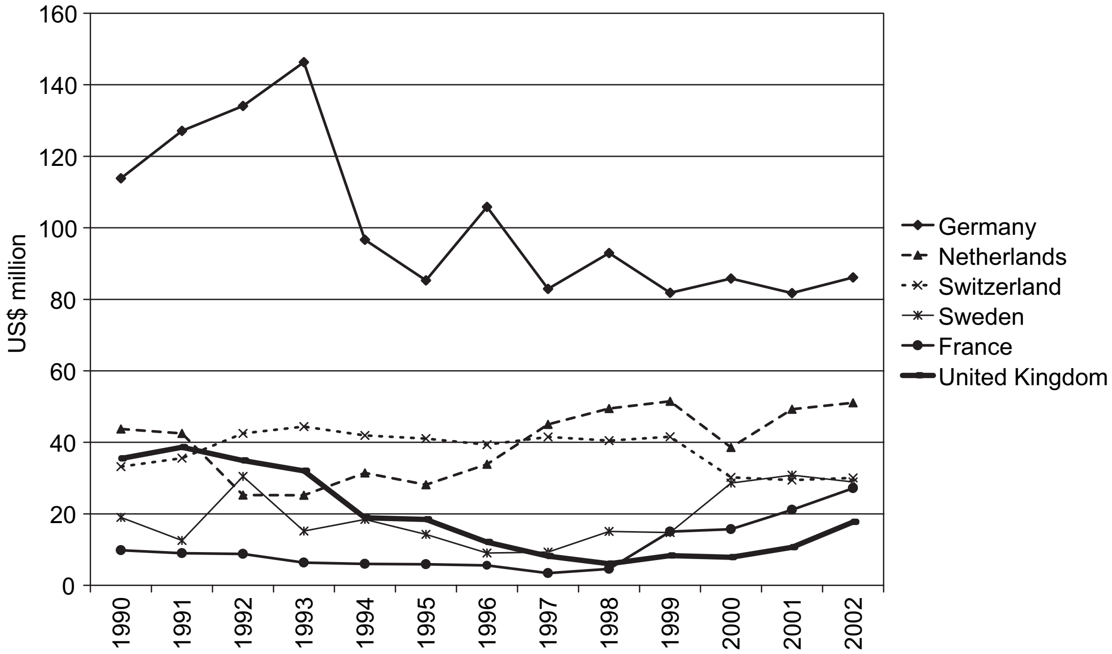
Issues which may hamper development include: public acceptability, planning constraints and institutional barriers, for example, lack of clarity over planning consents, permitting of plants, skills issues, and investment regimes. While most renewables are environmentally benign, in that emissions of carbon dioxide and other air pollutants associated with them are typically very low (even after allowing for their manufacture), they do have a number of other local environmental impacts. For example, wind turbines may be visually intrusive, particularly if they are located in areas which are highly prized for their beauty or isolation. This can cause considerable local opposition, and care is needed to ensure that technologies are located sensitively, and that techniques to mitigate impacts are used where possible.

Funding for RD&D

A significant problem facing renewables and other low carbon generating technologies is that, following the liberalisation of the UK energy market, the current price of electricity is so low that it is not economically viable to develop and introduce new generating technologies to the market, unless they can be developed at a low cost and can provide electricity predictably at competitive wholesale prices. The solution to date has been to subsidise RD&D; renewables have benefited from Government support for RD&D and, in the absence of any other solution, this will need to continue.

Renewable energy RD&D in the UK is funded through a number of routes; the main ones supported by the Government and the public sector, together with EU funding. In addition, there is industry funded RD&D, and commercial deployment of renewables in the UK is supported by the Renewables Obligation. The House of Lords Science and Technology Committee suggested in their report, The practicalities of developing renewable energy, that the level of funding for RD&D is not sufficient if the UK is to meet its renewable energy targets. While UK expenditure has increased in recent years, it is still lower than in several other European countries (see figure 1); US expenditure on renewables RD&D is about $250 million per annum.

Figure 1
Annual RD&D Budget for Renewable Energy (Million US $)
[Source: International Energy Agency]



A recent DTI/Carbon Trust review[198] found that there appears to be a funding gap in moving renewables to the pre-commercial stage, and from the pre-commercial to the supported commercial stage. They also considered that the current landscape for renewables funding is complex, which suggests that a clearer overall strategy for UK RD&D in both renewables and other new energy technologies, together with a clearer map of RD&D funding and clearer demarcation of roles of different funding bodies could be useful. This could be a potential activity for the new UK Energy Research Centre. A clearer research "atlas" indicating institutions and developers carrying out relevant RD&D could also encourage graduates and postgraduates to consider working in this field by clearly showing the variety of career opportunities available.

For physicists currently wishing to work in this area, the main source of public UK funding is the EPSRC's SUPERGEN programme. The EPSRC has been tasked with taking a clear lead in driving forward the sustainable energy agenda and covering the full spectrum of energy research issues, and was given extra funds in the 2004 Spending Review to expand support for research and training necessary to underpin future energy options (including renewables)[199].

However, the amount of RD&D spend available through SUPERGEN is far too small to drive the necessary research, let alone the far greater effort needed to transfer this into production. Renewables seem to have developed a "low cost" view of their implementation, which will not drive the actual costs of developing energy sources on the scale needed.

20 September 2005

Memorandum submitted by the Institutional Investors Group on Climate Change (IIGCC)

1. Institutional Investors and Climate Change Policy

The Institutional Investors Group on Climate Change (IIGCC) was established in 2001 as a European initiative to promote the assessment and active management of the investment risks and opportunities posed by climate change. Our membership comprises 26 leading European investors, including both pension funds and fund managers, with total assets of over Euro1.4 trillion. A list of our members is provided overleaf.

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198 Renewables Innovation Review, DTI/Carbon Trust, 2004. www.dti.gov.uk/energy/renewables/ policy/renewables—innovation—review.shtml
199 EPSRC, 2005. "Delivery Plan 2005/06–2007/08", www.epsrc.ac.uk

As a group, we have three main objectives:

- to equip our members with the knowledge and tools to integrate climate change into their investment practices;
- to act as champions of the importance of climate risk within the investment community; and
- to advocate to public policy makers the need for a proactive, orderly and efficient transition to a low carbon economy, and thereby a secure climate system.

In our view, getting policy on climate change right is critical for protecting and enhancing the value of our investments on behalf of our clients and beneficiaries. We recognise that climate change is a product of market failure: the absence of appropriate incentives has led to individuals and companies externalising the costs associated with greenhouse gas emissions, generating significant risks to both the global environment and the global economy. As a result, public policy innovation is essential not only to minimise the damage caused by climate change, but also to maximise the opportunities from the transition to a low carbon economy. Without credible public policy frameworks, companies and their investors will be handicapped in planning how they respond to the climate change challenge. Moreover, a policy framework that fails to take account of the strategic nature of climate change could result in discontinuous change in the future, a sub-optimal outcome for long-term institutional investors.

2. IIGCC's View on the Inquiry

We recognise the importance of the issues being considered by the Committee. As IIGCC is a collaboration between investors with varied views on the environmental, technology and economic challenges at the heart of the Committee's investigation, we are not in a position to present a single, commonly agreed, view on the questions raised by the Committee in its Terms of Reference. However, we would like to propose three factors that we believe should inform the Committee's discussions, namely economics, time-horizon and innovation.

- Economics: Climate change has quickly moved from being an environmental threat to a strategic economic challenge of the first-order—both in terms of the physical impacts of a destabilised climate and the need to transform the energy and other sectors to deliver sufficient carbon reductions. As investors, we believe it is imperative that a sound economic approach is applied to future climate change and energy policy formulation. This means integrating the environmental and security costs of all energy options into decision-making. In this regard, the entry into force of the EU Emissions Trading Scheme has shown the effectiveness of market-based approaches that make the cost of carbon visible to investors in ways that other tools have failed to do.
- Time Horizon: Climate change is a uniquely long-lived threat, with impacts likely to extend for hundreds of years into the future. The policy response needs to be equally long-term, and we strongly support the 2050 targets that have been set in the Government's Energy White Paper. The challenge is to translate these aspirations into intermediate goals that can provide certainty for business and investors. Without these clear milestones, investors face two sets of risks. The first relate to the direct risks of climate change to investments; a failure to respond effectively will increase the risks associated with extreme weather events and other changes in the climate. The second relate to the lack of policy certainty. Specifically, in the absence of appropriate intermediate and long-term targets, government policy will not provide the necessary certainty for companies to move towards a low carbon economy while minimising disruptions to existing business activities (eg avoiding the need to retire capital stock much earlier than planned). That is, governments need to specify and commit to meeting long-term policy goals, in order for companies to make economically efficient investment decisions that properly incorporate climate change factors.
- Innovation: Climate change is a disruptive force for the British and global economies. Successful responses will require considerable technological and societal innovation to develop new products and processes that can thrive in a carbon-constrained world. This will require that attention be paid to the potential for renewables, lower CO_2 intensity energy sources AND energy efficiency to allow us to respond effectively. Looking forward, the UK has the potential to profit from all three areas. For example, the UK is a leader in emerging low carbon/renewable options such as wave power and bio-fuels. The provision of appropriate investment support to allow these technologies to be further developed and commercialised is essential, and it is here that the financial services industry has a critical role to play. London's AIM market has become an attractive global arena for the providers of low carbon solutions—technology and services—to raise capital. Further attention is needed to ensure that the City of London leverages its world-leading skills to ensure that it continues to lead the way in terms of new financial products that address climate risks and opportunities.

10 October 2005

Memorandum submitted by the Institution of Civil Engineers

INSTITUTION OF CIVIL ENGINEERS

The Institution of Civil Engineers (ICE) is a UK-based international organisation with over 75,000 members ranging from professional civil engineers to students. It is an educational and qualifying body and has charitable status under UK law. Founded in 1818, ICE has become recognised worldwide for its excellence as a centre of learning, as a qualifying body and as a public voice for the profession.

INTRODUCTION

The ICE welcomes the opportunity to present the following statements and evidence as part of the inquiry.

A. *The extent of the "generation gap"*

Q1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

1.1 The Supply and Demand Forecast for Electricity shown in the Annex is taken from the JESS (Joint Energy Security of Supply working group) report of November 2004. This is based on Dti 2004 projections. It shows that by 2020–35 to 40% of electricity supply will need to come from generation capacity which does not exist at present. This capacity is needed to replace ageing nuclear and coal generation stations. The estimate assumes that the government target for renewables of 15% of electricity supply will be met and that the balance of 25% of electricity supply will come from new gas CCGT capacity. Please see the Annex.

B. *Financial costs and investment considerations*

Q2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

Q2.1 *What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?*

2.1.1 The table reproduced below from the Nuclear Industry Association "Energy Choices", website[200] provides a comparison of capital and generating costs and construction periods for nuclear, gas, coal, on-shore and off-shore wind. The table identifies the relatively high capital cost for nuclear compared to other generation options but that most of the studies show that nuclear generating costs are competitive.

	MIT (2003) $	*DGEMP (2003) euros*	*T&L (2003) euros*	*RAE (2003) £*	*UofC (2004) $*	*CERI (2004) Can$*	*OECD (2005) $*
Capital Cost per kW							
Nuclear	2,000	1,413	1,900	1,150	1,500	2,347	1,000–2,000
Gas	500	523	600	300	590	711	400–800
Coal	1,300	1,281	860	820	1,189	1,600	1,000–1,500
Wind On-shore	n/a	n/a	1,100	740	n/a	n/a	1,000–1,500
Wind Off-shore	n/a	n/a		920	n/a	n/a	1,500–2,500
Construction period—years							
Nuclear	5	5	5	5	5	6	4–6
Gas	2	2	2	2	3	2	2–3
Coal	4	3	3	4	4	4	4
Wind On-shore	n/a	n/a	—	2	n/a	n/a	1–2
Wind Off-shore	n/a	n/a		2	n/a	n/a	1–2
Cost of Capital or D rate %							
Nuclear	11.5	8	5	7.5	12.5	10	5 10
Gas	9.6	8	5	7.5	9.5	10	5 10
Coal	9.6	8	5	7.5	9.5	10	5 10
Wind On-shore	n/a	n/a	5	7.5	n/a	n/a	5 10
Wind Off-shore	n/a	n/a		7.5	n/a	n/a	5 10
Gas Price	3.50/MBTU	3.30/MBTU	3.00/GJ	2.18/GJ	3.39/MBTU	6.47/MBTU	3.5-4.5/GJ

[200] http://www.energy-choices.com/page.aspx?pageId = 154

	MIT (2003) $	*DGEMP (2003)* euros	*T&L (2003)* euros	*RAE (2003)* £	*UofC (2004)* $	*CERI (2004)* Can$	*OECD (2005)* $	
Electricity price per MWh								
Nuclear	67	28	24	23	51	73	21–31	30–50
Gas	38	35	32	22	33	75	37–50	40–63
Coal	42	34	28	25	35	59	25–50	35–60
Wind On-shore	n/a	n/a	50.1	37–54	n/a	n/a	35–95	45–140
Wind Off-shore	n/a	n/a		55–72	n/a	n/a	50–95	65–120

Table References:

(1) MIT Study, the Future of Nuclear Power.

(2) General Directorate for Energy and Raw Materials (DGEMP) of the French Ministry of the Economy, Finance and Industry.

(3) Tarjanne, Lappeenranta University of Technology, Finland.

(4) Royal Academy of Engineering, The Cost of Generating Electricity.

(5) University of Chicago Study, The Economic Future of Nuclear Power.

(6) Canadian Energy Research Institute 2004.

(7) OECD Projected Costs of Generating Electricity (2005 Update).

Q2.2 *With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?*

2.2.1 As can be seen from the previous answer there is a range of new build costs for which there is a consensus of agreement from a range of different bodies. Confidence in the robustness of the new build estimates will however depend on the approach adopted for the implementation of a new build programme.

2.2.2 In the past UK nuclear power station project experience was characterised by:

— "Cost plus" type contracts.

— Virtually every design is different from its predecessors.

— Designs are all of "UK-origin" (apart from Sizewell B).

— Designs often re-designed throughout licensing and approvals process, leading to extra costs and delays.

— Lengthy and unpredictable licensing processes and public inquiries.

2.2.3 New build cost estimates are realistic and robust providing some straightforward and practical framework for building new units is implemented.

— Consortia formed possibly from major utility groups where risk is shared among the parties.

— "Turnkey" contractual arrangements with reactor vendor and major constructors and equipment manufacturers.

— Adoption of a proven internationally recognised design, implemented in the UK with minimum modification.

— A regulatory approach that takes account of licensing approval obtained for the reactor design in its country of origin and elsewhere.

— Implementation of the current UK licensing and approvals processes in a way which ensures timely and predictable delivery of regulatory clearances and planning consents.

2.2.4 With regard to the "hidden costs" referred to in the question, the position is as follows:

— Waste—nuclear waste management costs are all included in the overall generation costs indicated above. Irrespective of the final solution for the disposal of power station wastes they only represent a small proportion of nuclear generating costs. It is important to separate costs for the small volumes of waste produced by the latest reactor designs from the cost liabilities associated with the very large volumes of "legacy" wastes produced the UK military programmes and previous and less efficient reactor designs.

— Insurance—UK nuclear power stations carry both material damage and liability insurance. This insurance cover is in place for every civil nuclear site in the UK. It is understood that there is an upper limit currently of £140 million as set in the Nuclear Installations Act and that this may increase to €700 million under EU legislation The UK insurance industry should be able to provide this cover on a commercial basis.

— Security—As any new stations would be at least as structurally robust as existing stations no new issues of principle or policy are anticipated. The security costs are only a minor part (about 2%) of overall operational and maintenance costs.

Q2.3 *Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?*

2.3.1 No, it is un-realistic to suggest that renewables could provide all the new capacity needed in the timescale required. Many of the renewable technologies still need many years of development. However mainstream incineration with energy recovery is technically proven, the biodegradable fraction of mixed waste is classified as a renewable, and this could generate over 4% of the UK's power by 2020[201]. Wind energy and hydropower are also developed technologies. We should make as much use of these as we can. However there are limitations to what is feasible, especially for hydropower due to our low topography. Therefore the rate of increase in generation by renewables would have to be far greater than can be expected in order to fill the gap which will be left by retirement of existing nuclear and coal fired stations.

Q2.4 *What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?*

2.4.1 Micro generation should be seen in the context of generation at the point of use of electricity, and therefore some electricity transmission costs are reduced. However there is a small increase in the additional costs of fuel transport to the consumer's premises, (except in the case of micro renewables). In the near to mid term, micro generation will not make a significant contribution to the nation's generation capacity, but in the longer term these advanced technologies, in conjunction with energy efficiency measures might contribute up to 20% of domestic energy consumption on an annual basis.

2.4.2 It is important to note the difference between capacity (in MW) and energy (in MWh). Adding base load power, operating efficiently, as part of a mixed generation portfolio would substantially reduce emissions. Considered use of large scale and distributed storage technologies would ensure that base load plant and stochastic renewable generation were integrated and operated efficiently.

Q3. *What is the attitude of financial institutions to investment in different forms of generation?*

Q3.1 *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?*

3.1.1 The perceived risks (and therefore obstacles) to investment in new nuclear build principally relate to uncertainties over the timescales and costs associated with the licensing and approvals processes and the current lack of a long term waste management policy planning. Uncertainty in the future power generation market is probably less of a factor than these two areas.

3.1.2 The large-scale nature of the investment required in a new nuclear programme (ie £1 billion plus per station) should not be an overriding obstacle. Other major infrastructure projects require and attract similar or greater levels of investment.

3.1.3 Investment in CCGT and renewables are both subject to uncertainty. In the case of CCGT there uncertainties surrounding future gas costs and gas supply availability that is in direct contrast to nuclear, which has secure and stable fuel costs, and availability. Renewables are subject to the same planning process uncertainties which would potentially impact on a nuclear programme, are also subject to investor concern over the timescale and extent of financial support through the Renewables Obligation and are also faced with technical uncertainty particularly for offshore installation.

Q3.2 *How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

3.2.1 Any decision by the private sector to invest in new nuclear build will be subject to a detailed commercial appraisal of capital and operating costs, current and long term market conditions and the perceived risks to the success of the programme. It will also be dependant on how risks are shared between the parties to such a project. The exact scale and nature of any Government support required is difficult to quantify without the results of such an analysis. Depending on the structure of developer and constructor consortia etc, Government financial support may not be required, providing the key uncertainties of licensing and approvals timescales and waste policy, are addressed by Government. In this event the issue of compatibility with liberalised markets would not apply.

[201] Lee, P, Fitzsimons, D, & Parker, D "Quantification of the Potential Energy from Residuals in the UK"; Report commissioned by The Institution of Civil Engineers & The Renewable Power Association, March 2005.

Q3.3 *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

3.3.1 Government has made it quite clear that any investment in a new nuclear build programme will come from the private sector. If this is undertaken on a purely commercial basis (with no subsidies) it should not impact on renewables and energy efficiency providing Government support for these areas remains unchanged.

C. *Strategic benefits*

Q4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

Q4.1 *To what extent and over what timeframe would nuclear new build reduce carbon emissions?*

4.1.1 1GWe of nuclear power over its operating life would reduce annual carbon dioxide emissions by:

Around 7.5 million tonnes if displacing coal-fired generation,

Around three million tonnes if displacing gas-fired generation.

If a new build programme replaced the current nuclear power station fleet it would in total save around ten times the above figures.

4.1.2 If a new build programme was initiated immediately it should be possible to have commissioned the first new station by 2015–16 with an additional new station commissioned every 18 to 24 months. This would go some way to offsetting the projected closure of the existing nuclear power station fleet (particularly if potential life extensions are implemented) and would ultimately replace and maintain the current contributions made to carbon emission reductions by the UK nuclear power stations.

Q4.2 *To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?*

4.2.1 Recent history has shown that reliance on one fuel source (eg coal at the time of the miners strike) makes the UK electricity supply vulnerable to the actions of individual groups. If gas becomes as dominant a fuel source as coal was in the 1980s the situation could be repeated with the added dimension that that influencing factors could lie outside the UK. This can be avoided by ensuring there is a diverse energy mix gas, coal, renewables and nuclear which reduces the impact of the loss of a particular fuel sector. This will require a construction programme of new nuclear stations to be started soon otherwise nuclear will be providing just 3% of UK electricity in under 20 years time, compared with around 20% today.

4.2.2 A new nuclear programme would provide reliable baseload generation using a fuel (ie Uranium) that is plentiful as a raw material, and comes from stable countries such as Australia and Canada. Furthermore, it is highly credible to retain strategic stocks of nuclear fuel to offset the risk of any sustained disruption to supply. The fabricated fuel to supply a fleet of 10 new reactors (sufficient to replace the current nuclear fleet) for a year would occupy only around 100 cubic metres.

4.2.3 A new nuclear programme would provide reliable baseload generation using a fuel (ie Uranium) that is plentiful as a raw material, and comes from stable countries such as Australia and Canada. Furthermore, it is highly credible to retain strategic stocks of nuclear fuel to offset the risk of any sustained disruption to supply. The fabricated fuel to supply a fleet of 10 new reactors (sufficient to replace the current nuclear fleet) for a year would occupy only around 100 cubic metres.

4.2.4 In addition to supply reliability a nuclear power fraction would also provide valuable cost stability. This is because the cost of raw uranium ore accounts for only 5–10% of the overall generating cost of electricity from nuclear stations. Any increase in the global market prices for uranium fuel would therefore have a relatively small impact on nuclear generating costs.

Q4.3 *Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?*

4.3.1 It is the responsibility of the Government's security regulator Office for Civil Nuclear Security (OCNS) to ensure the security of all aspects of nuclear operations in the UK. The OCNS Director in his 2004 annual report continued to confirm confidence in the security provisions of the nuclear industry and that the security measures applied are proportionate to the threats faced.

4.3.2 Nuclear power stations are amongst the most robust civil structures in the world and their design and construction undergoes rigorous regulatory review. A key part of the design process is to take account of impact from forces generated by external events both natural and manmade including terrorist attacks. The layout and structural design fully accounts for these extreme events and impacts. In addition to the design measures the operation of the stations are also subject to rigorous security arrangements covering staff vetting, access control etc. As a result the potential threat to nuclear power station from external forces is minimised.

Q5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

5.1 The nuclear option is not an alternative to renewables. Both are needed as part of a balanced energy supply. The generation gap will be too large to be filled by either one alone. Microgeneration is at far too early a stage to judge what contribution it may make in the future. Energy efficiency should be a contributor to the energy supply equation but it seems unlikely to make any more than a small contribution. Total electricity consumption has increased from 382TWh in 1999 to 401TWh in 2004; so energy efficiency appears, at best, to have limited the increase in consumption.

D. *Other issues*

Q6. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

6.1 Nuclear energy scores well on full life cycle emissions of carbon dioxide when compared with other generation sources. Nuclear is comparable with renewables and is considerably lower than fossil fuel plants.

6.2 A recent International Atomic Energy Agency (IAEA) report shows the results of assessments both direct and indirect emissions for different generation sources. For nuclear it provides figures for the full life cycle ie mining, fuel enrichment and manufacturing and spent fuel treatment. The report concludes that in general nuclear energy is almost a factor of 20 lower than the best fossil fuelled plant (latest gas-fired technology) and a factor of over 60 lower than older, coal-fired technology. The latest nuclear power stations can achieve further improvement by more than a factor of two on these figures.

Q7. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

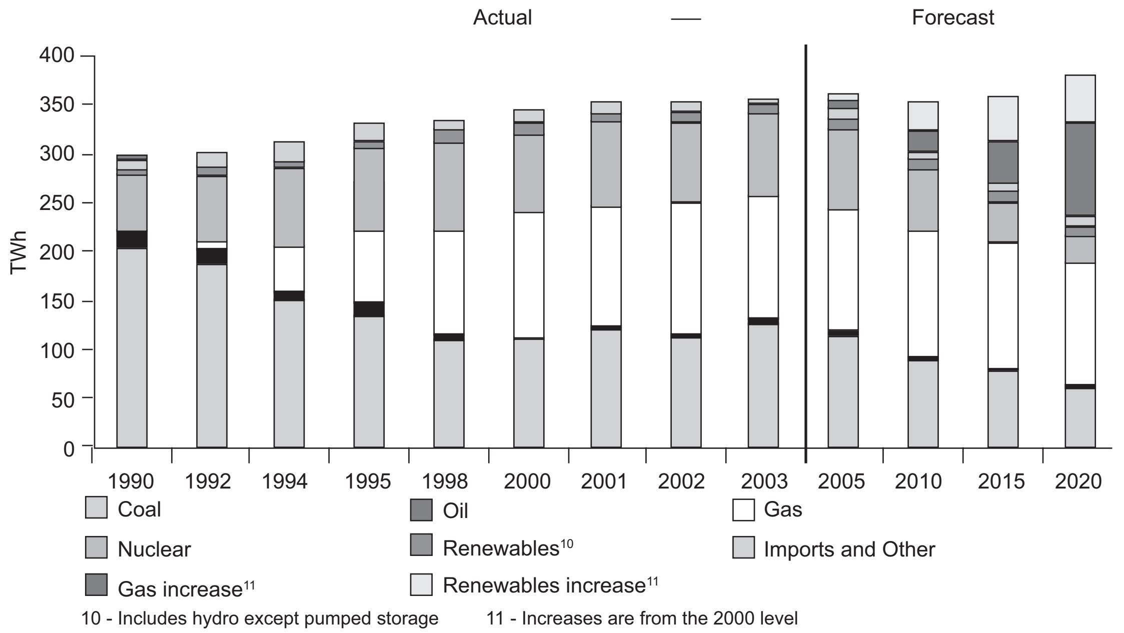
7.1 The Committee on Radioactive Waste Management (CoRWM) ongoing process to identify the most appropriate UK solution for the management of radioactive wastes is scheduled to make recommendations to Government in 2006. The depth and quality of the work done to date by CoRWM, gives every confidence that an effective and technically feasible solution will be identified and the report will be delivered on schedule.

7.2 Once the recommendation has been made and adopted by Government that should clear any perceived obstacle to new nuclear build. The start of a new build programme should not be conditional on further development of the preferred option. Indeed there should be no reason to delay the start of early activities such a review of energy policy and the potential future role of nuclear whilst the CoWRM process is being finalised.

Annex

SUPPLY AND DEMAND FORECASTS—ELECTRICITY[202]

Electricity generation by fuel type—UK



DTI - Joint Energy Security of Supply Working Group (JESS) Fifth Report, November 2004

7.3 Context: The chart shows how electricity demand is likely to be met by different forms of generation. It is based on current DTI's projections and illustrates the potential requirement for new investment.

7.4 Key points: Within the overall total, changes are likely in the generation mix and new investment will be needed to replace generation plant once closed. By 2010 gas fired generation is modelled to be producing 18 TWh more than was produced in 2000, rising to an additional 94 TWh in 2020. A mixture of large-scale plant and CHP will meet this generation, although the exact contribution of both, and of gas itself, will be dependent on relative costs and availability of other sources. In contrast nuclear's contribution is expected to drop from its peak of 90 TWh in 1998 to 65 TWh in 2010 and 27 TWh in 2020. In DTI's Updated Energy Projections renewables are modelled to reach their 10% target in 2010 and their 15% target in 2015, remaining at that level in 2020.

7.5 Background: The data presented are measured in TWh, therefore improvements in efficiency and utilisation can increase output without the need for new build.

22 September 2005

Memorandum submitted by the Institution of Electrical Engineers

The Institution of Electrical Engineers is pleased to respond to the Environmental Audit Committee's inquiry on "Keeping the Lights On: Nuclear, Renewables and Climate Change". The IEE is submitting a response in the form of an Annex which addresses a number of the questions raised by the inquiry, where the IEE feels best qualified to contribute to the debate. The IEE's submission includes an assessment of the extent of, and the factors affecting, the potential "generation gap"; estimates of the different cost components and delivery timescales for current and forthcoming electricity generating technologies; and an assessment of the capacity and strategic benefits of renewables and nuclear power in the context of security of supply.

The IEE's 120,000 members are drawn from a broad range of engineering disciplines, representing a wide range of expertise from technical specialists to business leaders. Many of the most experienced members of the IEE, and their sector peers, voluntarily participate in a variety of IEE policy guidance groups. To these

[202] Historic: DTI, Digest of UK Energy Statistics 2004—Table 5.6 and corresponding tables in earlier editions.
Projections: Current DTI Projections November 2004.

groups they bring their wealth of personal experience and knowledge, independent of commercial interests, to address the policy issues of the day and give the IEE independent and authoritative views of trends in technology and engineering. This response has been prepared on behalf of the IEE Trustees by the Energy Sector Panel whose details can be found at: http://www.iee.org/Policy/sectorpanels/energy/index.cfm Input from the IEE Membership was requested in preparing this response.

Summary

The IEE maintains that all conventional and low carbon technologies presently hold various types and levels of risk. These can only be balanced out by maintaining a degree of diversity. The principle of diversity should apply to the primary sources, the development of technologies, the physical assets, and the knowledge essential to maintain them, in order to ensure the UK's adaptability to future energy demands.

Energy policy has significant social and political dimensions, and we acknowledge that a wider social dialogue is required beyond the engineering community to resolve these.

The Extent of the "Generation Gap"

The generation market's behaviour is the aggregation of commercial decisions by all its players. There are a number of uncertainties affecting projections of generation capacity over coming years, a significant component of which is policy uncertainty. In our response, we supply estimates based on widely used power market models. We conclude that if no new new dispatchable plant (ie coal, gas, nuclear or similar, that can generate on demand) plant is constructed we believe shortages of capacity could be in the order of 4 GW in 2010, 9 GW in 2015 and 12 GW in 2020. If the market responds this shortage could be eliminated, though this may come at the expense of reduced diversity in the supply mix.

Financial Costs and Investment Considerations

Estimates of the different cost components and construction timescales of current and forthcoming generating technologies are supplied, based on available evidence and reasonable assumptions regarding technology and fuel costs. Regarding the potential for generation from renewable sources, we argue that the parameters for future development are contingent on the acceptability of the price impacts of fiscal support mechanisms, and on the technical challenges of integrating renewables into the electricity system.

Strategic Benefits

Nuclear power can contribute to security of supply within a low-carbon generation mix by providing secure base load electricity. New nuclear build would require lead times of 9–13 years in total; however, the operating lives of the existing fleet may be extended. Renewables offer long-term security of supply, but in the short term the variability of certain renewables needs to be managed.

Detailed Response

1. In terms of the electricity system, the IEE believes that a prudent energy policy should seek to balance the need for security of supply with the environmental imperative of reducing carbon emissions, within reasonable cost bounds. In its two-year review of the Energy White Paper, the IEE stated that:

> "All conventional and low carbon technologies presently hold various types and levels of risk. These can only be balanced out by maintaining a degree of diversity. The principle of diversity should apply to the primary sources, the development of technologies, the physical assets, and the knowledge essential to maintain them, in order to ensure the UK's adaptability to future energy demands."[203]

2. The IEE's submission will be limited mainly to technical and engineering issues. Energy policy has significant social and political dimensions, and we acknowledge that a larger social dialogue is required beyond the engineering community to resolve these. Attributable costs such as the cost of emissions abatement, decommissioning, and the environmental impacts of all types of generation are subject to such considerations and are therefore a matter for wider social debate.

[203] *"The Energy White Paper, Two Years On"* (February 2005) http://www.iee.org/Policy/sectorpanels/energy/IEE_Energy_Policy_Briefing_Feb05.pdf

THE EXTENT OF THE "GENERATION GAP"

What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?

3. The generation market's behaviour is the aggregation of commercial decisions by all its players, which are driven by considerations such as short and long term profit potential, the impact of environmental regulation, as well as technical and safety considerations. This is difficult to predict with certainty and estimates are likely to change over time.

4. NUCLEAR. Our present expectation is that the phase-out of nuclear power stations will remove 2.4 GW of Magnox plant by 2010. The AGR stations will enjoy longer lives, most likely in excess of their currently projected design lives, and the recent announcement by British Energy of a 10 year life extension for Dungeness B bears this out. Overall we predict reductions in total nuclear capacity of:

- 3.4 GW by 2010, rising to
- 4.6 GW by 2015 and
- 7 GW by 2020.

5. COAL. It is harder to predict coal plant closures, as these will depend on the response of station owners to environmental regulatory pressures and to conditions in the energy market, particularly the competitive position of coal. At the moment:

- 13 GW of coal fired capacity has "opted in" to Large Combustion Plant Directive 2 (LCPD2), implying it will invest or has invested as appropriate in flue gas cleanup to run into the medium to long term.
- 6.1 GW of coal plant has opted out of LCPD2, meaning that it will run at low load into the future and must close by 2015.
- 9.6 GW of coal plant has not yet committed (including all the plant in Scotland), implying uncertainty as to whether this plant will receive investment and stay open, or be run down for closure.

Trends in carbon pricing which will also impact the prospects for coal plant strongly.

6. Predicting this behaviour is difficult, but we believe that:

- around 0.5 GW of coal plant will shut by 2010;
- increasing to 4 GW by 2013;
- 8 GW by 2016; and
- 9 GW by 2020.

Whether this results in a generation gap will depend on the extent to which new gas fired and renewable plant is built, and on what happens to electricity demand.

7. GAS. There are currently no new gas fired combined cycle plants under construction in the UK, but a large number of proposed projects are in development that could at least in theory be brought forward in 3–4 years. Owing to the extent of uncertainty in the market, generators are at present not willing to commit to the financial risks of commencing construction, preferring to focus on low cost development work. Such uncertainties include the cost of carbon, the extent of coal plant closures, government policy changes including the possibility of new nuclear build, future gas prices, and the extent of renewables build. However, rising wholesale prices resulting from generation shortage could in themselves encourage construction of new plant.

8. Subject to investors becoming confident, we would expect:

- around 4 GW of gas-fired combined cycle capacity to be commissioned by 2010, with
- a further 5 GW by 2015, and
- 3 GW by 2020.

Clearly if these projects do not come forward generation will be short, but this will be a result of market confidence rather than more fundamental issues of supply and demand. An important strategic factor relating to gas plant build is concern over over-reliance on imported gas and the extent of world supply and the UK's import and storage capacity.

9. RENEWABLES. Renewable generation (particularly wind) is currently the subject of intense activity as a result of highly attractive government incentives.

- National Grid anticipates 5.5 GW of new wind capacity by 2011/12;
- beyond this we would expect around 3.5 GW more by 2015; and
- a further 3 GW by 2020.

There are uncertainties in this—offshore wind technology is not yet fully proven and could be vulnerable to a loss of confidence if early projects do not perform, while planning and transmission constraints may limit the development of onshore wind. Other renewables (eg wave, tidal, biomass) are not strongly incentivised at present and are generally technically immature, leading to our assuming very low deployment levels at this stage.

10. DEMAND. National Grid continues to predict demand increases at the transmission network level (ie net of distributed generation and savings from energy efficiency). They currently predict peak demand increasing from 61.5 GW in 2004–05 to 65 GW in 2011–12, however these predictions are subject to wide ranges of uncertainty (plus 9.7 GW, minus 16.9 GW). Clearly the potential of energy efficiency measures and installation of distributed generation to reduce demand on the network is substantial, but has not been subject to practical implementation. The potential for demand side measures has not been sufficiently explored. The current suite of energy efficiency measures has performed disappointingly, and there is clearly a need for innovative policy measures in this area. However, since electricity systems have to be planned conservatively (to minimise the chances of power shortages), we believe it appropriate to base policy decisions on continuing gradual increase of demand at the transmission network level, unless and until there is real evidence of this changing.

11. There are a number of uncertainties affecting projections of generation capacity over coming years. If no new dispatchable plant is constructed we believe shortages of capacity could be in the order of 4 GW in 2010, 9 GW in 2015 and 12 GW in 2020. If the market responds with new gas plant this shortage could be eliminated, though this may come at the expense of reduced diversity in the supply mix.

Financial Costs and Investment Considerations

What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

12. Capital costs for different generation technologies are reasonably well established for gas and onshore wind, less certain for offshore wind and clean coal[204], and very uncertain for wave, tidal and nuclear. Our estimates of construction costs for utility scale plant are:

- £0.4 million/MW for gas fired combined cycle;
- £0.8 million/MW for onshore wind;
- around £0.9 million/MW for clean coal;
- around £1.4 million/MW for offshore wind; and
- we conjecture £1.5 million/MW for wave and tidal.
- We are unwilling to comment on likely nuclear costs as there is a large element of cost uncertainty at the present time, much of it related to contingent (including legislative) costs.

Transmission costs are not included in these estimates, as these depend on plant location. In general, gas, coal and nuclear plant will tend to be constructed close to strong transmission links whereas renewable plant tends to be away from such links.

13. Cost of generated electricity requires making assumptions about cost of finance, availability, efficiency and fuel cost. Of these, fuel cost is currently subject to the greatest uncertainty. Based on fuel prices of £3/GJ for natural gas and £1.65/GJ for coal, we calculate cost of generated electricity at the station gate to be:

- 3p/kWh for gas CCGT;
- 4.8p/kWh for onshore wind;
- around 3.5p/kWh for clean coal;
- around 6.9p/kWh for offshore wind; and
- we conjecture around 10p/kWh for wave and tidal.
- As well as the uncertainty of nuclear capital cost, there remains uncertainty over end of life clean-up costs which affect the electricity cost from nuclear.

It is noteworthy that clean coal plant could become cost effective if gas prices rise further compared to coal. These prices do not allow for the cost of carbon credits, which is currently highly uncertain into the future, but has the potential to bring thermally generated electricity costs much closer to some renewables. They also exclude the costs associated with intermittency of renewable power, which vary depending on the

[204] "Clean coal" is used here to refer to high-efficiency coal-fired plant, rather than carbon capture.

extent of intermittent renewables on the system. There is an ongoing debate around the real costs of intermittency. The UK Energy Research Centre (UKERC) is currently undertaking an extensive independent assessment study of the published evidence which is due for publication at the end of the year.

14. Construction timescales fall into two components—the time to gain permits, shape the project and get financing, and the build time. Assuming permitting for a given site is straightforward and therefore allowing a two year pre-construction development period, total time from first studies to first generation would be:

— around four years for a gas fired plant;

— three years for onshore wind;

— five years for clean coal;

— three to four years for offshore wind; and

— three to four years for wave and tidal.

These times can become much longer if planning issues for the project and/or its electrical transmission connections become problematic.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

15. The arguments over technical and physical capacity revolve around two issues:

— Is the resource available at cost effective prices to support high levels of renewable generation?

— Can the renewables be integrated into the electricity system in a way that allows an adequately reliable service to be provided to customers?

16. Available onshore resources include wind, hydro, energy crops, waste, solar, and offshore there is wind, wave and tidal energy. A range of studies have been undertaken as to the extent of these resources and we would respectfully refer the committee to these. As a generalisation, there is an extensive untapped renewable potential offshore. Energy crops and waste may hold significant potential for renewable generation onshore, although the precise extent is still subject to assessment. Offshore the principal barriers are technology development and cost reduction, whilst onshore, policy development to support the energy crop supply chain and the use of waste for electricity generation would assist in their further development. Again in general, renewable generation (except onshore wind and hydro) has high capital costs compared to thermal plant, meaning its widespread deployment in place of thermal power would create significant price impacts. The cost differential may be lessened if carbon prices strengthen further, but electricity customers may have to become accustomed to paying more for electricity.

17. The integration of renewable power into the electricity system presents challenges.

— Firstly, the location of renewable resources is often remote from load centres and existing transmission infrastructure. Large transmission line connections are necessary, and gaining planning consent for the construction of new transmission lines presents serious difficulties. Wind energy development is currently stalling in Scotland as a result of this, while the last major transmission line planning process took eight years to gain consent.

— Secondly, some renewables (principally wind) produce a variable output and need some level of back-up to ensure continuity of supply to customers. This issue is sometimes overplayed, and studies have shown the level and cost of such back-up to be modest provided wind is less than 10% of the generating capacity. However as this rises towards and beyond 20% the cost of back-up will become more and more significant.

Strategic Benefits

If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

18. Should a decision to build a new nuclear station be made today, the licensing and planning process would be expected to take around five to eight years before construction could commence. Construction itself would be expected to take four to five years.

19. Noting the inevitable constraints of resource in a large construction programme we would suggest indicatively that around 1 GW of nuclear capacity per annum could be added thereafter. Once operational the nuclear plant would have negligible carbon emissions and would displace gas and coal fired plant. The mix of such displacement would depend on market conditions at the time.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

20. Nuclear generation provides base load electricity that is not vulnerable to short term fluctuations in fuel supplies, or renewable energy resource. As such it would make a positive contribution to electricity supply security in the same way as the present nuclear fleet. To achieve the same security from gas fired plant would depend entirely on managing fuel supply diversity, import capacity and the provision of gas storage infrastructure. Coal fired plant offers similar security to nuclear since international coal markets are highly liquid and supplies are readily available, as is import infrastructure, as well as remaining UK mine capacity. Renewables offer long term security of supply as the resource is internal to the UK, but in the short term the intermittency of certain renewables needs to be managed. While a secondary matter, we would note here that an increasing proportion of nuclear plant is detrimental in the rare but very onerous situation of a national electricity grid failure (as has happened elsewhere in the world recently). This is because nuclear stations cannot come back on line quickly after an unplanned disconnection from the grid. In the recent major USA disruption the return of full supplies to consumers was hampered by the unavailability of exports from nuclear generation in Canada for this reason.

22 September 2005

Memorandum submitted by the Institution of Mechanical Engineers

Executive Summary

This response has been prepared by the Institution of Mechanical Engineers (IMechE) on behalf of its membership, comprising over 75,000 professional engineers, of which over 15,000 have a specific interest in the electricity/power sector.

The views expressed have been collated from IMechE members in senior management positions in companies and utilities operating in the field, academics, and experts in all aspects of renewables, fossil and nuclear power generation. It is therefore hoped that this response is balanced and does not unduly favour one type of power generation technology over the rest.

Hard challenges are facing the power sector:

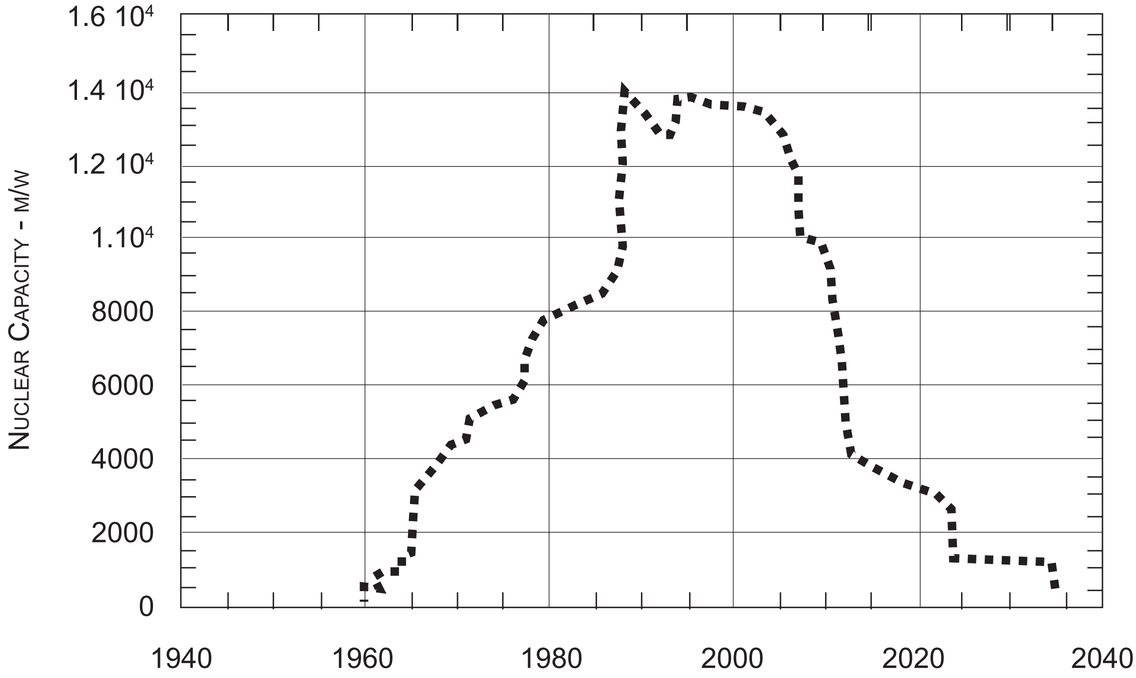
1. Growth in electricity generated from renewable sources has been slow and will be unable to offset planned retirement of coal-fired and nuclear stations.
2. The country has now become a net importer of oil and gas, this endangers security of supplies and exposes consumers to world price volatility.
3. Dependence on coal and gas is contributing to overall CO_2 emissions growing at 1–2% a year.

The development of new nuclear generation is therefore important to minimise CO_2 emissions and reduce reliance on gas, however, such development should not be at the detriment of renewable or clean coal power generation. All these technologies together have an important role to play in providing fuel diversification and minimising environmental emissions.

The IMechE strongly supports a balanced approach to the development of new power generation in the UK, recommending the use of renewable, fossil and nuclear sources to a point where the country is not overly reliant on any one option. The resulting mix of generating technologies will minimise technical, fuel supply and financial risks, while retaining competitive electricity prices.

Question 1—Supply and Demand

Increased in consumption and retirement of both existing coal and nuclear plants will result in an estimated shortfall in generation of approximately 120TWh per year, by 2015. The expected decrease in nuclear capacity is shown in the graph below:



Theoretically there are sufficient renewable resources to provide the UK energy needs, although this may not be the most cost-effective or publicly-acceptable solution. Economic, technical, planning and social factors have constrained the growth of renewable energy, micro generation and energy saving measures to date; it is therefore highly unlikely that these sources, on their own, will be able to meet future shortfalls in generation, for the period under review.

Even with renewables developed to the fullest practical extent, there will remain a significant need for additional nuclear, gas and clean coal generation. Such a generation mix will minimise over-dependence on a particular technology (and therefore fuel) and would serve the best interests of the UK.

QUESTION 2—GENERATION COSTS

Independent reports indicate that nuclear electricity is price competitive with gas and clean coal technologies. However it should be noted that the assumptions used to derive costs for nuclear, fossil and renewable generation, are a hotly debated subject, and the findings of such reports should be treated with caution.

Published costs estimates for nuclear plants are considered realistic and cost overruns are less likely than in the past, as construction contracts will be based on fixed prices with performance penalties, thus shifting construction risks from plant owners to contractors.

There is sufficient experience to quantify decommissioning and waste disposal costs, however, Government policy on waste management will determine the final cost of waste disposal. Investors will require such costs to be clarified before committing any investment. The introduction of legal requirements for future operators to create financial reserves (based on conservative estimates) to finance these activities is recommended.

QUESTION 3—FINANCING A NEW NUCLEAR PROGRAMME

Current estimates indicate that the economics of new nuclear plants are robust and will not require financial support from Government.

Given the past regulatory UK track record, financiers are nervous to fund additional power infrastructure and nuclear in particular. There is a need for Government to create a stable regulatory and planning environment for the electricity sector, to attract investment and, with regards to nuclear, may in addition be required to underwrite part of the risks associated with construction, insurance and waste disposal of nuclear plants.

If the financial community were to regain its past confidence in the sector, and if investment opportunities were structured in such a way as to allocate risks to those parties capable of managing them, then there should be sufficient funds to finance fossil, renewable and nuclear projects.

Question 4—Public Benefits of a Nuclear Programme

It is estimated that the first new nuclear plant will not be operational before the middle of the next decade, with almost a further decade to complete the replacement of existing nuclear facilities. Electricity production lost from retiring plants will be partly replaced by renewables, but predominantly by additional gas or clean coal plants. This will therefore result in an increase in CO_2 emissions in the short term, followed by a stabilisation in emissions once the nuclear program is underway. Any delays in commencing nuclear construction will result in a further net increase in CO_2 emissions from the UK's power generation capacity.

Nuclear can also contribute to security of supply by providing fuel diversification without over-dependence on gas and by moderating electricity prices volatility.

Terrorism will remain a concern. This risk is manageable and it is not unique to nuclear plants. The transmission grid is considered to be far more vulnerable.

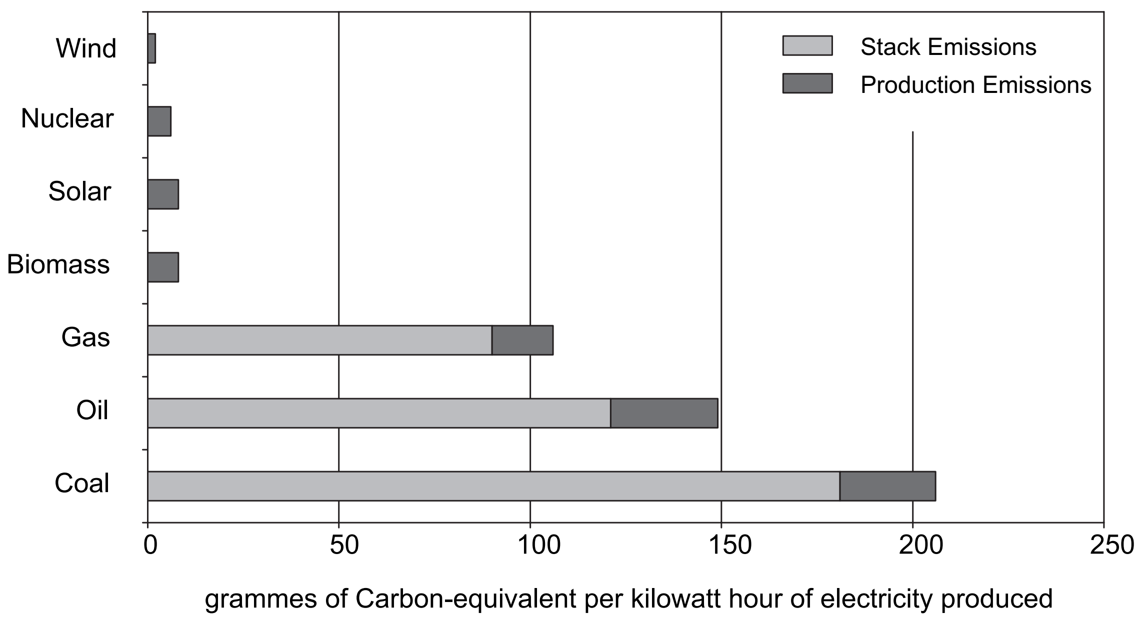
Question 5—Compatibility of Nuclear with the Energy White Paper

Investments in the development of a nuclear program, renewables and clean coal technologies are not incompatible; on the contrary they are complementary and necessary to ensure a diversified generation mix thus ensuring security of supply.

Question 6—Nuclear Carbon Emissions

Quoted CO_2 emissions from nuclear plants (including fuel production and reprocessing, construction, operation and decommissioning) are approximately 5 grams of CO_2 per kWh for Torness in the UK, and 3.3 grams of CO_2 per kWh for Vattenfall PWR in Finland; these figures are similar to emissions produced from renewable sources and considerably less than for fossil plants. The graph below shows CO_2 emissions for different technologies.

Figure 1 - Greenhouse Gas Emissions from Power Production Chains (Source IAEA Bulletin 42, Article 4)



Question 7—Management of Nuclear Waste

Scientifically acceptable solutions to deal with nuclear waste are already available, but it is important to reach public consensus on the approach to be adopted for the UK. The public needs to be engaged to address their concerns through the provision of facts, figures and credible arguments. In addition it is possible that financial institutions will be unwilling to provide finances if their participation in the proposed nuclear program would result in adverse publicity.

Licensing of new nuclear plants will most likely be required before these issues have been completely resolved. Delays in licensing will threaten the security of supply, potentially de-stabilise energy prices and lead to increased CO_2 emissions.

Finally it is worth noting that replacing all the current UK nuclear capacity with reactors would add, over their lifetime, less than 10% by volume to the UK's nuclear waste inventory.

Introduction

The Institution of Mechanical Engineers (IMechE) is a professional body representing over 75,000 professional engineers in the UK and overseas. Of these, over 15,000 have a specific interest in the electricity/power sector.

Our membership is involved in all aspects of power generation using fossil fuels, renewable sources and nuclear, therefore it is hoped that our response will be balanced and will not unduly favour one type of power generation technology over the rest.

The IMechE strongly supports a balanced approach to the development of new power generation in the UK, thus recommending the use of renewable, clean fossil and nuclear sources to a point where the country is not overly reliant on any one option. Such a "portfolio" approach will minimise technical, fuel, environmental and financial risks, while retaining competitive electricity prices.

The remainder of this response is dedicated to answering the specific questions asked by the Select Committee. Any issues requiring a more detailed analysis, are covered in appendices.

In addition, it is worth noting that the IMechE published a response to the Energy White Paper. Much of the response is relevant to this inquiry. The text can be found at http://www.imeche.org.uk/media/parliament/position_statements.asp

Question 1

What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?

The recent defence of the reserve margin, made by the National Grid Company last winter suggests that there is no immediate problem, and the fact that generation was able to meet peak demand during the relatively mild winter of 2004–05 provides limited evidence that their assessments were accurate. However, demand is rising year-on-year, at a greater rate than energy-saving initiatives are able to reduce consumption. Without new plant being brought into service, the only way in which this demand can be satisfied, is by reducing margins. This is not sustainable, requiring only a period of severe weather before power cut measures become necessary.

Severe weather in winter often results in increased gas consumption, that is co-incident with an increased demand for power. The consequence is that many utility companies with both power and gas businesses have to make a commercial choice between selling gas and producing power. This can result in some gas fired plants being turned down or off, because it is commercially to the utilities' advantage to do so, as they are responding to the power and gas markets pricing signals.

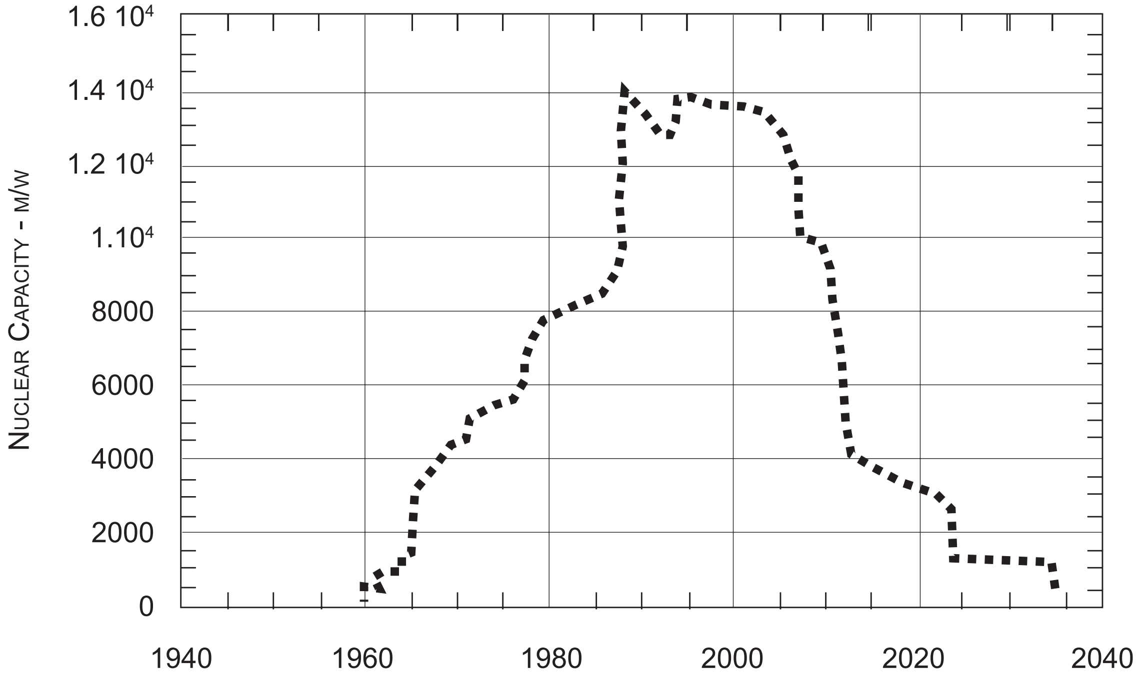
In addition lead times for the construction of power plants is at least four years and there are uncertainties regarding the ability of the market to respond in a timely manner to supply and demand signals. There is thus the potential for a short-term generation gap.

In the medium term, existing coal power stations are life-limited by a number of factors:

1. The age of existing plants.
2. The Large Combustion Plant Directive, reducing coal-fired plant capacity and/or limiting operating hours. However 15 GW of coal fired plant are or will be fitted with FGD/LoNOx and therefore available beyond 2015.
3. The EU Emissions Trading Scheme, raising costs and limiting emissions and therefore generation.
4. The likelihood of even tighter emissions controls in the future (eg Mercury, which is becoming an important issue in the USA).

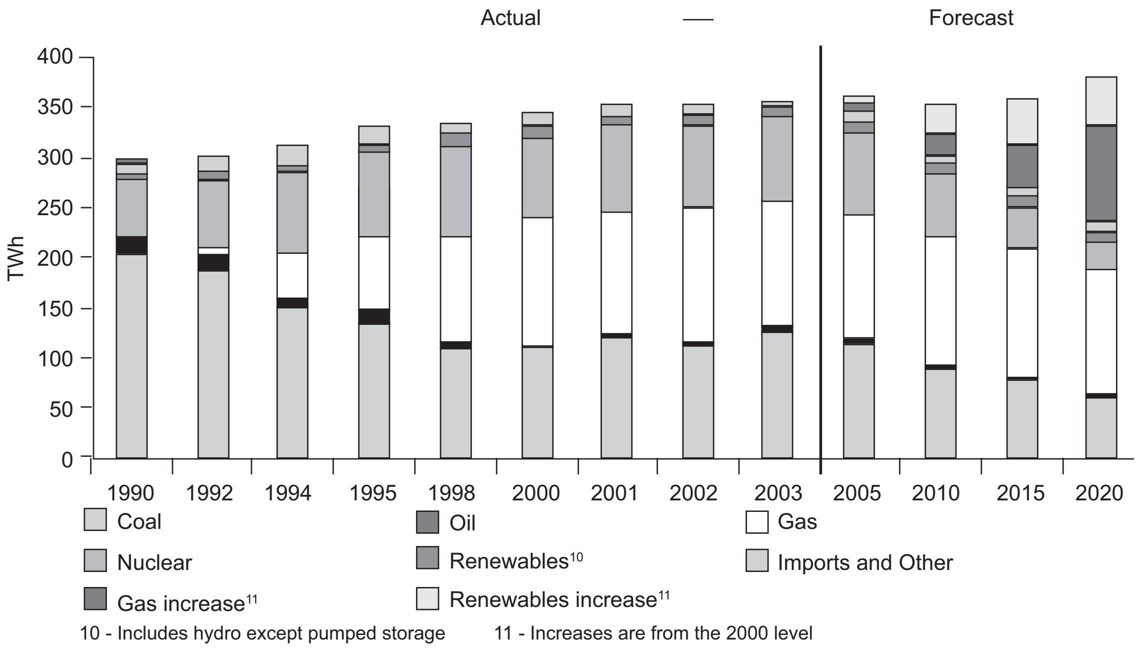
Unless there is a substantial improvement in incentives for micro-generation, it is not expected that this technology will be able to contribute in a meaningful way to energy production, and without similar incentives for energy efficiency measures, electricity demand will continue growing (recent historical data shows a 1.5% increase per year).

The life of the Magnox stations will not be extended, with the last plant at Wylfa due to close in 2010. The majority of the AGRs are scheduled to shutdown by 2015. The lives of most AGRs have been extended and it is not clear at this time that further substantial life extensions will be possible. By 2015 nuclear plant closures will reduce nuclear generation capacity from the current level of 12,000 MW to less than 4,000 MW, see graph below:



While it is hoped that the current regulatory framework will enable renewable sources to contribute 15% of electricity production by 2015, the present rate of growth is too slow to meet this target, and the renewable contribution to overall electricity production will be insufficient to meet forecast shortfalls in generation.

The graph below (produced by the DTI) indicates a need for 120TWh per year of additional electricity production by 2015. This equates to 18–27GW of additional capacity, depending on type of plant and load factor assumptions.



DTI - Joint Energy Security of Supply Working Group (JESS) Fifth Report, November 2004

It is unlikely that any single technology on its own will be able to fulfil the forecast shortfall in generation. Over-dependence on a particular technology (and therefore fuel) would not serve the best interests of the UK.

QUESTION 2—FIRST BULLET

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

It is almost impossible to answer this question with great accuracy and there is a high level of debate within the industry regarding published figures.

Historically many cost comparisons were based solely on construction and operating costs, but there is now a realisation that other factors have a significant impact. Some of these factors are listed below:

1. Method of financing: off or on-balance sheet will significantly affect the cost of capital for the project.
2. Financial charges: level of gearing, interest rates and loan duration will change depending on the financial community's perception of construction, technological and operational risks.
3. Project required rate of return will change depending on the level of risks perceived by investors.
4. Additional infrastructure required such as: grid connections, grid reinforcements, additional roads, gas pipelines and railway lines.
5. Avoided cost with embedded generation for additional transmission lines.
6. Plant and local issues such as cooling systems, transmission charges and local taxation.
7. Estimates of future fuel prices.
8. Plant reliability and availability.
9. Development costs and timescales associated with bringing the project to the point of construction.
10. Back-up for intermittency (if appropriate).
11. Costs of carbon emissions trading or carbon capture and CO_2 storage.
12. Incorporation of full "end-of-life" costs, including decommissioning and "making good" the land utilised.

Many people are now advocating a true "whole life cycle" (or "cradle-to-grave") analysis for each of the generating technologies, only then can a true cost comparison be made. In sustainability terms (economic, environmental & societal), to consider only construction and operating costs is not considered adequate. Until the market (rather than society) is forced to pay for these additional costs, it will continue to only react to the known costs including regulatory and fiscal. In addition countries and utilities look at a portfolio of plants rather the costs of any technology in isolation, since a portfolio approach will decrease risk.

Notwithstanding the above, recent published studies demonstrate that nuclear power will generate electricity at a cost comparable with gas or clean coal (fuel costs assumptions for gas and coal greatly impact this analysis). These studies focus primarily on construction and operating costs and, depending on the study, take into consideration some of the factors listed above, therefore the findings of these studies should be treated with considerable caution.

On the subject of costs, Annex 1 provides a list of recent studies, while Annex 2 provides a critical appraisal of recent reports, as well as a summary of construction and operational costs for different types of plants, as required by the Select Committee.

With regards to the construction period, the major issues to be considered are:

1. Availability of materials; for example delivery times of eight months for certain steels is now commonplace.
2. Ability to pre-order major components such as gas turbines.
3. Development period required to bring a project from the drawing board to start of construction. This is the principal area of uncertainty and this timeframe is highly dependant on planning and permitting.

Bearing these issues in mind, the table below provides an estimate of timescales for:

1. Project Development: starting from project inception to a firm commitment to build (including all regulatory and planning approvals).
2. Construction: starting from the end of the Project Development phase to the production of the first unit of commercial electricity (including detailed, site-specific design, construction and commissioning).

Plant type	Project development Months	Construction Months	Total Months
800 MW CCGT	24–36	24–30	48–66
900 MW coal (with FGD)	24–36	30–36	54–72
800 MW IGCC	36–48	30–40	66–88
1,000 MW nuclear PWR	55–65	50–60	105–125
20 MW wind onshore	24–36	12	36–48
100 MW wind offshore	30–42	18–24	48–66

CCGT = Closed Cycle Gas Turbines
FDG = Flue Gas Desulphurisation
IGCC = Integrated Gasification Combined Cycle
PWR = Pressurised Water Reactor

Note that a reduction in project development timescales may be possible for nuclear and IGCC units following successful approval of the "first of a kind" plant. Though for the former a clear planning and regulatory framework is required.

Question 2—Second Bullet

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

The UK track record in the construction of nuclear plants is no longer a yardstick to forecast the future. Previous practices were based on cost-reimbursable construction contracts managed by the CEGB, where the designs often changed as the construction progressed, resulting in cost and time overruns. The current deregulated UK electricity market means that any future plants will be funded largely by the private sector, based on commercial firm price contracts with penalties for non performance, from established international vendors where the design will be fixed before construction starts. Worldwide experience (France, China and Finland) has shown that this strategy produces plants that operate safely and reliably with predictable construction and operating costs.

Nuclear fuel accounts for 5% of the overall cost of the electricity produced in nuclear power plants, therefore any change in fuel prices have little impact on the overall cost of electricity. Notwithstanding the fact that market prices for nuclear ore have trebled over the last two years, fuel costs are still considered stable compared with natural gas.

Experts in the field believe that the costs of decommissioning, waste disposal and security are all reasonably understood and conservative provisions for all these activities should be built into the cost projections for new nuclear plants. New plant operators should establish a fund to finance decommissioning and waste disposal, built-up from a proportion of operating revenues, this approach has been adopted in other countries. The creation of financial reserves for decommissioning and waste disposal should be made a legal requirement on all nuclear plant owners.

Insurance of nuclear facilities is understood, as long as current arrangements continue the insurance of new facilities should be no different from the current facilities.

Government policy on waste management and the allotment of costs for disposal of existing and newly generated waste will determine the final cost of waste disposal. Investors will require Government policy for nuclear power and its waste management together with the associated costs to be clarified before committing significant investment.

Question 2—Third Bullet

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

It has been demonstrated that, in theory, there are sufficient renewable resources to provide the UK energy needs, although this may not be the most cost-effective or publicly-acceptable solution to meeting the energy needs of the nation. The growth of renewable energy to date has been constrained largely by:

1. Cumbersome planning/permitting procedures.
2. Economic constraints.
3. Visual-impact considerations, as well as a "not in my back yard" culture.

4. Long lead times in the power industry.

It is not yet clear how much these factors will change in future, it is therefore considered unlikely that renewable sources will be able to supply sufficient electricity to fill the gap created by plant closures and increases in demand, for the period under review.

From a technical and commercial viewpoint, power generation from hydro-electric, tidal barrages, biomass, waste combustion (using conventional boiler technologies) and landfill gas recovery is very well-proven. Among the newer technologies, only onshore wind and photovoltaics have truly passed the demonstration phase and are now mature technologies exploited commercially. Many other renewable technologies (wave, tidal, marine current, solar Rankine cycles and offshore wind) are at different stages of development and will require time to become commercially viable. Offshore wind technology has now almost reached maturity and is expected to make a significant contribution to meeting Government renewable targets over the next 10 years. It should also be noted that well-proven, non-generating, renewable technologies, such as solar thermal, air, aquifer and ground-source heat pumps, as well as "passive" solar buildings, can significantly reduce the amount of natural gas required for domestic heating.

Government funding has provided a stimulus in academic research to help exploit some of the renewable energy sources mentioned above, although little support has been provided at the demonstration and implementation stage of renewables and other low carbon technologies. Funding in this area could significantly reduce the long lead times in the industry to bring technologies to the commercial stage and support potential exports.

A limiting factor to all generating technologies based on large-scale centralised plant, is that a power transmission grid infrastructure is required. As most renewable generation is from relatively small-scale, de-centralised plants, embedded within the distribution grid, this problem is largely alleviated, although other problems are created and are currently being addressed. This problem will however remain as long as power generation remains located remote from consumption, as is sometimes the case for wind power.

From a regulatory viewpoint, the Renewable Obligation Certificates ("ROCs") system appears to have provided a necessary stimulus to develop renewable generation and needs to be extended to certain other areas to ensure that Government's sustainability and emissions targets are achieved. However, the market discontinuities should the ROC quota ever be achieved (they become worthless) does need to be considered when setting targets.

The financial incentives supplied by ROCs are expensive, although one could foresee a reduction in subsidies in the future as technologies mature and the true cost of carbon emissions become apparent.

Support for early stage of technology adoption, upgrading of the grid and streamlining of the permitting process, as well as public re-education programs, are the areas that will provide the greatest stimulus to the growth of the renewable sector. Furthermore efforts to develop viable energy-efficiency measures will maximise the effectiveness of renewable power generation and minimise the impact of alternatives.

In any event the choice is not between nuclear and renewables technologies, but rather to minimise the effect of ageing fossil-fired plants, so that any additional growth in renewables beyond current forecasts, can be used to cover the shortfall left by retiring fossil fired plant.

Question 2—Fourth Bullet

What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

As for generation costs, defining plant efficiencies is complex and open to debate. In addition efficiencies are only an important comparator where fuel costs are a high percentage of total costs. For nuclear plants, where fuel costs are low, or for many renewable technologies where the "fuel" is freely available, efficiency is not relevant. A better parameter to evaluate different types of plants is on their lifetime costs.

Notwithstanding the above, the table below provides indicative efficiencies for different types of new large scale generation plant, where efficiency is defined as the ratio of output energy over input energy.

Type of new plant	*Plant efficiency (LHV) Low Heating Value*
500 MW CCGT	57%–60%
900 MW coal (with FGD)	44%–50%
800 MW IGCC	42%–50%
1,000 MW PWR	33%–35%

With regards to micro generation:

1. Micro-wind typically consists of 1–2kW devices for use typically rated at 12m/s wind speed.
2. Photovoltaic in the UK has a typical load factor of around 8% and produces around 750kWh/kWp/year.
3. Micro-CHP units are available up to 6kW in size, but a typical domestic unit will be 1–2kW.

Despite its size, micro-generation has several advantages:

1. It can make a significant contribution to an individual building's energy requirement.
2. When aggregated across the country's building stock, it would make a large contribution to energy requirements.
3. It serves as a potentially useful form of generation to help manage peak load periods, thus reducing the overall large-scale generating capacity required.
4. It helps provide diversity of supply and
5. It promotes customer engagement which helps to focus customers on their energy usage.

To date market penetration of micro-generation has been very slow and a large uptake from households will be required to make any contribution to UK generation. Under the current capital grant schemes, micro-generation will not have an impact on the planning of new large-scale generating capacity.

If the Government were keen to support micro-generation, it would have to consider:

1. More attractive grant schemes.
2. Availability of "two-way metering" systems for the measurement of power used and power produced.
3. Exploiting the DIY/house owning culture in the UK, which will install generation and heating schemes for prestige as well as economy.

Funding for any of the initiatives proposed above should not be at the expense of developing carbon abatement and renewable technologies.

Question 3—First Bullet

What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

Investment decisions by banks, utilities, investors and insurance companies will depend on the perceived balance between risks and financial returns compared not only with similar investments in the electricity sector but also with investments in other sectors of the economy.

Investors in the power generation sector (nuclear, fossil and renewable plants) will closely analyse the following:

1. Market structure and its regulation, to ensure that the investment will provide adequate, predictable and stable cash flow over its lifetime.
2. Ability of the plant to repay its debt even under adverse market conditions, and associated level of financial guarantees provided by equity holders/government at different stages of the plant life (construction, operation and de-commissioning).
3. Political and regulatory risk. Many organisations consider this to be highly relevant given the recent track record of insolvencies in the sector resulting from regulatory changes.
4. Potential environmental liabilities in the event of an accident or at the decommissioning stage.
5. Structure of the investment, to ensure that each stakeholder only bears those risks and liabilities that it is capable of managing both from an operational and financial standpoint.

In comparing the perceived risks associated with nuclear and CCGT plants, there are several differences that do not "favour" nuclear:

1. Construction risks: costs overruns, construction delays and performance guarantees

   It is predicted that in future, nuclear and CCGT plants will use similar contract strategies for plant construction, demanding performance guarantees from contractors, thus removing most construction risks from investors. The length of the construction period (approximately five years for nuclear compared with two years for CCGTs) coupled with potential delays (and therefore cost overruns) arising from public interference on a new nuclear plant build will cause investors to exercise a higher level of scrutiny over this aspect. The present banking practices to postpone the commencement of debt repayment until start of commercial operation may also have to be revisited due to the long construction period.

2. Decommissioning

   Although decommissioning costs are only a small proportion of overall costs, and companies owning new nuclear facilities will make financial provisions, the risk of decommissioning cost overruns remains.
3. Political and regulatory risk

   This issue is particularly relevant for nuclear plants because of the long lead times providing more scope for political intervention, change of Government, etc Changes in environmental/decommissioning laws may also be a significant deterrent to investment.
4. Spent fuel and waste disposal costs.
5. Terrorist attacks on the plant or its supply chain (although other forms of power generation suffer from the same risk).
6. Potential for widespread public resistance (although public attitudes are changing).
7. Availability of construction, plant operational and environmental liability insurances.
8. Cash flow profile

   Because nuclear fuel costs are low, the majority of expenditure will be disbursed during the construction period, while for fossil plants fuel costs are over 50% of total expenditure and this cost can be financed from electricity sales.

On a risk spectrum, nuclear plants are going to be perceived as more risky investments than CCGTs or other conventional fossil fuelled power plants for all the reasons discussed above.

The perceived risks associated with renewable plants very much depend on the technology used. Onshore wind is well proven and perceived as very low risk, offshore wind, wave and tidal are considered more risky but such perception will improve as these technologies demonstrate a successful operational track record. Photo-voltaics, hydro and biomass combustion are also proven and low risk, while biomass gasification is still perceived as risky. ROCs payments for renewable energy help to provide a bankable revenue stream, thus reducing the overall investment risks in these technologies.

It should be noted that it is impossible to discuss risks in such a generic manner. Risks should be discussed in relation to specific projects, since each project will have a unique risk profile. At the extreme, even the development of a nuclear project could be perceived as relatively low risk by investors, if all the risks are taken by other parties.

The challenge will therefore be to structure the investment in any new nuclear build, in such a manner that the risks to investors and financial institutions are not substantially greater than present investments in other forms of generation. If this can be achieved, financial institutions will be willing to provide long term debt facilities. Recent experience in Finland could be one of the ways in which a nuclear project in the UK could be financed.

Finally, the willingness of banks to finance a nuclear programme will also depend on public acceptance of the technology, otherwise their involvement will lead to adverse publicity and damage their retail business.

Question 3—Second Bullet

How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

Government support can be provided in several ways:

1. Direct financial support.
2. Absorbing some of the risks that would otherwise be carried by investors.
3. Providing a stable environment that will ensure long term regulatory and commercial certainties.

Current estimates indicate that the economics of new nuclear plants are robust and do not require Government support for construction and operation. However, before commercial companies decide to invest, they will require confidence that the engineering design is going to be acceptable to the regulatory bodies, primarily the NII and EA (or SEPA), and that it is likely to receive a licence to allow construction. The assessment of the potential nuclear power plant designs and their licensability is a pre-licensing activity that will need to be requested by the Government. For this activity to be perceived by the public as a truly independent assessment of the technology, it will require Government funding with minimal involvement from potential owners and vendors.

Once the technology has been assessed as licensable, it will be up to commercial companies to seek the necessary licenses, finance construction and to put in place electricity trading contracts to assure a return on the investment. Such an approach is entirely compatible with a liberalised energy market.

Any risks in excess of the risks currently taken by investors in funding CCGTs or projects using established renewable technologies, will have to be borne wholly or in part by government. Depending on the structure of the project, these may include certain aspects of construction, operation, insurance and decommissioning risks that can not be covered by the private sector.

Any involvement by government, in the development/implementation of a single project, providing investors with a competitive advantage is incompatible with a liberalised energy market, particularly if government were to supply financial support/guarantees to individual private companies, even if such support were in some way "ring fenced".

However it is the responsibility of governments to set direction, address market failures, and to put in place policies and measures that minimise, for example, the risk of power supply disruptions and to develop regulations to ensure that liberalised markets have adequate incentives to support government policies. An obvious case in point is the current government support for the renewable sector. In this respect providing clear and predictable regulatory and policy framework, to remove uncertainty for potential investors in nuclear power would not be incompatible with a liberalised energy market.

Question 3—Third Bullet

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

With regards to the issue of capital flows, it is believed that there is sufficient liquidity in the market to finance any project in the power sector, provided that such project has been properly structured and risks have been adequately mitigated.

Lack of liquidity would only arise if the market were to perceive the electricity sector as more risky than other industrial sectors. It is the responsibility of governments and regulators to ensure that this problem does not develop. The regulatory track record in the UK of frequent legislative changes, uncertainties with carbon emissions, combined with recent energy market price volatility, means that financial institutions will be much more cautious in future in financing any new major development in fossil generation. Financing of renewable projects on the other hand is considered an easier proposition because of the government's regulatory and financial support for the sector, the small size of each individual investment and the comparatively short lead times.

It is considered that replacing nuclear capacity with nuclear will not in itself have a detrimental influence on renewables and energy efficiency, provided that policies and incentive mechanisms in these areas are adequately maintained. Furthermore, new build is likely to be funded by the private sector/privatised companies, rather than public funds.

The main effect of new nuclear capacity will be to discourage the construction of additional gas or coal plants.

In addition, any near-term investment in nuclear is likely to be in construction rather than research and development ("R&D"), as leading contender designs for new nuclear plants have already been approved and licensed in other Western nations, and in some cases new plants are already under construction. Therefore a major investment in nuclear will not affect R&D for renewables, energy efficiency or clean coal technology/carbon sequestration.

Question 4

If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?

The Energy White Paper states that reducing carbon emissions, maintaining a secure electricity supply and providing affordable electricity are important goals for the UK. A nuclear construction programme will contribute to fulfilling these goals. Government should therefore:

1. Provide policy support for nuclear power.
2. Work towards public acceptance of this technology to ensure its continuing role in a mixed generation portfolio.
3. Ensure that the proposed new nuclear plants are safe and environmentally acceptable through regulatory scrutiny.

If commercial organisations then decide that there is an economic incentive to build such plants then the Government should provide support at a policy level rather than through direct financial support.

Question 4—First Bullet

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

Given current regulatory and political timeframes, it is expected that it will take five to six years before building of a new nuclear station could begin. Coupled with a five year build period, the first nuclear plant will not be operational before the middle of the next decade. Assuming a further construction programme of one 1,000 MW unit a year, it will take almost a further decade to replace the nuclear capacity scheduled to close over this period.

Based on the timeframe forecast above, new nuclear capacity will not be built in time to replace retiring plants. Consequently the power generation "mix" will comprise primarily of fossil and renewables together with a declining proportion of nuclear. It is therefore expected there will be an increase in carbon emissions form the power generation sector over the next 15 years.

Such a nuclear programme cannot provide short-term emission reduction from the present levels, but it will ensure that emission increases are minimised and, in the long-term, stabilised. The construction of each new nuclear plant will avoid the production of over three million tonnes of CO_2 per year by negating the need for new CCGT plants. This figure would be even higher for clean coal or LNG fuelled plants.

Question 4—Second Bullet

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

Security of supply is determined by several factors:

1. Availability of stand-by generating capacity.
2. Electricity grid redundancy.
3. Availability of fuels.
4. Quality of operational staff.

Nuclear generation contributes to security of supply by reducing fuel supply risks and providing large amounts of reliable base-load generation:

1. Plants are relatively immune from fuel shortages and supply disruptions as reactors are refuelled on a bi-annual basis.
2. Even if there were to be a problem in replacing fuel, and a scheduled refuelling were missed, a nuclear station would not have to close. Unlike a conventional fossil station, the output power level would decrease steadily over several months.
3. Fuel requirements are very low—finished fuel requirements for a fleet of 10 new reactors would be of the order of $100m^3$ per year—small enough to easily fit into a modest house. It is therefore perfectly feasible to maintain a strategic stock of fuel, in case of interruptions to supply.
4. Uranium is estimated to be relatively abundant and available from stable and friendly sources, eg Australia and Canada.
5. There are no specialised transport or infrastructure requirements for the import of uranium, unlike gas which requires pipelines, LNG transport vessels, import terminals and specialist storage facilities.
6. Increased diversification in fuels and fuel suppliers, thus reducing risk.
7. Reducing reliance on gas supplies sourced from politically unstable regions of the world.

In addition, nuclear plants in the generation mix serve to temper price volatility.

It is also relevant to note that to ensure reliability and avoidance of accidents, it is important to create an environment where some of our best Engineers are employed in the nuclear industry; where the availability of operational, maintenance and service staff will be fundamental to security of power generation supply. This needs a realistic and supportive training culture to be embedded within the power sector's regulatory structure, to ensure that the operational phase is fully supported. It will not simply happen by itself.

Question 4—Third Bullet

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

Yes, nonetheless like any strategically important infrastructure facility, there will always be a need to consider the implications of malicious attack on a nuclear plant. However this risk can be reasonably managed because:

1. Nuclear power plants are some of the most robust civil structures ever constructed and can withstand massive impacts.
2. Safety and security measures built into these plants means that they are relatively protected against sabotage and external attack.
3. Civil nuclear power plants are subject to regulation by the Office of Civil Nuclear Security (OCNS) which liases closely with NII. The NII has the specific remit to ensure security of such installations, and the ability to close them if not satisfied that security can be assured.

4. The number of plants is limited and each plant is in a single location of limited size, it is therefore much easier to secure than pipelines running across continents. However the security arrangements for the nuclear fuel supply chain from exporting countries will also need to be protected.
5. Nuclear fuel is not sourced from politically unstable or hostile countries.

Given the recent level of terrorist activities, it would be advisable for the UK to review its security measures not only for power plants, but also for the transmission network, because this is the most vulnerable part of the electricity infrastructure.

Question 5

In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, micro-generation, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?

The IMechE advocates that a balanced approach to the development of new power generation is the best and safest approach to meeting the goals set in the Energy White Paper. Therefore the use of a mix of renewable, fossil and nuclear sources, micro-generation and energy efficiency measures is recommended to a point where the country is not overly reliant on any one option.

Within the advocated generation mix, new nuclear plants that approximately offset retired nuclear capacity, will offer:

1. A secure base-load supply of electricity that complements modulating generation produced from gas and coal.
2. Technological and fuel diversification, thus reducing overall generation risks.
3. Long-term stabilization in carbon emissions by avoiding the need for additional new coal and gas fired plants to cover the shortfall.
4. Electricity production at competitive prices, thus allowing for the provision of financial incentives to further develop renewable energy sources, micro-energy systems and the hydrogen economy.

Renewables, micro-generation and energy efficiency measures will almost certainly not, on their own, provide sufficient generation to meet demand in the available timescale, even if a major programme of investment were undertaken. Constraints for growth are mainly associated with permitting and public acceptability (although these issues are by no means restricted to renewables). An investment programme will help but not significantly remove these obstacles; diverting resources from nuclear, clean coal technologies and traditional forms of generation could endanger security of supply, carbon reduction goals and could be an extremely risky political and economic strategy.

Although this Inquiry is focussed primarily on the role of nuclear and renewable technologies, the IMechE believes that developments in industry-related areas such as advanced clean fossil power generation, CO_2 capture, storage and Enhanced Oil Recovery technologies, should also be further encouraged to retain fuel diversification and provide potential export opportunities.

Investments in the development of a nuclear program, renewables and clean coal technologies are not incompatible, on the contrary they are all necessary to ensure a diversified generation mix thus ensuring security of supply.

Question 6

How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?

As with many issues regarding nuclear power, there is a wide range of numbers available depending on the source.

The most thorough study of CO_2 emissions from nuclear plants has been carried out by Vattenfall in Finland, for its 3 PWRs and their BWR (Boiling Water Reactor). The results were published in their 2004 Environmental Product Declaration publication and show CO_2 emissions of 3.3 grams per kWh.

British Energy carried out a similar independent study for the life-cycle emissions associated with the AGR nuclear power station at Torness, the results are shown graphically below and indicate CO_2 emissions of 5.05 grams per kWh:

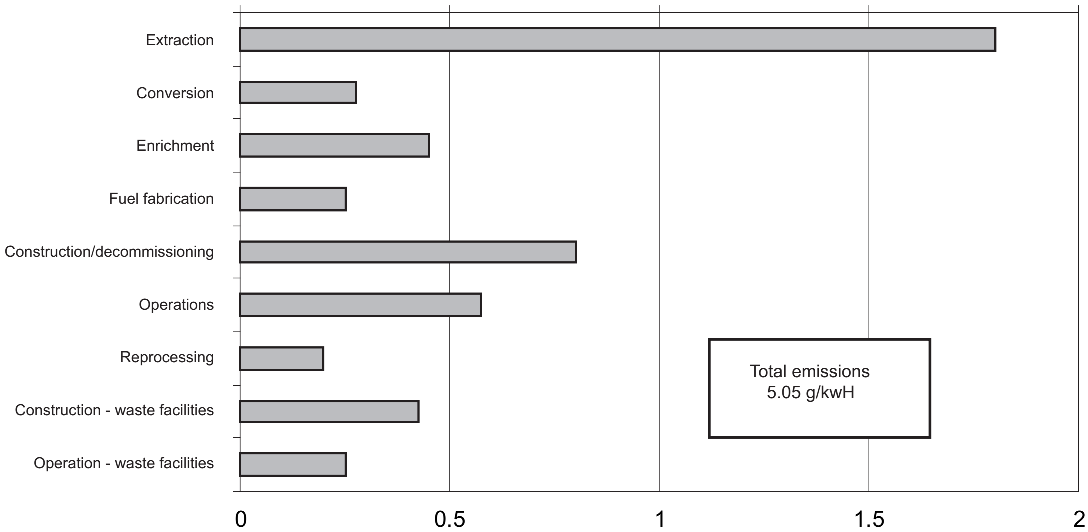
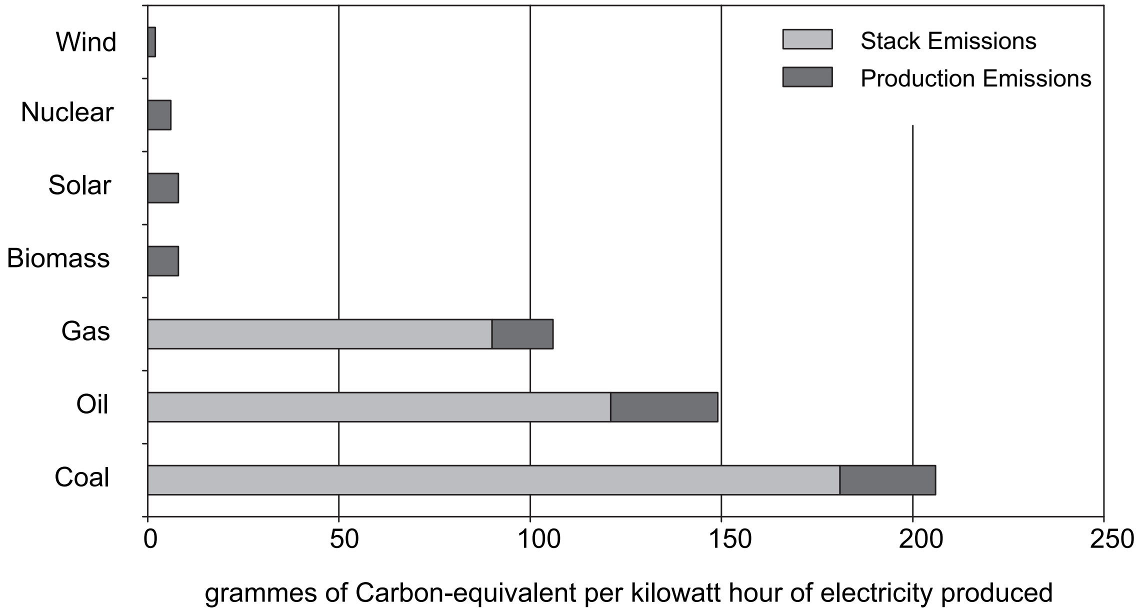


Figure 7 - Life-cycle CO2 emissions for Torness nuclear power station
Source- EPD for Torness Nuclear Power Station, AEA Technology (for British Energy Group plc)

When compared with operational emissions of gas and coal fired plants, CO_2 emissions/kWh from a nuclear plant through its life-cycle are about a factor of 80 and 180 lower respectively.

The most comprehensive generic study that compares the amount of greenhouse gases generated by power plant “chains” which include fuel production, construction, operation and decommissioning was undertaken by the IAEA in 2000. The findings are shown in graphical form below:

Figure 1 - Greenhouse Gas Emissions from Power Production Chains (Source IAEA Bulletin 42, Article 4)



Question 7

Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?

Scientifically acceptable solutions to deal with nuclear waste are already available and have been adopted by countries around the world. CoRWM is due to report in 2006 and will make recommendations based on extensive public consultation, it will then be up to DEFRA to adopt and implement these recommendations.

It is important to reach practical compromises balancing public and media opinion, with cost effective engineering solutions. This will require government, in partnership with industry and professional engineering institutions, to engage the public openly, to address their concerns through the provision of facts and credible arguments.

While some significant movement towards an acceptable solution is required to provide public confidence in the industry and the technology, it is most likely that licensing of new nuclear plants will be required before these issues have been completely resolved. Delays in licensing will threaten the security of our electricity supply, potentially de-stabilise energy prices and lead to increased carbon emissions. The process of licensing a new nuclear design will take time and it should be started as soon as practical, in the expectation of a successful output from the CoRWM process.

Finally it is worth noting that additional nuclear reactors will have little impact on the volume of accumulated nuclear waste to date. Replacing all the current UK nuclear capacity with AP1000 reactors would add, over their lifetime, under 10% in volume to the UK's nuclear waste inventory. In addition spent fuel can be safely stored for at least a century on the reactor site, making a new build programme technically independent of a long term waste solution.

Annex 1

COST OF GENERATION (LIST OF SOURCES)

Source Ref	*Date*	*Author*	*Title*
Eon	9 August 2005	Fathing	Power Technology response
CER	26 July 2005	Foley	Best New Entrant Price 2006
DTI	1 June 2005	DTI	Microgeneration Strategy And Low Carbon Buildings Programme
IEA/OECD/NEA	1998	NEA	Projected Costs of Generating Electricity: 2005 Update
SPRU	5 November 2004	Awerbuch & Sauter	Exploiting The Oil-Gdp Effect To Support Renewables Deployment

Source Ref	*Date*	*Author*	*Title*
IMechE	1 May 2004	IMechE	UK Energy Policy—Challenges and Opportunities
APGTF	1 May 2004	Otter	A Vison for clean Fossil Power Generation
Carbon Trust	1 April 2004	Mott MacDonald	Renewable Networks Impact Study
BWEA	10 March 2004	BWEA	True Cost of Wind Power
RAE	1 March 2004	PB Power	Cost of Generating Electricity
OXERA	1 February 2004	OXERA	Results of renewables market modelling
OECD/NEA	10 November 2003	OECD/NEA	Nuclear Electricity Generation: What are the External Costs
CCS	1 September 2003	DTI	Review of the Feasibility of Carbon Dioxide Capture and Storage in the UK
DTI No 4	1 June 2003	DTI	DTI Economics paper No 4 Options for a Low Carbon Future
EWP Annex	7 March 2003	FES	ENERGY WHITE PAPER—Supplementary Annexes
EWP	1 February 2003	DTI	ENERGY WHITE PAPER—Our Energy Future—Creating a Low Carbon Economy
FES	1 February 2003	FES	Options for a Low Carbon Future—Phase 2
Awerbuch	1 January 2003	Awerbuch	The True Cost of Fossil-Fired Electricity in the EU: A CAPM-based Approach
ExternE	2003	EC	External Costs: Research results on socio-environmental damages due to electricity and transport
Ilex/UMIST	1 October 2002	Strbac	Quantifying the System Costs of Additional Renewables in 2020 (SCAR Report)
IEA	5 September 2002	Awerbuch & Berger	Energy Diversification and Security in the EU: Mean-Variance Portfolio Analysis of Electricity Generating Mixes and its Implications for Renewables
PIU	1 February 2002	PIU	Performance and Innovation Unit Report, The Energy Review
IEA	2001	IEA	Nuclear power in the OECD
RCEP	1 June 2000	RCEP	Energy the Changing Climate
ExternE	1999	EC	ExternE: Externalities of Energy: National Implementation
Treasury	1 November 1998	Marchshall	Economic Instruments and the Business Use of Energy
IMechE	1998	IMechE	2020 Vision: The Engineering Challenges of Energy
IEA/OECD/NEA	1998	NEA	Projected Costs of Generating Electricity: 1998 Update

Annex 2

COST OF GENERATION (APPRAISAL OF RECENT REPORTS)

This analysis sets out to collect and summarise electricity generation costs worked out by and reported from four "up to date" and recognised sources, which give international as well as UK coverage. These are:

Royal Academy of Engineering (RAE)	Cost of Generating Electricity, March 2004
International Energy Agency	Projected Costs of generating Electricity 2005
Enviros Consulting Ltd	Costs of Supplying Renewable Energy 2005
Canadian Energy Research Institute (CERI)	Economics of Nuclear Power 2005

The figures given are based purely on "financial" costs and do not take account of the societal and environmental impacts of each of the technologies as would be required by a "sustainability" analysis.

There are many other papers on this subject but these are often examining one specific generation route only, eg wind-power. Others are directed primarily at intermittency of renewables and carbon saving capability; this analysis does not attempt to address either of these issues. Many of these more specialised papers reference and use data from the above sources.

The RAE, Enviros and CERI papers provide an established typical plant cost without detail of the various sources. The IEA Report lists all the plants used in their data gathering, column 2 below shows the average of this data. Column 4 gives an average from 1, 2, and 3. The "range" of costs is established from the scope of plants listed by the IEA paper (leaving out non standard extremes) and this range is extended to include overflow of costs from 1 and 3, where this arises.

It is not claimed that the reported figures below are precise values, there is obviously much variation in plant costs dependent on country, location, financing route and other project details, for instance discount rates ranging from 5% to 10% may be used in calculating production costs. It can also be misleading to try to make direct comparisons between the purely financial costs of a newly-developed, privately-funded technology with that of conventional, often state-funded, technologies. Conversion rate for $/£ varies with time. It is not practical to re-adjust all figures to a common base.

PLANT CAPITAL COSTS IN £/kW OF CAPACITY

	1	*2*	*3*	*4*	*5*
Plant Type	RAE	IEA (average)	CERI	Average	Range
Coal	818	781	800	799	469–937
Gas	315	375	352	347	225–626
Nuclear	1,150	1,093	1,173	1,138	687–1,562
CHP	—	750	—	750	343–1,060
Wind Onshore	740	805	—	805	625–1,062
Wind Offshore	920	1,265	—	1,093	920–1,656
Wave	1,400	—	—	1,400	—
Biomass	1,840	—	—	1,840	—
Hydro	—	1,875	—	1,875	937–4,753
Solar	—	2,819	—	2,819	2,026–6,526

ELECTRICITY COSTS IN p/kWH (INCLUDING CONSTRUCTION COSTS BUT EXCLUDING CARBON COSTS)

	1	*2*	*3*	*4*	*5*	*6*
Plant Type	RAE	IEA(Average)	CERI	Enviros	Average	Range
Coal	3.54	2.37 (1.75–3.68)	2.95	—	2.95	1.75–3.68
Gas	3.10	2.37 (2.6–3.69)	3.75	—	3.29	2.68–3.75
Nuclear	2.26	2.03 (1.94–3.25)	3.65	—	2.64	1.94–3.65
CHP	—	2.99 (2.19–5.0)	—	—	2.99	2.19–5.0
Wind Onshore	5.35***	5.04* (2.87–9)	—	4.0–10.0	5.19	2.87–10
Wind Offshore	7.19***	5.04*	—	7.5	6.57	Up to 10
Wave	6.63**	—	—	13.7	10.16	—
Biomass	6.67	—	—	6.6 (2.7 co-fire)	6.63	—
Tidal	—	—	—	10.8	10.8	—
Hydro	—	4.06	—	6.7–8.4	5.8	3.87–9.25
Solar	—	36.1	—	55.5	45.8	12.5–117

Note: * IEA costs for "on and offshore" wind are combined.
** Cost predicted from prototype data.
*** These figures include highly controversial and contested figures for "back-up" supply costs; without this, the figures are 3.68 (not 5.35) for onshore wind and 5.5 (not 7.19) for offshore.

General Observations

The cost range for all technologies is quite wide and indicates that, whereas the basic hardware costs are well established, other project factors, which include discount rate, country economy, location and installation/hook up details etc. strongly influence the final costs. Volatility of fuel prices, waste disposal costs and "end-of-life" plant costs have not been included in these figures. Furthermore, historical cost curves showing technology advances, confidence by financiers with respect to risk and growth in capacity have demonstrated that capital and generation costs of the newer technologies will continue to fall.

Observations for Coal Plants

UK costs appear to be at the top end of the range. It should be noted that the coal plants referenced by IEA numbered 27, being mainly PF or FBC, however there were three IGCC plants included, of which two were within the cost range and the third (proposal only), which included carbon capture, was marginally over the cost range for coal at £1,030/kWe and its production cost was reported at 3.7p/kWh.

Observations for Gas Fired Plants

The IEA referenced 23 plants, all of which were CCGT except one. On the face of it, gas would seem to be competitive with coal, but it is not thought that any of the reported gas plant performances has taken into account the escalating wholesale gas prices (approximately 40% change over the last year has been stated). If this trend were to continue, gas plant costing will need to be re-assessed, bearing in mind that up to 70% life costs are accounted by fuel. It is worth noting that a major new build of gas fired plants to strengthen the grid was planned in the USA two years ago, but because of high local gas prices, this programme has been replaced with a "coal build" one.

Observations for Nuclear Plants

Plant costs are becoming reasonably established for standardised PWR and BWR, both cost and delivery are being endorsed by various plants recently or currently being built, there are about 16 projects in progress in the far East. The technology is basically competitive but economics are influenced by the more complex long term funding arrangements needed. Besides the reported plant costs, a further costing by MIT in 2004 cited a capital cost of £1,111/kWe and production cost of 3.6p/kWh⁄just above the range but explained by a higher 12% interest rate. Discount rate (or rate of return) is the biggest influence on nuclear economics.

Observations for Renewables

There is not yet much useful data on tidal and wave costs to facilitate cost range reporting and reported solar photovoltaic data is also sketchy, which is disappointing as both Germany and Japan have extensive installations. It is clear, however, that none of these technologies is yet near financial competitiveness. Biomass is more financially competitive for co-firing than for dedicated plants, although this does not take account of the benefits that these dedicated plants will have on distributed generation. The main core of large-scale hydropower is longstanding and installation of new landfill gas sites is reaching a limit.

The most financially competitive source of renewable energy is currently wind power, where much more information on costs is available. It is clear that whereas engineering and hardware costs are well defined, the overall project costs are strongly influenced by other factors including load factor, country, site, grid connection, accessibility and other details, both IEA and Enviros report a wide range of prices. Windpower Monthly Data also reports costs ranging from 2.9p/kWh to 5.0p/kWh onshore and 5.2p to 6.9p offshore. Enviros notes that with the best sites onshore costs of 4p/kWh are likely, but notes that the best sites are rapidly being used up. Over 3,000 MW of new installation has been applied for, much off shore, and about 500 MW of build is thought to be in hand. To date just over 1,000 MW of wind-power is operational and this produced 1,905 GWh in 2004.

In conclusion, reliance in basing energy planning on typical costs for plant types, related mainly to the hardware costing is questionable, as the project circumstances, location and conditions can vary the final price significantly. Also awareness of probable fuel cost increases is likely to be a much more important ingredient in future pricing.

21 September 2005

Memorandum submitted by Professor Brian Launder

Thank you for the invitation to comment and I'm certainly glad there's to be an enquiry. Here are some brief thoughts:

If the surface transport sector is to become anything near carbon free there'll need to be a major replacement over the coming decade of fossil-fuelled cars by hydrogen or battery-powered vehicles. Thus, in computing the electrical power required from power stations, one needs to include the electrical demands that the production of H2 or the energy for battery recharging will itself entail.

The failure to tax aviation fuel (and aircraft) or to introduce some equivalent taxation system on tickets to recognize CO_2 emissions from air travel is a serious anomaly in transport policy that urgently needs to be addressed.

Yes, regrettably, it's my personal belief that we do need new nuclear power stations. Small scale renewables provide energy that is expensive/difficult to harvest, and usually requires back-up provision as supplies are not correlated with demand.

It seems perverse for the UK to be even considering "going it alone" with new Generation 3 reactors. The French have a track record of plotting a succesful strategy and running a much larger system of nuclear power stations that we have. Moreover, perhaps because of the successful use of nuclear for so much of their electrical energy, the French public is much less hostile to nuclear power than that in the UK. I am of the view that the UK would be well advised to throw in their lot with the French, let the protype Generation 3 (and, later, if they're needed, Generation 4) reactors be built in France (that seems the only way they can be built soon enough) so that construction of, I guess, some half dozen or more "production-line" stations in the UK can get underway in the next 10–12 years. (I mention, as an aside, that the French led Airbus consortium has done great things for Europe's ailing commercial aircraft industry.)

My colleagues here at the Tyndall Centre for Climate Change Research feel I am unduly pessimistic about our supplying sufficient carbon-free energy from truly renewable (non-nuclear) sources. They feel that a combination of efficiency improvements, large-scale planting of bio-fuel grasses, offshore wind, tide and wave power, supported by various taxation and "smart metering" measures could enable us to avoid nuclear re-build even given the loss of capacity from the progressive closure of existing stations.

As my earlier remarks have indicated, I do not share that degree of optimism partly because I feel the currently proposed carbon-reduction targets are far too modest. Perhaps, however, one can avoid going to Generation 4 reactors if one does embrace all the measures noted in the previous point, in conjunction with carbon capture and storage.

7 September 2005

Memorandum submitted by Amory Lovins

I have the honour to submit herewith some materials that I hope may help the Committee's inquiry. Unfortunately, word of your work reached me only very recently whilst I was in Sweden, and a heavy travel and writing schedule have made it impossible for me to prepare a special paper for the Committee before today's deadline. However, I should do my best to respond to any further questions from the Committee, and if desired, could testify either by Internet videoconference or, during my mid-March 2006 visit to the UK, in person if your inquiry were still underway at that time.

A Brief Sketch of My Background

Physicist Amory Lovins is cofounder and Chief Executive of Rocky Mountain Institute (www.rmi.org), a 23-year-old independent entrepreneurial public charity, and Chairman of its engineering spinoff Fiberforge, Inc. (www.fiberforge.com). Published in 29 books and hundreds of papers, his work has been recognized by the "Alternative Nobel", Onassis, Nissan, Shingo, and Mitchell Prizes, a MacArthur Fellowship, the Happold Medal of the UK construction industry, nine honourary doctorates, and the Heinz, Lindbergh, World Technology, and Time "Hero for the Planet" Awards. He lived in the UK 1967–1981 and was a Junior Research Fellow of Merton College, Oxford (MA Oxon by Spec Resoln). His most recent books are an Economist 2002 book of the year—Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size (www.smallisprofitable.org)—and the Pentagon-cosponsored Winning the Oil Endgame (www.oilendgame.com). His three decades' global consultancy for industry and governments (including USDOE and USDoD) spans all energy sectors and about fifty countries, including extensive work in the nuclear and utility industries and invited testimony before nuclear-related proceedings and inquiries in many countries. Three of his books and dozens of professional papers focus on nuclear issues, of which he has been an independent student since the 1960s, when his physics research won national awards from G.E., Westinghouse, American Nuclear Society, and the Chairman of the US Atomic Energy Commission.

My organisation is also briefly described in slide 30 of the CEC attachment [not printed].

My most apposite recent writing for this inquiry is the invited testimony I gave five days ago to the California Energy Commission's hearing on nuclear power policy, slightly updated and with a few extra background slides added at the end for those who wish to dig deeper [not printed]. A PowerPoint (for Mac OS X) file is attached, and a hard copy will go out to you by airmail post tomorrow, together with a hard copy of this note and its attachments [not printed].

Please forgive the attached PPT file's occasional use of US (originally British) units, such as MCF (thousand cubic standard feet) for natural gas; one MCF has a heat content of approximately one GJ. For general background on climate strategy—on which my first professional paper was in 1968—please see my attached September 2005 Scientific American article, "More Profit from Less Carbon." Its bibliography shows a URL with extensive further citations [not printed].

Perhaps a prefatory comment is in order. There is a certain sense of déjàvu in this inquiry. I recall many years ago submitting testimony to a Select Committee of the House of Commons—I think together with Walt Patterson—predicting that any orders placed for PWRs would prove painfully costly and that their overall economics would disappoint. Over the past several decades I have repeatedly said the same about reprocessing, which has indeed turned out, as expected, to raise the cost of once-through LWR fuel cycles by roughly 4-5–fold and to complicate waste management. The British taxpayer has already twice bailed out the national nuclear enterprise at great expense. I should have thought that by now the basic lessons of this industry's economics and credibility would have been learnt—that everyone would understand that the way forward for energy policy is to take market economics seriously, stand back, let the winners win and the losers lose, design an orderly terminal phase for the nuclear adventure, and avoid further embarrassment. But it seems that the proponents have no shame and have, like an earlier ancien régime, learnt nothing and forgotten nothing. So evidently some further reminders are needed about economic fundamentals, where the case today is immensely stronger than ever in the past.

Here, then, are the key arguments in my 16 August 2005 CEC testimony:

1. Nuclear power worldwide has already been eclipsed by its supposedly small and slow decentralised rivals (renewables other than big hydro, and CHP). Slides 3–4, [not printed] documented by a spreadsheet and a methodological memorandum posted at www.rmi.org/sitepages/pid171.php#E05-04, compare nuclear power with its no- or low-carbon decentralised competitors: renewables including hydropower only up to 10 MWe, and fossil-fueled CHP, respectively—the latter typically reducing CO_2 emissions by ~30–80% depending on before-and-after fuels and design details. These data, not previously assembled, show that the decentralised generators overtook nuclear power in worldwide installed capacity in 2002 and in annual electricity output in 2005. (Dr Eric Martinot at Tsinghua University in Beijing is to publish his own detailed comparison next month, with very similar results.) The remarkably faster absolute growth of the decentralised options, in MWe added, is shown in slide 4 [not printed] by year and by technology. Five years from now, the respective industries project that nuclear power's net capacity addition will total only 1/177th as much as the decentralised competitors'. Whilst this will doubtless not prove to be exactly the right number, its direction is clear, and its implications for nuclear advocates are devastating. Those who contend that only nuclear power is big and fast enough to cope with climate change, or that the non-nuclear ways to reduce carbon emissions have excessive "dry hole" risks of nondeployment, have apparently overlooked this actual market behaviour showing exactly the opposite. (Of course, as Schneider and Froggatt show—please see slides 5 and 31-33—nuclear power is about to begin a long but inexorable global decline due simply to the aging of existing plants.)

2. Demand-side installations may well be even bigger and faster than these winning decentralised supply-side competitors, but are not being properly measured globally nor, in most cases, nationally. For lack of data, slides 3-4 omit demand-side competitors (end-use efficiency and electric load management or demand [Not printed] response). These are probably saving more GWp and TWh/y than the decentralised supply-side resources are adding, but as they are not well tracked statistically (they formerly were in the US but not for the past decade or so), I couldn't properly graph their progress. Nonetheless, as a rough indication, the US Energy Information Administration's Annual Energy Review 2004 shows that in 2003 alone, utilities' demand-side programmes—which are far from the only and may not even be the main cause of saving electricity and shifting peak loads—saved 23 GWp and 50 TWh/y in the US, which is one-fourth of the world electricity market. This approaches the 28 GW added by the decentralised supply-side resources in 2003 worldwide, vs 0.6 GW of nuclear net additions.

Remarkably, nobody is keeping track, worldwide or in almost any country, of how much electricity is being saved at what cost. Thus both policymakers and investors are "flying blind", to their peril. Exactly such invisibility of demand-side achievements created the mid-1980s US fiasco of overinvestment in supply, glutted demand, crashed prices, and bankrupt suppliers. The current US administration seems determined to see this very bad film all over again: since 1996, US electric intensity and primary energy intensity of GDP have respectively declined at rates averaging 1.5 and 2.3% per annum—2-3x faster than in the previous decade—recently causing investors to lose nearly all their money in nearly 200 GW of combined-cycle plants built to meet nonexistent demand. Yet during 1996–2004 inclusive, some 78% of the increase in US energy services has been "fueled" by reduced energy intensity rather than by increases in physical energy supply. Since official statistics focus only on the other 22%—the recognised supply side—this means policymakers and investors are seeing less than one-fourth of reality. I hope your Committee will strongly encourage Government to correct this informational imbalance.

3. Both electric end-use efficiency and decentralised generation cost much less than new nuclear plants per delivered (retail) kWh. This comparison, using nominal but conservative values based on wide US market experience, is presented in slide 7 [not printed] and in the animation of slides 8-21. Supplementary slide 34 [not printed] amplifies some illustrative US demand-side costs. Note the decline in programme costs in both California and the Pacific Northwest in recent years when efficiency efforts (interrupted by restructuring) have been revived—much as on previous occasions—and the very low costs of most savings in the commercial and industrial sectors, vs all-sector programmes whose average costs are raised by heavy investments in lagging and draughtproofing houses and flats.

4. The cost of all these non-nuclear competitors is relentlessly declining. Please see slides 21-22 [not printed]. Clark Gellings of the Electric Power Research Institute told me last month that he agrees the electric "efficiency resource" is getting cheaper and bigger because better technologies, their lower costs in volume production (often in Asia), and more streamlined delivery are together more than offsetting the depletion of efficiency opportunities. Moreover, my consulting team's practise has demonstrated in very diverse industrial sectors and building types that integrative design—optimising whole systems for multiple benefits rather than isolated components for single benefits—typically makes very large energy savings cost

less than small or no savings. (Natural Capitalism, www.natcap.org, gives many earlier examples.) That is, rediscovering good Victorian whole-system design can generally make investments to energy efficiency yield expanding rather than diminishing returns. This is why slide 20 [not printed] shows that the $0.01/kWh typical cost of saving electricity in the business sector can decrease to negative values in properly designed new installations across all sectors.

5. Conventional comparison between new central stations—nuclear, coal, or gas—thus miss the point. All three of these centralised options are grossly uncompetitive with demand-side and decentralised supply-side investments. Hence the bleak economic prospects for nuclear power summarised in slide 6. Counting the 207 "distributed benefits" (slide 37) documented in Small Is Profitable would typically give decentralised investments a further order-of-magnitude cost advantage not counted here.

Please note also slide 42's empirical data suggesting that currently popular declining-cost assumptions [not printed] merit caution: US coal and nuclear plants through ~1980 experienced not a learning curve but a "forgetting curve"—a neoclassical supply curve of increasing real cost with increasing installations. The main underlying reason for this appears to be that the more plants are built, the more likely it is something will go wrong amongst them and that one will be close enough for you to notice, so you are more likely to exert pressure on the political and regulatory system to make each new plant cleaner or safer. Cleanliness can be both directly perceived and much improved at modest cost that is reasonably bounded. However, risks from nuclear plants are not so directly testable by the senses, often depend on differing personal judgments of probabilities, and can drive investment in greater safety or security without any obvious upper bound. One implication is that inherently benign technologies are more likely to win wide acceptance. Another is that decentralised technologies, by allocating their costs and benefits to the same people (not to different people at opposite ends of the wires or at different times), automatically internalise their perceived impacts and thus are unlikely to elicit open-ended regulatory intervention.

6. The decentralised competitors, both demand- and supply-side, offer a considerably larger resource base, especially in diversified portfolios, than nuclear power can. Please see slide 23 [not printed]. The ~2-4x range of potential efficiency gain for the US comes respectively from Clark Gellings' analysis at EPRI (in 1990 for the 2000 base, including 9-15% of spontaneous savings then expected) and from a far more detailed RMI long-term analysis documented in more than 2,500 dense technical pages documented to more than 5,500 sourcenotes (the Competitek/E Source library, www.esource.com). Both sets of results were summarized in Dr Gellings's and my joint article in the September 1990 Scientific American (enclosed with the postal version); our differences were mainly methodological not substantive, as noted in my 1991 Ann. Rev. En. Envt. survey article. Please see also my 2004 Encyclopaedia of Energy article "Energy efficiency: taxonomic overview", a copy of which is attached as 383—402.PDF [not printed]

My background paper currently in editing, "Energy Policy for National Insecurity", will more fully document the well-established arguments that neither the intermittence nor the land-use of certain renewables need be of serious concern at large scale, given thoughtful siting and proper system engineering. This paper will soon be posted at www.rmi.org/sitepages/pid171.php#E05-04. Meanwhile you will find many helpful references up to spring 2002 in Small Is Profitable, op. cit. supra. Indeed, it has been known since IIASA's ~1977 analyses that land-use for nuclear, coal, and [relatively inefficient] solar fuel cycles is broadly similar per TWe-y of output.

Please see also slide 38 [not printed], which shows that whilst conventional projections show very large increases in renewable energy supply are possible (and would be necessary if one did not make least-cost investments on the demand side, which none of the projections shown takes seriously), these plausible renewable expansions far surpass both the current scale and the declining officially forecast future scale of the nuclear enterprise [not printed]

7. Neither of the main arguments for nuclear power—displacing oil and mitigating climate change—can withstand serious scrutiny. Please see slide 24. [not printed]

As to oil: for a very detailed Pentagon-cosponsored synthesis of how to eliminate US oil dependence over the next few decades, led by business for profit, please see Winning the Oil Endgame, free (with its supporting analyses) at www.oilendgame.com. Its Executive Summary is attached hereto. As a free byproduct of the profitable oil savings, US CO_2 emissions projected for 2025 would drop by 26%. I have not performed a comparably detailed analysis for the UK, but am confident that despite many differences of detail, a broadly similar potential would be found there.

As to climate: of special importance to your inquiry is the opportunity-cost argument in slide 24's second main bullet [not printed]. If, for example, saving electricity cost one-third as much per delivered kWh as a new nuclear plant (the actual ratio would generally be much larger than threefold), then every £ spent on a new nuclear plant could have bought three times as much carbon displacement if invested in efficiency instead. The net result of choosing the costly nuclear investment will thus be to keep on burning two unnecessary units of coal for each unit displaced by nuclear power—thus making climate change worse than had the least-cost option been bought instead. The more concerned we are about climate change, the greater rigour we need in applying such a marginal cost-benefit calculus to our investments, so that we are confident of winning the most carbon displacement, soonest, per £ invested. On grounds of both cost-effectiveness and speed, nuclear power falls near the bottom of the list of investment priorities. Thus as soon as one realises that the available, practical, and empirically more successful portfolio includes efficiency, CHP, and renewables as well as central coal or gas stations, the supposed case for substituting nuclear for coal power falls to the ground. (Obviously a low- rather than no-carbon resource—CHP rather than renewables or efficiency—requires the reduced but nonzero carbon emissions to be taken into account, but the decision outcome will be the same: nuclear loses on carbon displaced per £ or per year.)

8. All options have their difficulties with implementation at scale, and hence a nonzero "dry-hole" risk that they will not actually get built or will not operate timely and durably. But these risks are empirically greater for nuclear power than for a proper portfolio of its no- and low-carbon competitors on the demand and supply sides. Please see slides 25 and slides 35-36, and review slides 3-4, for compelling illustrations from actual market behaviour [not printed].

9. In view of these findings, further private investments in nuclear power are unlikely, and further public investments in it are counterproductive: they would actually reduce and retard CO_2 reductions by diverting money, time, and talent away from the biggest and fastest solutions. Slide 39 summarises why the just-approved major increase in US nuclear subsidies, though an extraordinary distortion of markets, is unlikely to overcome the fundamental economic disadvantages shown in slides 8-20. That is a good thing because of the unpleasant implications and discouragingly small benefits of large-scale nuclear expansion (slides 40) [notprinted] and the leverage of market-driven nuclear phaseout for discouraging further proliferation of nuclear bombs (slide 41). (The proliferation analysis is set out in detail in my 1979 out-of-print book Energy/War: Breaking the Nuclear Link, summarised in the Summer 1980 issue of Foreign Affairs, "Nuclear Power and Nuclear Bombs", and technically supported by my Nature review article of 28 February 1980.)

Having worked in the UK for more than three decades, I am well acquainted with the many differences of detail between my largely US-based analysis for the California Energy Commission and UK conditions. However, I believe that for the purposes of your inquiry, these differences are far less important than the similarities, and that all the same conclusions, mutatis mutandis, would remain valid for the UK.

My team at RMI is currently completing a far more detailed examination of the US gas and electricity sectors than the already very suggestive one in Winning the Oil Endgame, which showed, for example, how to save half of U.S. natural-gas use—half of it directly, the rest by electrical demand-side management displacing gas-fired power generation—at an average cost below $1/GJ. I would not be surprised if the UK had a comparable or even a larger potential for saving natural gas, and would urge this as a focus for concerted and modern analysis across all sectors.

The potential for saving UK electricity is among the largest in the industrialised world, yet will remain largely uncaptured so long as Parliament continues to give energy suppliers and customers contrary incentives. Ever since Parliament set and the Regulator, at the start of the restructing era, first implemented the formula for forming the retail prices of electricity and gas (the Government of the day having rejected an amendment in the Lords seeking to prevent the problem), distributors have effectively been rewarded for selling more energy and penalised for cutting customers' bills. This and other factors nearly destroyed the fledgling efficiency industry. Dr Stephen Littlechild was unable to mend this perverse incentive within the constraints of the legislation. May I suggest that doing so is probably the biggest single leverage point in UK energy policy and merits Parliament's prompt attention? The basic goal should be first to decouple revenues from sales volumes—so that distributors are no longer rewarded for selling more energy nor penalised for selling less—and then to let distributors keep, as extra profit, part of whatever they save the customers, so that both parties have fully aligned incentives. This has already been done in some other jurisdictions, with a very salutary effect on both parties' behaviour. The independent and not-for-profit Regulatory Assistance Project, www.raponline.org, stands ready to help the UK authorities to design and implement this vital reform. This alone would go a long way to profitably meeting UK climate-protection goals.

22 September 2005

Memorandum submitted by Medact

INTRODUCTION

1. Medact is a UK charity for global health, working on issues related to conflict, poverty and the environment. It is the UK affiliate of International Physicians for the Prevention of Nuclear War (IPPNW: Nobel Peace Prize 1985). Medact warmly welcomes this opportunity to submit evidence to the House of Commons Environmental Audit Committee for its enquiry on Nuclear, Renewables, and Climate Change. Medact will restrict its evidence to section D, ie Other Issues, and will address, inter alia, questions 6 and 7 set out below:

> 6. How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?
>
> 7. Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended by the RCEP?

2. Before we commence, we register our concern at the Committee's precondition, in its terms of reference, that "nuclear new build" refers only to "a programme of building at least eight AP1000 reactors". Considering only a minimum of eight reactors of only one reactor type is unduly limiting and surprising. For example, Why not "one" reactor or "no" reactors? Why not other reactor types? These questions need to be addressed.

3. Building eight AP1000 reactors is what the nuclear industry wants. The Committee should bear in mind that the industry is seeking government subsidies of about £15 to £20 billion to build its chosen programme of reactors. The Committee should therefore critically examine all aspects of the matter and not merely what the industry wants or prefers. In other words, the Committee should follow its own, not the industry's, agenda.

How carbon-free is nuclear energy?

4. Concerns about global warming and UK greenhouse gas emissions are widely shared in Britain and rightly so. For this reason, many people have looked for alternative means of supplying our economic needs without producing greenhouse gases. A very common reaction is to suggest nuclear power, as in many people's minds this does not produce CO_2. This is a widely held view, even by celebrity environmental leaders who should know better, but unfortunately it is wishful thinking. It is understandable in our concern about global warming, but nevertheless it is wrong. The reality is otherwise for two reasons. First, nuclear, alas, is not carbon-free. Second, nuclear new-build would make only a small contribution, if any, to reducing the UK's greenhouse gas emissions.

5. While most nuclear reactors[205] do not emit CO_2 gas, reactors are a relatively small part of the nuclear fuel cycle which emits very large amounts of CO_2 gas. These arise from the activities of the front end of the fuel cycle (uranium mining, ore milling, UF_6 conversion, fuel enrichment and fabrication), and its back end (nuclear waste handling, encapsulation, transportation and disposal in some future waste repository—assuming one is constructed).

6. Life cycle analyses (LCAs) of the internal and external costs (including especially energy costs) of industries are often used to analyse the true impacts of ALL their processes. A number of LCA studies have examined CO_2 gas emissions [usually expressed as CO_2 equivalents per kWh] for different methods of producing electricity. Much depends on the models used and on the assumptions and rate parameters in these models.

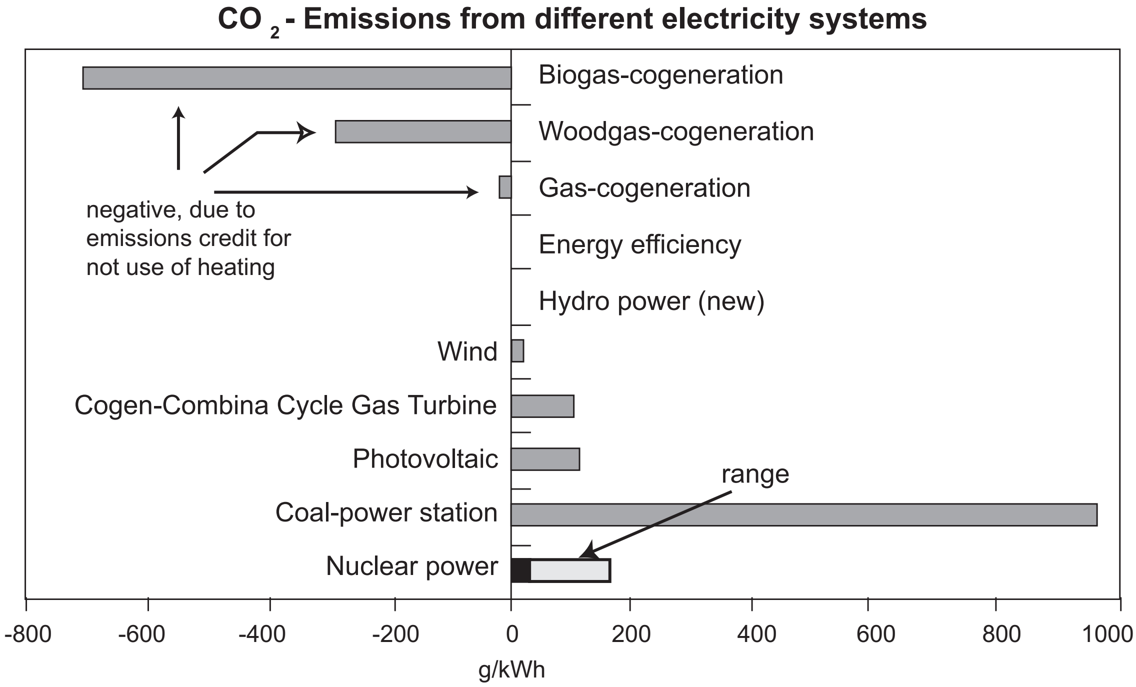
7. The most comprehensive models in this area have been constructed by the Öko Institut (1998) and by Professors Smith and van Leeuwen at the University of Groningen, see http://www.oprit.rug.nl/deenen/Technical.html The work of Smith and van Leeuwen has been critically examined and welcomed by Professor Mortimer at Sheffield Polytechnic. See http://www.no2nuclearpower.org.uk/articles/mortimer_se74.php

8. Both studies conclude that the nuclear fuel cycle can create relatively large amounts of CO_2 emissions depending on assumptions used. The most important aspects of the nuclear fuel cycle were the uranium ore grade and the method used for fuel enrichment. (Currently two methods are used for enriching the fissile content of uranium fuel, namely centrifuge separation and gas diffusion.) The lower the uranium concentration in ore, the higher the amounts of CO2 generated. Gas diffusion is much more energy and CO_2 intensive as a means of enrichment than centrifuge separation. Using a range of reasonable assumptions, Smith and van Leeuwen determined that nuclear generated about a third as much CO_2 per kWh as conventional mid-sized gas-fired electricity generation. Using pessimistic assumptions, nuclear could generate even more CO_2 per kWh than a gas-fired system.

9. A key point that Smith and van Leeuwen, as well as Mortimer, make is that, because we would increasingly have to rely on poorer quality uranium ores in the future, CO_2 emissions from the nuclear cycle would increase.

10. The Öko Institut report made substantially similar conclusions, see table below reproduced from the Öko report.

[205] Technically speaking, Magnox and AGR nuclear reactors release coolant CO_2 gas each time they depressurize or refuel, ie about every 12 to 16 months. Typically, an AGR reactor will discharge about 200 tonnes of CO_2 each time it depressurizes. So, current UK nuclear reactors emit about 3,000 tonnes of CO_2 each year. This would not occur with LWR or AP type reactors.



11. A number of industry studies (WNA, 2004) have countered by alleging that nuclear is no worse than the renewables as regards CO_2 production. But this is not the case. The Öko report examined this allegation and concluded "In comparison with the specific CO_2 savings of alternative systems, like electricity savings [ie efficiency], cogeneration and renewable energy systems, nuclear power stations come off badly". The Öko conclusions are supported by earlier studies by IEA (1998, 2002) and CRIEPI (1995), the research arm of the Japanese nuclear industry, and an older study by Mortimer, see http://www.no2nuclearpower.org.uk/articles/mortimer_se74.php In summary, the Öko report showed nuclear CO_2 emissions up to 4 to 5 times greater than those from the renewables, IEA/CRIEPI up to 2 fold greater, and Mortimer 3 to 4 fold greater. Its overall conclusion was that the nuclear cycle results in "significant" emissions of CO_2 compared with other forms of electricity generation. This would apply to any future nuclear fuel cycle as much as it does to the present one as the front and back ends of the present nuclear fuel cycle would remain substantially the same in any new reactor system.

Is nuclear capable of reducing Britain's greenhouse gas emissions?

13. There is a widespread view that nuclear power generation will provide a major solution to the nation's greenhouse gas emissions. The Committee will clearly wish to ascertain whether this view is correct and what its real potential would be for UK greenhouse gas reduction. In fact, most of UK annual CO_2 production is not from electricity generation but from transportation and energy sources such as oil and coal. Electricity generation is responsible for 25% of UK annual CO_2 production. If contributions from aviation were included in UK greenhouse gas statistics (currently they are not), this fraction would be even smaller.

14. Because nuclear reactors cannot follow daily fluctuations in electricity demand (for safety reasons, they cannot be switched on/off and cannot be cranked up and down to follow demand), the maximum realistic contribution any new set of reactors could make to Britain's electricity needs would be about what it is today, ie ~25%. Also, CO_2 represents only 83% of all greenhouse gases. Therefore the theoretical maximum percentage of UK greenhouse gases which could be addressed by nuclear is 25% x 25% x 83% = 5%—a rather small potential. In other words, CO_2 savings does not provide a strong reason for deciding to build more nuclear power stations.

Is nuclear a cost-effective way to reduce CO_2 emissions?

15. Given its poor CO_2 savings per kWh, it is instructive to compare the cost effectiveness of other ways of reducing CO_2 emissions. The first point is that nuclear is very expensive. In 2003, the US Congressional Budget Office estimated the cost of each proposed AP 1000 MW reactor to be £1.4 to £2 billion (at an exchange rate of US $1.5 = £1), assuming that 10 reactors were built, ie a total cost of £14 to £20 billion. Clearly this would mean massive Government subventions and all manner of subsidies. However many studies have shown that, £ per £, nuclear is 5 to 7 times less cost-effective than efficiency/renewables in reducing CO_2 emissions. See Keepin and Kats (1990); Lovins (2001).

16. Lovins has stated (2001):

> "Each dollar invested in electric efficiency displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power, without any nasty side effects. If climate change is the problem, nuclear power isn't the solution. It's an expensive, one-size-fits-all technology that diverts money and time from cheaper, safer, more resilient alternatives."

17. He has also explained (2004):

> "If we suppose pessimistically that saving a kilowatt hour costs as much as three cents, while generating a new nuclear kilowatt costs optimistically as little as six cents, delivered. . . then each six cents you spent on such a nuclear kilowatt hour could have bought two efficiency kilowatt hours instead. Therefore, by buying the costlier instead of the cheaper option first, you generated an additional kilowatt-hour from, say, coal that would have been avoided if you'd bought the cheapest things first".

18. In other words, to tackle greenhouse gas emissions most effectively we must choose the cheapest forms of carbon abatement first. Provided there are still energy efficiency gains to be made, these will provide a more financially effective way of spending public money than subsidising new nuclear power stations.

Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended by the RCEP?

19. In 1976, the Royal Commission on Environmental Pollution stated "There should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived, highly radioactive waste for the indefinite future." (paragraph 533 of the Flowers Report)

20. Although this was written almost 30 years ago, a safe method of dealing with nuclear waste STILL does not exist anywhere in the world. Therefore this comment is still as true now as it was then. In moral terms, it is unethical to embark on a second programme of nuclear build without solving the problems of the first. In Medact's view, the nuclear option is not a sustainable development. Indeed, with its major problems of nuclear waste, proliferation dangers, radioactive discharges and uranium depletion, nuclear energy is the epitome of unsustainability. In our view, it is highly unethical to pass these problems to future generations.

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20 September 2005

Memorandum submitted by Tom Midgley

An objection often raised against the widespread use of renewable power sources is that they are not guaranteed to be constantly available. I would like to put to the committee the thought that matching supply to demand is inevitably a complex business, and that while variable supply increases that complexity it is not beyond the wit of man.

Need for an Analytical Model for Power Availability and Demand

Our electricity supply system has been built around the reality that demand for power varies through the day, from day to day, geographically, and with the seasons. The current design of the electricity system assumes that supply will be constantly available and—for the most part—controllable[206].

This is not a necessary assumption. Many of the natural power sources available to us—wind, wave, solar—are neither constant nor controllable, and if we are to make best use of them rethinking and redesign will obviously be necessary.

If we move from a few, large, controllable generators to a many, smaller sources with time-varying outputs, it becomes a statistical question what mix of technologies will best provide electricity at an appropriate service level.

It might be for example that a certain mix of wind and solar power would require backup from coal-fired stations on 14 days of the year to meet demand, but that by substituting some wave power this would be reduced to five days.

I would hope that this committee would be able to recommend that analytical tools should be developed, able to establish the optimal mix of power sources to provide a defined level of security of supply, taking into account the statistical distribution of the supply technologies—wind, wave, solar—and the daily and seasonal demand for electricity.

Whilst our requirement is to perform this analysis for the UK, the optimum mix will be very different in other parts of the world, and we would render the world an enormous service if our analysis were done in such a way that the different parameters of each country could be simply "plugged in". Thus, in the UK an important factor is the wintertime correlation between the high demand for heat and the peak availability of wave power, in Bahrain the simultaneous demand for air-conditioning and the availability of solar electricity would be more significant.

22 September 2005

Memorandum submitted by Leslie Mitchell FREng

Dr Mitchell has spent his career in the electricity industry. Beginning in CEGB Research at Berkeley Nuclear Laboratories, concerned with commissioning problems on Magnox reactors, his interests developed to embrace all aspects of electricity generation. At the time of privatisation of CEGB, he was responsible for all three CEGB headquarters laboratories. Privatisation brought a career change when he took responsibility for business planning in National Power—Nuclear. This was at a particularly interesting time for nuclear power. As Director of Technology for Nuclear Electric and later Magnox Electric, he contributed substantially to the improvements in performance of the UK gas-cooled reactors. He is now a consultant on energy and environmental matters and until it was disbanded was a member of the Government's advisory committee on Radioactive Waste Management.

1. Introductory Remarks

1.1 I believe that the Inquiry is timely in view of the increasingly important concerns being expressed publicly regarding the realism and robustness of the current energy policies. Energy is a business with long time horizons. Plant is expensive and designed for lifetimes of up to 40 years. Operators need to be reasonably assured that they can make a return on investments and environmentalists need to satisfy themselves that the potential of plant is realised as a significant contributor to capital cost is the energy used at various stages of construction from mining of materials through fabrication and construction. This is true for all plant. Therefore the main requirement of a policy is that it stands the test of time.

1.2 It is but 18 months since the Energy White Paper was published in March 2003. While the concept of an energy policy was a welcome change from the previous *laissez-faire* policies, the importance of the challenges being made to its validity indicates that, in its formulation, too much weight was given to short-term issues and too little to the risks attached to the policy.

1.3 There appears to be no need to list the many questions that have been raised regarding the policy as the second paragraph of the announcement of the Inquiry lists several of them and, from this, it can be judged that the EAC attaches considerable importance to them. Indeed, they are clearly the main driver behind the Inquiry. Thus I take this as common ground.

1.4 In my view the EAC Inquiry can make a major contribution to environmental and energy planning if it can introduce a proper balance into the evaluation of the strategic options. To this end, I suggest that the Inquiry should adopt techniques used by businesses to devise and test strategies.

[206] The exception of course is Nuclear Generation which is extremely inflexible, hence the millions of night-storage heaters which were installed to try to use the output at times of low demand.

1.5 Suggestions regarding an approach that could be adopted will form the main thrust of this submission rather than provision of answers to the particular questions. Others are better placed to provide the necessary data.

2. A Framework for Decisions

2.1 Even with relatively simple problems it is rare for all the factors that need to be taken into account to point in the same direction. It is for this reason that considerable attention has been paid to methods of decision analysis. For determination of appropriate strategies, a commonly used technique is multi-attribute analysis. This requires the construction of a matrix that identifies the available options together with the major factors that could influence the decision. Each option is assessed against each factor and allocated a score based on how well it matches that requirement and, very importantly, a weighting factor reflecting the importance ascribed to the particular factor.

2.2 As can be deduced from the questions posed in announcement of Inquiry document, the problem that the EAC has posed for itself is multi-faceted and a technique similar to the one described above will be essential to manage the data input and, eventually, to assist in the communication of the reasons that lie behind any decision that emerges.

2.3 It should go without saying that the process must be objective and this means applying each factor to all options. There are examples in the list of questions where answers are being requested regarding nuclear power when it is silent on the same question for other options. A clear example of this is question 6 regarding whether or not nuclear power is carbon-free. The subsidiary points in that question that mining, construction and operation might all consume energy are valid. But they apply equally to any plant—ore is mined to produce steel, and smelting and fabrication consume energy. Adopting an appropriate methodology would impose a discipline that would prevent such questions being asked of only one option.

2.4 The factors chosen need to:

- Reflect the benefits in, for example, meeting environmental targets or providing security of supply
- Define the status of the technology in terms of confidence that it will meet claims for it
- Identify any barriers to implementation on the scale or rate supposed
- Address relative cost issues

2.5 Some factors, such as the means of financing a project, have such a wide range of variables, many of which are changeable at the discretion of Government, that it becomes confusing to include them all in the first pass. In this event, it is preferable to separate the development of strategy into two phases; the first considering the desirable goal and the second addressing means by which it could be achieved.

2.6 To answer the questions posed by the EAC requires access to reliable data. As indicated above, I leave this to others but it also requires judgements on matters such as factors to be included in an assessment and weightings to be applied. The remainder of this submission offers advice on the four points below:

- Factors I deem to be important that are not included in the EAC's list of questions
- An indication of the relative weighting that I believe to be appropriate for the more important factors
- An outline strategy
- Suggestions for overcoming barriers to implementation

3. Factors Not Obviously Included in the List of EAC Questions

3.1 The most obvious omission is an assessment of the value of diversity in the overall energy mix. Clearly, diversity can remove sensitivity to a number of factors outside the control of the UK such as

- Availability of non-indigenous primary fuels
- Price changes in primary fuels
- Failure of one energy source to meet its technical or environmental targets
- Failure of one source to meet its target contribution.

3.2 In considering the importance of diversity it should be noted that the questions being asked of the 2003 strategy relate to shortcomings on at least two of these issues.

4. Views on the Weighting of Factors

4.1 I have not sought to undertake a comprehensive analysis of the form suggested above, that would be prejudging the outcome of the Inquiry. Therefore, the comments below should not be interpreted as indicating a complete list of factors to be taken into account. Rather, the discussion below addresses only the relative weighting of four of the factors I believe to be the more important. They appear in order of weighting that I judge to be appropriate.

4.2 *Contribution to environmental goals* This should have the highest weighting. The Prime Minister has recently identified global warming as the greatest challenge being faced today.

4.2 *Security of supply* Following from the comments on diversity of supply above, I perceive that the root cause of the shortcomings in the 2003 strategy were that it failed to address properly the risks unavoidably associated with such a narrowly based policy. The importance of energy to the UK economy is such that it is foolish to gamble on such matters.

4.3 *Contribution to energy saving* Clearly, an important objective, but in scoring any factor under this broad heading account should be taken of the value of using fuels that have no alternative use.

4.4 *Cost* I would relegate cost to a relatively weak fourth position for two reasons:

(a) Cost has always been seen as the major parameter governing choice of fuel. However, an examination of the history of investment in electricity generation plant over the past 50 years would show that various times the primary fuel of choice, on cost grounds, has included coal, nuclear, oil and gas but, rarely, has any preference remained true for a decade. The most spectacular change occurred when the CEGB was constructing five large oil-fired power stations at just the time OPEC formed. Those plants have never been fully utilised. None of these price changes was accurately forecast—all came as a surprise, even the tripling of oil prices on the formation of OPEC. Thus claims regarding the efficiency of the market and advocates of anyone fuel who claim to see the future with clarity should be viewed with scepticism.

It does not require much imagination to see the parallels between the OPEC event and today's oil and gas market.

(b) The differences between the costs of generation from the different fuels are actually fairly small. They can be the difference between profit and loss to an operator in a free market but are not necessarily so important in a macroeconomic sense in relation to the size of the national energy bill. What is demonstrably needed is a little "insurance" to protect against the uncertainty.

A major deficiency in the electricity market place is that it is all about today's price—a consumer has no way of paying an insurance premium for long-term security even if he/she recognises the need. But would the premium be affordable and how and to whom should it be paid?

If the premium is used to buy diversity, it is easy to show that any premium that would be required is low. It would be the cost to the consumer of departing from a policy of using only the lowest cost option. As an example, suppose it was decided that 10% of required capacity should be met by plant with generation costs 10% dearer than today's cheapest source. This would add 1% to total generation cost for all electricity. However, because generation is only a fraction of the retail price, it would add only the same fraction of 1% to domestic electricity bills. This would be a remarkably small premium.

5. An Outline Strategy

5.1 The arguments presented above lead to an inescapable conclusion that, to deliver what is necessary, the overall objective must be to create a an energy market built on a diversity of fuels that can contribute positively to a reduction in "green house gases." The environmental issues will restrict the range of options available but it will be essential to use any that can contribute and for Government to allocate targets for the capacity of each. To a degree these targets must be subjective but a sensitivity analysis to possible future events would provide a framework for testing the robustness of supply with different assumptions.

6. Suggestions for Overcoming Barriers to Implementation

6.1 The operation of the electricity market will be seen as a barrier to implementing the above strategy as it could be seen as inhibiting competition. There will certainly be no change without changes in the market structure.

6.2 It should be remembered that the present market developed following privatisation of the electricity industry. The Electricity Bill that enabled this initially saw the need to protect two primary sources that were judged unable to survive in an entirely free market, namely, renewables and nuclear. The forms of protection for the two differed and that for nuclear has since lapsed but the protection for renewables remains and, indeed, the 2003 strategy is dependent upon its continuation in some form.

6.3 Renewables have not entered the market because they are a preferred source on the grounds of cost—they have always been more expensive than other generation sources. To introduce them against market forces, the Electricity Bill created a premium market that required electricity distributors to purchase a defined portion of their electricity capacity from renewable sources. By this means the price paid to renewables sources could be different from that paid in the main market. Bids were invited to fill this capacity and the choice of type of renewable and/or operator based on cost, thereby preserving competition but within this limited market. Operators needed to have a reasonable expectation of a return on their investment and looked for long-term contracts. For these to be possible assurances were provided about the continuity of this premium market into the future.

6.4 This model appears to have worked well. It delivers a strategic objective whilst maintaining an acceptable level of competition. If it were to be applied to other primary fuels that meet the environmental standards to be included in the strategy, there could be several independent markets. Just as it has for renewables, this would eliminate concerns about the ability to finance different options.

6.5 It would have the advantage of providing the Government with levers to influence energy strategy to meet their wider goals whilst, at the same time, preserving sufficient competition to ensure value for the consumer.

19 September 2005

Memorandum submitted by Mitsui Babcock

Mitsui Babcock is a British company (HQ in Crawley; R&D, Manufacture and Services in Renfrew) established in 1891, and wholly owned by Mitsui Engineering and Shipbuilding Co. Japan, since 1995. We employ 4,000 people worldwide (3,800 in the UK, of whom 1,000 are in Scotland). We serve all sectors of the Energy industry in UK and Europe. In the UK, whilst we have interests in nuclear, renewables, oil and gas, our largest business area is coal-fired power plant. In Asia Pacific and the Americas our main focus is coal-fired power plant.

In China, we have supplied 4 GW of coal-fired plant in the last decade and in 2003, when approaching 100 GW of pulverised coal fired power plant was ordered, we had around 15% of the boilers for this market, more than 10 GW being high efficiency supercritical boilers. Currently we are bidding coal-fired supercritical boiler plant in Germany, USA and China.

As a UK company, we support the government's objectives in energy, the environment and enterprise. We have successfully developed cleaner coal technology products with the assistance of the DTI's Cleaner Coal R&D programme and exported these. We have a portfolio of Carbon Abatement Technologies for fossil fired plant at various stages of development ready for full-scale demonstration and are pressing the government to recognise the major opportunities which such technologies bring for carbon dioxide abatement world-wide.

Our response focuses on measures to obtain significant cost effective reductions in CO_2 emissions from fossil power generation additional to those obtained by energy efficiency and renewable measures.

Introduction

We welcome yet another "Energy inquiry" since it gives us the opportunity to raise issues that are very important with respect to implementing the objectives of the Energy White Paper—urgent issues which go beyond energy efficiency improvements and deployment of renewables and address directly how to contribute to security of supplies, "Keeping the Lights On" and reducing carbon emissions by addressing technologies for coal-fired plants.

Our response is limited to comments pertaining to the generation mix, the generation gap that is developing and the relative costs of generation technologies.

We understand that the Nuclear Industry Association (of which we are members) will respond to the detailed questions on Nuclear power, and we support the Institute of Mechanical Engineers' response, which has a similar focus.

Question 1—Need for a Balanced Portfolio

A balanced portfolio of electricity generation types is necessary to safeguard security of supplies, costs of electricity (against fuel price hikes) and to allow varying generation to match the varying load demand.

For example:

(i) It would be wrong to focus too much generation capacity on nuclear because nuclear is a baseload technology and needs to be backed up by technologies that can match load demand. It is, however, essentially CO_2 free and relatively price stable.

(ii) It is clear from Danish and German experience that too large a proportion of intermittent renewables generation (wind) causes grid stability issues. Also, the renewable capacity needs to be fully backed up by alternative capacity for times when there is no wind.

(iii) Coal and gas provide baseload and load-following capacity. Modern plant are more efficient and produce much less CO_2 than the older plant currently in service. Both coal and gas could in future be retrofitted with carbon dioxide capture and the carbon dioxide stored permanently underground.

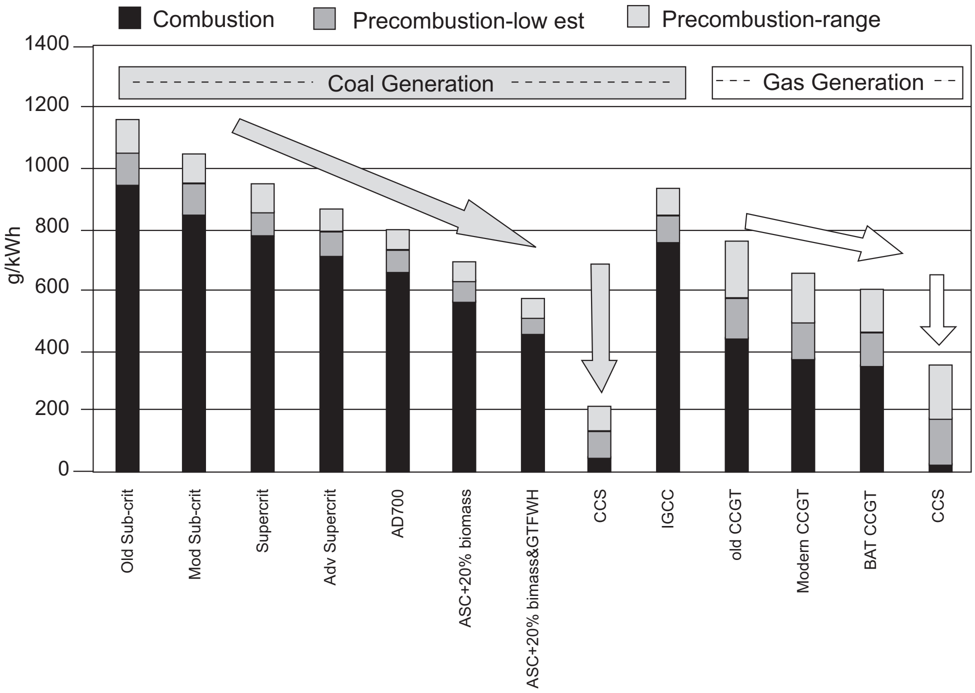
(iv) The advantages of coal over gas are its relative abundance ($>$200 years supplies), its sources (UK and stable countries around the world) and its ability to be cheaply stockpiled.

(v) Whilst generation from old coal-fired power stations produces more carbon dioxide than gas-fired CCGTs, modern clean coal technologies, which can also incorporate biomass cofiring, are closer to CCGT performance[207]. There is also evidence that total lifecycle GHG emissions from gas can exceed those from coal. This is due to methane leakage from pipelines, CO_2 stripped out when gas is produced, and CO_2 produced during liquefaction and regasification of LNG.

Advanced Supercritical plant will emit 23% less carbon dioxide than current old coal-fired plant. Fitted with biomass cofiring, the total carbon dioxide reduction can be 40%. Such plant can be designed to be capture-ready (ie capable of having carbon dioxide capture equipment retrofitted later).

With carbon dioxide capture and storage, around 90% of the carbon dioxide would be captured. See Figure 1.

Figure 1
Carbon Dioxide abatement for coal and gas



Experience shows that the current generation capacity mix (nuclear 16%, coal 38%, gas 33%), with a growing proportion of intermittent renewables, provides an appropriately balanced portfolio. The challenge is how to replace a large amount of generating capacity which will be retired by 2015 whilst preserving this balance and further reducing carbon emissions.

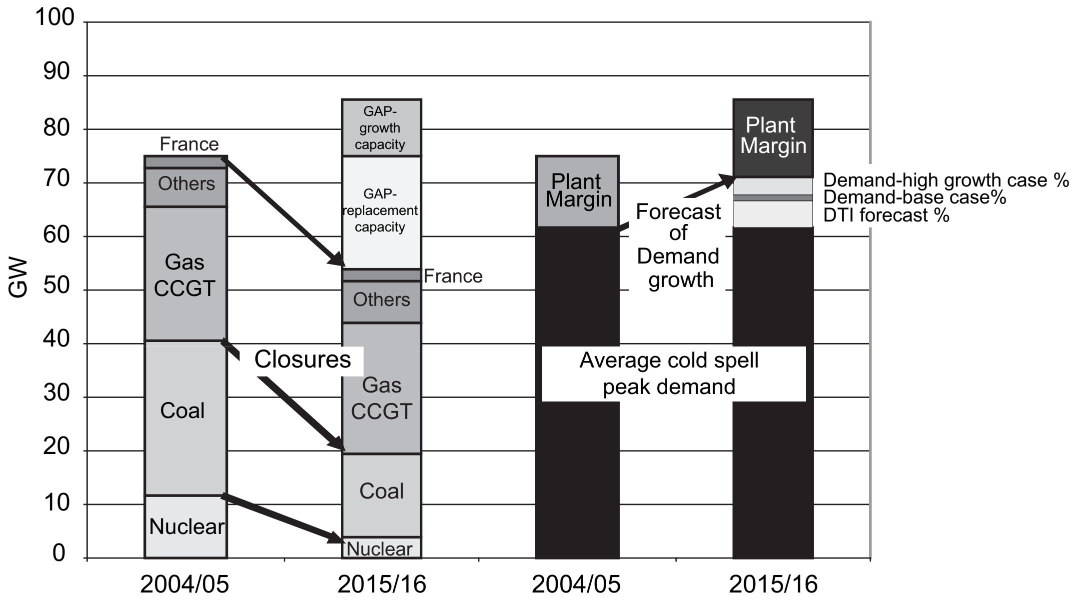
The DTI's modelling (A Strategy for Developing Carbon Abatement Strategy for Fossil Fuel Use) shows this can be achieved by introducing carbon abatement technologies for coal-fired and gas-fired plant, including carbon dioxide capture and storage. The amount of coal and gas (+ CCS) that is ultimately needed depends on whether nuclear is closed down, replaced or expanded.

Question 1—The Extent of the "Generation Gap"

The generation gap will arise due to the closure of nuclear stations and the closure of those coal-fired stations which "opt-out" of the LCPD. This will reduce the available generation capacity at times of peak demand. In Figure 2, the available generation in 2015 is compared with the required generation capacity.

[207] D J Spalding, G B Welford, J L King and J M Farley, "Retrofit Options for Carbon Abatement of Coal-Fired Boiler Plant", IMechE Seminar on Steam Power Plant Update, London, September 20, 2005.

Figure 2
Comparison of Generation Capacity (GW) with ACS Peak Demand



Nuclear Closures

The nuclear plants that are scheduled to close by 2015 are listed in Table 1.

Table 1

NUCLEAR PLANTS SCHEDULED TO CLOSE BY 2015

Dungeness A 1 & 2	450 MW
Sizewell A 1 & 2	420 MW
Oldbury 1 & 2	437 MW
Dungeness B 1 & 2	1100 MW
Wylfa 1 & 2	980 MW
Hinkley Point B 1 & 2	1220 MW
Hunterston B 1 & 2	1190 MW
Hartlepool 1 & 2	1210 MW
Heysham 1 & 2	1150 MW
Total	8157 MW

These closures will reduce the nuclear generation capacity from 11.9 GW in 2004–05 to 3.8 GW in 2015.

Note: If life extensions proposed by British Energy are approved, the closures will be 3400 MW by 2015 and 5760 MW by 2019.

Coal Closures

Currently, out of 27,915 MW of coal-fired plant in England, Wales and Scotland, 15,156 MW have fitted or have announced they are fitting FGD—consistent with Opting In to the LCPD in 2004–05. 13,279 MW of plants are not fitting FGD and would appear to be Opting Out of the LCPD. See Table 2. These plants will only be allowed to operate a total of 20,000 hours between 2008 and 2015 and must close by 2015, removing 13,279 MW of capacity, leaving 14.6 GW in 2015–16.

Opted in *ie FGD installed or planned*	*MWe*
Drax Power Station	3870
Cottam Power Station	2008
West Burton Power Station	1972
Aberthaw Power Station	1455
Ratcliffe on Soar Power Station	2000

Opted in *ie FGD installed or planned*	*MWe*
Uskmouth Power Plant	393
Ferrybridge "C" Power Station†	978
Fiddlers Ferry Power Station†	981
Eggborough Power Station†	980
	14636

Opted Out *ie no plan for FGD announced*	*MWe*
Ironbridge Power Station	970
Kingsnorth Power Station	1940
Rugeley Power Station	1006
Didcot A Power Station	1940
Cockenzie Power Station	1152
Tilbury Power Station	1029
Longannet Power Station	2304
Ferryfridge "C" Power Station†	978
Fiddlers Ferry Power Station†	981
Eggborough Power Station†	980
	13278

† Plant assumed to be ½ opted in and ½ opted out

Table 2: Coal-fired Power Plants (England, Wales and Scotland)

Total Closures

This gives total closures of 16.7 GW to 21 GW by 2015.

These closures are very significant—amounting to 18% to 25% of the installed electricity generation capacity in the UK, which was 75 GW in 2004–05.

Required Generation Capacity

The Average Cold Spell (ACS) peak demand in 2004–05 was 61.5 GW† and a plant margin of 21% (13 GW) was necessary to cover the risk of generating plant unavailability (eg breakdown) or higher than average peak demand (eg due to severe weather).

† NGC 2005 Seven Year Statement states 61.5 GW

In 2015–16 the ACS peak demand can be forecast as:

Basis	*Annual Growth %*	*ACS Peak Demand*	*Including Plant Margin (21%)*
No growth	0	62 GW	75 GW
DTI growth forecast	0.7%	66.7 GW	81 GW
NGC base case	0.9%	68 GW	82 GW
NGC high case	2.4%	71 GW	86 GW

Hence the required generation capacity in 2015 to maintain the current plant margin will be between 75 GW and 86 GW.

It follows that up to 21 GW of replacement plant and up to 11 GW of additional generation plant will be needed over the next 10 years.

Ability of Nuclear to Fill the Gap

It is being said elsewhere that it would take 10 years to build a new nuclear power plant (five years planning and licensing, and five years to build). Hence it is already too late for any of the expected generation gap in 2015 to be replaced by nuclear.

Coal or Gas

Clean Coal (with carbon abatement) and Gas (CCGT and/or CHP) are the only technologies available to meet this capacity gap in the required timescale. The plants closing are made up of a mixture of "baseload" plants (the nuclear plants) and "load following plants" (the coal and gas plants) which are used to balance electricity supply with demand (winter/summer, day/night). The replacement and additional plants must exhibit greater flexibility since they will co-exist alongside an increasing proportion of intermittent renewable generation. Between 21 GW and 32 GW of new coal or gas plant will need to be built over the next 10 years.

It takes about three years to build a new gas-fired power plant and about four years to build a new coal one.

Hence, to maintain security-of-supplies at times of peak demand, and to "keep the lights on" in 2016, we will need to see between 3,600 and 5,000 MW of plant completions each year from 2009 to 2015, which means between 3,600 and 5,000 MW of projects being started each year between 2005 to 2011.

Note:

Wind generation is excluded from the consideration of "how to fill the generation gap" because, whilst the ambitious targets to instal onshore and offshore wind may contribute significantly to the overall annual generation (in TWh), wind cannot be relied upon due to its intermittency to fill the gap on the days in the year when demand is at a maximum. Statistics from NCG indicate that the generation from wind is less than 10% of the nameplate installed capacity for 20% of the days in the year[208].

Question 2 and Question 3—Financial Costs and Investment Considerations

A comparison is given below of the relative investment requirements, costs-of-electricity, timescales, flexibilities and risk levels of the technologies that can be used for new electricity generation.

Prices quoted are from the Royal Academy of Engineering report and other back-up sources.

It should be noted that Clean Coal (Advanced Supercritical), whether New-Build or Retrofit, is very cost-competitive with Gas-fired CCGT. Advanced Supercritical plant will emit 23% less carbon dioxide than current old coal-fired plant. Fitted with biomass cofiring, the total carbon dioxide reduction can be 40%. Such plant can be designed to be capture-ready (ie capable of having carbon dioxide capture equipment retrofitted later). With carbon dioxide capture and storage, CO_2 emissions will be less than 10% of those from the original coal-fired plant.

	Capital Costs £/kWe	*Cost of Electricity p/kWh*	*Timescale Planning/ Licence*	*Project*	*Baseload/ Load Following*	*Project Risk*
Clean Coal (Advanced Supercritical Retrofit) (Note a)	£200–250/kWh	1.8–2.2 p/kWh	< 1 year	2 years	Load Following	Low
Clean Coal (Advanced Supercritical) (Note a)	£600-£860/kW†	2.5	1 year	3.5 years	Load Following	Low
Nuclear (Note b)	£1150/kW†	2.0–2.5	5 years	5 years min	Baseload	High
Gas—CCGT (Note c)	£300/kW†	3.0–4.2	1 year	3 years	Baseload/ Load Following	Low
Renewables (Wind) Onshore (Note d)	£630–740/kW†	5.5	2 years	2 years	Intermittent	Med
Renewables (Wind) Offshore (Note d)	£780–920/kW†	7.72	2 years	2 years	Intermittent	High
Clean Coal (ASC) with CCS (Note e)	£675/kW†	3.2–3.6 p/kWh	3/5 years	4 years	Baseload/ Load Following	High
Clean Coal (IGCC) Note f)	£800–1000/kW†	3.2	1 year	4 years	Baseload	High
Clean Coal (IGCC) with CCS (Note e, f)	£687/kW† (9)	3.2–3.6 p/kWh	3/5 years	4 years	Baseload	High
Gas CCGT with CCS (Note e) (Note c, e)	£1495/kW† £442/kW†	4.0–5.2 p/kWh	3/5 years	4 years	?	High

Notes:

(a) The cost-of-electricity for coal is given on the basis of a coal price of £30.5/te, which is the current cost of UK and world traded coal. The estimate is a company estimate supported by the RAe estimate[209].

(b) Nuclear costs are a range encompassing the estimate from the Royal Academy of Engineering report (2.3p/kWh).

(c) The cost-of-electricity quoted for gas—CCGT and gas CCGT with CCS—is highly dependent on the price of gas. The range quoted is for gas prices from 30p/therm to 50p/therm.

[208] National Grid PIU Supplementary Submission 28 September 2002.

[209] Royal Academy of Engineering report, "Cost of Generating Electricity", 2004.

(d) Renewables (Onshore and Offshore Wind) costs are derived from the Royal Academy of Engineering report excluding back-up generation and based on a 25% capacity factor.
(e) Cost for CCS include Capture but not Storage. No credit is given for Enhanced Oil Recovery. Estimates from IEA GHG Programme reports[210].
(f) There is a very wide range of estimates for IGCC ranging from £486/kW to more than £1000/kW. Promoters of IGCC in the USA indicate it is around 25% more expensive than Clean Coal (Advanced Supercritical).

Implications of Choice Between Coal and Gas on Balance of Portfolio

In 2004–05 the shares of the capacity portfolio were Nuclear 16%, Coal 38% and Gas 33%.

If all the replacement capacity was to be gas, these percentages would become Nuclear 4%, Coal 18%, and Gas 66% in 2015, making the UK electricity supply system very vulnerable with respect to security of supplies, particularly in severe winters when peak electricity demand and peak demand for gas for domestic heating coincide, as well as price hikes.

21 September 2005

Memorandum submitted by Paul Mobbs, Mobbs' Environmental Investigations

Summary

The UK has an energy problem. . . we use too much. As we enter an era of declining energy resources we must recognise and address this fact in the shortest possible time-scale.

Electricity is a means of carrying energy between two points. There is nothing intrinsically special about electricity as a carrier of energy, as compared to other conventional fuels. Therefore, in evaluating the future for electricity generation, we need to open up the debate to a far wider evaluation of how we use energy today. In fact, electricity consumption in the UK is only 18% of the final quantity of energy supplied to the economy; the amount of energy consumed as natural gas in the UK is far larger than the amount of energy consumed as electrical power. Consequently, the Committee must address the wider trends in energy use in order to ensure that the other 82% of the energy we consumed in the UK is not omitted from their deliberations.

Another issue not addressed in the questions posed by the Committee are the effects of global trends in future energy supply, in particular the global peak in both oil and natural gas production. Very simply, peak oil/peak gas is the point at which the level of production that can be sustained from the world's oil and gas fields can no longer meet the demands placed upon them. Our own North Sea oil production peaked in 2000, and most current projections place the global peak in oil production in 2007. Our North Sea gas production peaked recently, and the Parliamentary Office of Science and Technology cites a peak in global natural gas production occurring between 2020 and 2030.

The Environmental Audit Committee's inquiry puts emphasis on the "new build" of nuclear power plants. However, there is a key question omitted from the list of matters provided by the Committee—uranium resources. Most of the nuclear reactors around the globe use thermal reactor technology. The problem for the nuclear industry is that only 1% of the uranium resource can be utilised by thermal reactors—the rest is ultimately rejected.

The seemingly unlimited amounts of uranium alluded to by the nuclear industry are a fallacy because the figures do not take account of the energy required to extract the uranium. In reality there is a cut-off point beyond which the extraction of uranium is futile because the processing requires more energy than the uranium will ultimately produce. Primary uranium currently supplies around half the world's 64,000 tonnes/year demand, with the other half coming from ex-military uranium stocks. If we take global reserves at 4 million tonnes, this gives a resource lifetime of 62.5 years. However, if the nuclear industry were to expand by five times, and assuming there is no significant increase in thermal efficiency in nuclear plants, then uranium demand would rise to 320,000 tonnes per year, and the lifetime of the resource reduces to 12.5 years. Consequently, it would be unwise to discuss building new nuclear capacity without a thorough investigation of uranium resources, and the effect of reactor technologies and uranium production on the longevity of the nuclear option.

Renewable energy sources are limited by the area of land required to intercept a sufficient "flux" of energy to meet our energy demands. For example, producing biodiesel for just the cars registered on the UK's roads would require a land area slightly larger than the UK, and growing biomass to service our current electricity demand would require an area 2.5 times larger than the UK.

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[210] C A Roberts, J Gibbins, R Panesar and G Kelsall, "Potential for Improvement in Power Generation with Post-Combustion Capture of CO_2", Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies. Peer-reviewed Papers, Vancouver, BC, 5–9 September 2004.

The first stage in the process of developing truly sustainable energy resources within the UK would be to decentralise the national grid. This would allow a greater proportion of our energy demand to be met from local sources, which in turn allows for a greater diversity of efficient generation and renewable energy sources to be developed.

To ensure our future energy security we should look within our own borders to meet our energy needs. Across all sources, 40% of our current energy demand could be met from renewable energy sources. Using current technologies cutting energy consumption by 60% to meet this target is achievable, but adapting to a low energy economy would require a wholly new economic paradigm. This may sound incredible, or unachievable, but it has happened before. During the 18th Century the UK experienced a comparable change in its social and economic organisation with the coming of the Industrial Revolution.

We face a very simple choice. We cut our energy consumption, or progressively higher energy prices over the next two to three decades will cause immense damage to our national well-being. Instead of focusing on building new generating capacity, conventional or nuclear, the Committee should investigate the the development of "negative capacity", or nega-Watts. This will be more expensive in the short-term. However, an imminent downturn in global energy supply, with a commensurate rise in prices for all types of energy, means that it would be wrong to evaluating the costs of a transition to a low energy society using current prices as a baseline. Instead, the Committee should price various strategies in terms of energy and economic impacts at specific points in the future.

Unless we adopt such a course of action soon, the economic damage wrought by a declining global economy, as global energy resources shrink, will make the process of transition far more unpleasant. In order to adapt to a contracting global energy supply over the next century our future well-being must be linked to our capacity to use less energy.

Introduction

1. I have produced this paper to outline a number of issues related to our future energy supply. Whilst I understand that the Committee's primary interest in in the UK's electricity generating system, I believe that any discussion of electricity generation must take place within the wider debate over resource use across society as a whole.

2. I set up Mobbs' Environmental Investigations in early 1992, and since then I have worked as an independent environmental consultant for community-based organisations across the UK. My approach is multi-disciplinary, mixing environmental science, engineering and law, in order to produce a holistic view of the problems I am asked to investigate. Over the past 13 years I have taken part in numerous public inquiries, I have assisted individuals and organisations in remedying breaches of environmental regulations, and I have assessed many applications for development and pollution control authorisations.

3. More recently my work has involved in-depth research into specific areas. For the last three years I have been working, in association with networks of local community organisations, on the issue of energy futures. This work led to the publication of my recent book, *Energy Beyond Oil* [Mobbs, 2005]. My work on energy has also attracted interest from, and the publication of articles by, organisations such as Chatham House [RIIA, 2004], the Oxford Institute for Energy Studies [OIES, 2005] and the national media [*Times,* 2005].

4. The most important factor to bear in mind when evaluating the future of the UK's generating capacity is that electricity is a means of carrying energy between two points. There is nothing intrinsically special about electricity as a carrier of energy, as compared to other conventional fuels—other than the far greater level of flexibility and control it provides in comparison to other energy sources. Therefore in evaluating the future for electricity generation this paper does not assume that the prime decision should be on the future composition of our generating capacity. Instead, by looking at the thermodynamics of energy use within society as a whole, we need to open up the debate to a far wider evaluation of how we use energy today.

5. One of the key features of the Environmental Audit Committee's call for papers for its inquiry was the emphasis on the "new build" of nuclear power plants for power generation. Quite naturally then, the questions posed by the Committee tend to focus on the practicality and acceptability of nuclear powered generation. However, there is a key question omitted from the list—the issue of uranium resources. I believe that it is unwise to discuss building new nuclear capacity without a thorough investigation of uranium resources, and the impact of reactor technologies and uranium production on the longevity of the nuclear option.

6. It is important that we phrase the debate on electricity supply in terms of its relevance to the UK's energy economy. In reality, electricity consumption in 2004 was only 18% of the energy supplied at the point of use [DUKES, 2005a]. In other words, the Committee must address the wider trends in energy use in order to ensure that the other 82% of the energy we use in the UK is not omitted from their deliberations.

7. Another issue that is not clearly addressed in the questions posed by the Committee are the effects of national and global trends in present and future energy use, and how these might affect the electricity supply industry. Clearly the key trends in the next two to three decades are the global peaks in both oil and natural gas production. The UK's production of both oil and natural gas has peaked in recent years, but the global

peaks in oil and gas production create a far greater challenge to our economic and social well-being. The role of electricity, and the extent to which renewable sources of energy can make-up the shortfall in oil and gas, is a critical factor in how we address a global downturn in the availability of energy.

8. Finally, if we are looking at a downturn in global energy supply, with the obvious effect that prices for all types of energy will be higher, then it would be wrong for the Committee to look at the costs of different energy sources in terms of today's prices. In deciding what strategy to adopt in the future the Committee must review the various energy technologies available in terms of their relative costs in the future, not with reference to today's energy prices.

Electricity vs Energy—Electricity as a Subset of Energy Use

9. As noted in the introduction, electricity is not an energy source, it is a carrier of energy. We must therefore draw a distinction between the use of electricity in society and the overall demand for energy. Whilst electricity may be able to supplant the use of other fuels, it is produced, inefficiently, from a narrow range of other energy sources. Expanding the use of electricity in society has a serious effect on energy efficiency, the consumption of fuel, and consequently the emission of pollutants. But these impacts relate directly to the fuels used to generate power, not the the process of electricity generation itself.

10. By definition, within the government's current framing of the debate, any inquiry into the future of nuclear or renewable energy is an inquiry into electricity generation. However, concentrating on electricity production ignores perhaps the most valuable contribution of renewable energy in a temperate zone—heat. For each £1 invested, thermal solar systems provide 30 to 40 times more energy as heat than photovoltaic systems provide as electrical power. Likewise, the use of heat pumps to extract low-grade energy and to recover/recycle the energy discarded via waste air and water can reduce the demand for energy by two-thirds or more. Therefore if the Committee ignores the heat generating renewable energy sources, when in reality a large part of the energy we consume is to produce heat (around 70% in the average household), it will significantly under-estimate the role that renewable energy sources might play in our future energy economy.

11. Electricity is not, perhaps contrary to the popular conception of our energy supply, the largest source of energy within the UK economy. I believe that it is important for the Committee to analyse the energy question in terms of our total use of energy, not just electricity. It's also important to understand that, in 2004, although nuclear power provided just under 20% of the UK's electricity, it provided less than 8% of the UK's entire energy supply [DUKES, 2005a]. Using the million tonne of oil equivalent (mtoe) as a common measure across all fuel sources, in 2004 the UK economy (or rather, the UK's primary energy supply) took in 234.9mtoe [DUKES, 2005c]. Of this total, primary electricity—the power produced by nuclear plants in the UK—made up only 18.3mtoe, or 7.8% of the UK's primary energy supply. Renewable sources accounted for just 0.82mtoe (0.3%) of the primary energy supply, and waste combustion/digestion, which the DTI also regard as "renewable"", 3.3mtoe (1.4%) [DUKES, 2005h].

12. A significant proportion of the energy consumed by the UK is supplied to power plants where it is "transformed" into electrical power (see table 1). Currently just under one-third of the UK's primary energy supply is used to produce electrical power by the "major electricity generators". However, electricity only makes up 29.2mtoe of the 161.1mtoe (or 18.1%) of the energy that is directly "consumed" by the UK economy (the final supply or final consumption of energy) [DTI, 2005a]. This difference between the proportion of primary fuel consumed, and the balance of electricity within final supply, exists because 60% of the energy utilised by the major power generation companies is "wasted"—lost to the environment as a result of inefficient power generation.

Table 1

ENERGY SUPPLY AND THE ENERGY USED FOR POWER GENERATION, 2004

	Oil	*Coal*	*Gas*	*Nuclear*	*Other*	*Total*
Primary energy supply	76.5	39.3	96.1	18.2	4.8	234.9
Used for power generation	0.6	30.4	26.2	18.2	1.6	76.8
proportion of primary supply	*0.7%*	*77.3%*	*27.2%*	*100.0%*	*32.3%*	*32.7%*
Power produced (gross)	0.2	11.0	12.1	6.9	0.7	30.8
efficiency of generation	*28%*	*36%*	*46%*	*38%*	*46%*	*40%*
Energy "wasted"	0.4	19.4	14.1	11.3	0.8	46

All figures are in million tonnes of oil equivalent—mtoe
Sources: DUKES, 2005c; DUKES, 2005d; DUKES, 2005e

13. Despite appearances, we still live in the steam age. All of our conventional and nuclear power plants raise steam by using an energy source to produce heat. Then, using steam turbines (similar to the original system developed by Charles Parsons in 1884) the energy of the steam is converted into torque, which drives generating sets to produce electrical power (the principles of which were established by Faraday in the 1830s). In 2004, the gross thermal efficiency of our power generation systems was 46% for combined-cycle gas turbines (CCGTs), 38% for nuclear stations, and 36% for coal-fired stations [DUKES, 2005b]. Spread

over all generating sources the efficiency of generation was 40%. In other words, every 1kWh (kilo-Watt-hour) of power consumed in the UK entails the wastage of 1.5kWh of energy, mostly as heat dumped into the air or local rivers (note that in the South East and East Anglia, where drought is a serious problem, this also incurs a serious loss of water resources to the atmosphere). Consequently, whether the fuel source is coal, oil, gas, renewable biomass or nuclear, the thermal efficiency of steam-raising power generation plants has a far greater impact on the economics and emissions of power production than the fuel selected to produce the thermal load.

14. In 2004, domestic energy consumption only accounted for 30% of the UK's final energy consumption [DTI, 2005a]. The transport sector consumed 36% and the industrial and service sectors combined consume 34%. Energy consumption in the domestic sector is dominated by natural gas (70% of domestic energy comes from natural gas whilst only 20% comes from electricity [DUKES, 2005f]), whilst in the industrial and manufacturing sector electricity and natural gas are used in roughly equal amounts. Where electricity does dominate is in the commercial and retail sectors, where it makes up around two-thirds of the energy consumed.

15. The fact that electricity makes up only a minor part—18.1% to be precise—of final consumption of energy in the UK means that if the Committee concentrates solely on the generation of electricity it will ignore the major part—81.9%—of the energy problem. For example, the amount of natural gas consumed directly in the UK is far larger than the amount of energy consumed as electrical power. This issue is significant because of the demise of natural gas as a major source of energy in the near future (outlined below in relation to "peak gas"). In this context, I believe it is valid to raise the question of whether it is worthwhile worrying about the future of less than 8% (the nuclear component) of the UK's energy supply when 84% (the oil and gas) will soon begin to run short, and hence become very expensive, in the next one or two decades.

Future Energy Supply—Peak Oil, Peak Gas, and the Price of Energy

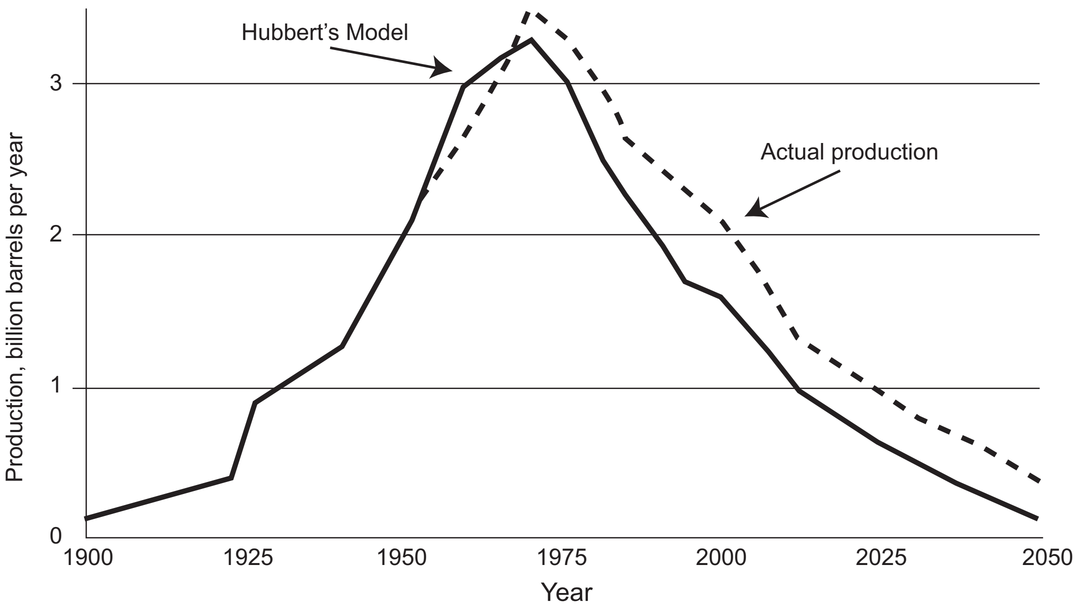
16. Whilst not directly related to the questions posed by the Committee, I believe that it is important that the Committee consider two trends that have the potential to cause serious problems for the UK's energy economy in the near future: Peak Oil and Peak Gas.

17. Most global authorities on energy quote the future lifetime of energy reserves in terms of a reserves/production ratio (or R/P ratio)—dividing the available reserve by the current consumption in order to produce an availability in years. In fact, the geophysical restrictions on the production of energy minerals mean that such a linear relationship does not exist, and in reality production follows a bell-curve. This is because the production of energy minerals is dependent not just upon the available proven or probable reserve, but also the quality of the reserves and the speed at which the minerals may be extracted.

18. In the late 1940s a leading US geologist, Marion King Hubbert, looked at the production of oil from oil fields in the "lower 48" states of the USA. He published various papers on his research, but the most important is considered to be his 1956 paper produced for the annual meeting of the American Petroleum Institute. In this paper he predicted that, based on trends in the discovery and growing consumption of oil in the USA, US oil production would peak in 1970 (see figure 1). Despite various criticisms of Hubbert over the intervening period, it was shown in the early 1970s that US oil production did indeed peak in that year, and the trend in the production of oil before and after the peak matched Hubbert's predictions.

Figure 1. Hubbert's Peak or Hubbert's Plot

Source: Mobbs, 2005



19. Very simply, peak oil is the point at which the level of production that can be sustained from any oilfield can no longer meet the demands placed upon it. Our own North Sea oil production peaked in 2000 (in fact, production fell by over 10% between 2003 and 2004), and other major oil fields around the globe are following predicted trends as they either progress towards or pass their peak of production. The controversial issue today is the use of Hubbert's method to predict a global peak in oil production.

20. Currently, most of the studies that use proven oil reserves as their basis predict a global peak in 2007. In fact, recent data from the US Energy Information Administration tends to confirm this date as they predict [USEIA, 2005] that average global oil demand will equal average global oil supply in late 2006. This is in contrast to the position of the US Geological Survey (USGS—whose figures in turn form the basis of the predictions of the International Energy Agency) who predict that global oil production will peak around 2035. However, the USGS's 2035 figure was produced as part of a *probabilistic analysis* of future oil production, and it only has a 50/50 chance of being right. If we work at the 95% confidence level, the USGS data in fact suggests a peak nearer 2015.

21. There are many variables involved, such as the dynamic interaction between rising prices and consumer demand which, at the global scale, may turn the neat Gaussian peak predicted by Hubbert into a more drawn-out plateau or *bumpy peak*. In any case, the concerns recently expressed about the accuracy of Middle Eastern oil reserve data could mean that recent supply problems may be indicative of an impending peak. It's not just the inability of OPEC to produce more oil that is indicative of a peak, but also the fact that more of the oil produced by the Gulf states is now heavy (or sour) crude, not the light (or sweet) crude that the world relies upon for the production of fuel oil.

22. Natural gas production undergoes a similar trend to oil. The UK's natural gas production plateaued between 2001 and 2003, and production is now falling. This decline in production, coupled with strongly increasing demand for power generation, means that the UK is now importing ever greater volumes of gas each year. In fact, even with the development of liquefied natural gas (LNG) import terminals near London and in West Wales, concerns are already being expressed as to whether the UK can supply its demand for gas during a severe Winter [NGT, 2005]. According to the Parliamentary Office of Science and Technology, global natural gas production is likely to peak sometime between 2020 and 2030 [POST, 2004] with similar consequences to the peak in oil supply. However, Peak Gas represents a more significant point in time because from that date the globe's total energy supply will steadily contract until a new, primarily renewable-powered, equilibrium is reached (perhaps at the end of this century).

23. The peaking of global oil and gas production does not mean that we are going to imminently run out. Peaking occurs half way through the lifetime of the resource, and so an amount of oil/gas equal to that already extracted is likely to be available from that date on. What will be problematic for the UK is that the year-on-year fall in production capacity will drive prices for oil and gas ever higher, as countries compete on price to secure access to the remaining production. This has significant implications for the UK economy because we are so dependent upon petroleum products. However, if current trends continue (and we ignore the economic effect of rising prices), by the date of Peak Gas the UK could be dependent on gas-fired generating capacity for the majority of its electricity supply, and the majority of its space heating requirements.

Nuclear Power and Uranium Supply

24. Nuclear power may appear to be a solution to a downturn in gas supplies. However, nuclear plants also have a potential fuel supply problem in the future, depending upon how fast the nuclear states develop their generating capacity over the next few decades.

25. Globally, using BP's global dataset, nuclear power provides 6.1% of global energy consumption [BP, 2005]. Using this same dataset, the UK produces around 8.0% of it's primary energy consumption from nuclear. However, to make any significant difference to a downturn in global oil and gas supply, or at a debatable level, to climate change (for example, by displacing the use of coal), the capacity of the nuclear sector would have to grow by at least five times. This has significant implications for the future of the globe's uranium reserve.

26. Most of the nuclear reactors around the globe use *thermal* reactor technology. Slow neutrons are used to fission atoms of one uranium isotope, uranium-235 (^{235}U), to produce heat. At the same time some neutrons are captured by another isotope of uranium, uranium-238 (^{238}U), and are converted (indirectly) to plutonium-239 (^{239}Pu). The fissioning of this "bred" plutonium produces around one-third of the heat load created by the thermal reactor. In terms of the uranium resource, the problem for the nuclear industry is that ^{235}U only makes up around 0.7% of the world's uranium. Therefore, including the uranium converted to plutonium, only about 1% of the uranium resource can be utilised by thermal reactors—the rest (made up of ^{238}U) is ultimately rejected.

27. Rather like oil reserves, there is some debate over how much usable uranium there is available around the globe. The International Energy Agency assess uranium reserves in terms of the costs of production—they estimate there are around 4 million tonnes of uranium recoverable for less than $130/kilo [IEA, 2001]. The European Commission have put the figure at 2 million tonnes [EC, 2001]. However, some figures in the nuclear industry quote the amount of recoverable uranium as being in excess of 4 billion tonnes [Price, 2002]: this figure is based on the theoretical amount of uranium on the Earth's surface irrespective of whether its recovery is feasible/economic or not. However, the seemingly unlimited amounts of uranium alluded to by the nuclear industry are a fallacy because the figures do not take account of the energy required to extract the uranium in a form suitable for the production of nuclear fuel. In reality there is a cut-off point beyond which the extraction of uranium is futile because the extraction and processing operations require more energy than the uranium will produce. This concept, called the *Energy Return On Energy Invested* (EROEI), is ultimately the limiting factor on how much energy we can produce from nuclear energy.

28. The EROEI for uranium is linked to the quality of the ore used to produce nuclear fuel. The lower the ore quality, the more rock must be processed, with a consequential increase in energy consumption. Recent data from the World Nuclear Association [WNA, 2005a] puts the energy cost of running a reactor (including uranium production and operation/decommissioning of the plant—but not the final disposal of radioactive wastes) at a few percent of the plant's output. However, this analysis is based upon ore with a uranium content of 0.2% (2,000 parts per million, or ppm). As lower quality ores are utilised the proportion of the plant's output used in the production of the fuel will grow, and hence, progressively, the net energy production of the nuclear sector as a whole will fall. A 1975 study put the cut-off point, where the energy used to produce power exceeded the energy content of the uranium ore, at 0.002% (20ppm) [Chapman, 1975]. Such a value would exclude many of the more diffuse sources of uranium, and would reduce the amount of usable uranium to just a few million tonnes.

29. Currently the low price for uranium, in part created by the release of ex-military stocks of uranium onto the market, means that only the highest quality ores are mined. Primary uranium currently supplies around half the world's 64,000 tonnes/year demand, with the other half coming from ex-military uranium stocks. If we take global reserves at 4 million tonnes, this gives an R/P ratio of 62.5 years. However, if the nuclear industry were to expand by five times, and assuming there is no significant increase in thermal efficiency in nuclear plants, then uranium demand would rise to 320,000 tonnes per year, and the R/P ratio would be 12.5 years.

30. The limited nature of the uranium resource has a very clear implication: If the world increased its nuclear capacity by five times, in order to displace the use of fossil fuels or forestall the effects of Peak Oil/Peak Gas, none of the hypothetical new reactors built in the UK would reach the end of their design lifetime before the world's proven uranium resource was exhausted. This problem was highlighted at the beginning of the commercial nuclear industry, and was the catalyst behind Britain's early experimentation with fast reactors (see below), subsequently abandoned in the 1980s.

31. In relation to the use of nuclear energy to off-set the use of fossil fuels, recent research published by the OECD [OECD, 1999] suggests that there is insufficient uranium to make a significant impact on the use of fossil fuels unless fast breeder reactors are developed in the near future. It should also be noted that the longevity of uranium resources were not considered as part of the government's recent Energy White Paper [HMSO, 2003]. In fact, without any real analysis of the uranium resource issue, whilst outlining issues for the white paper, the Downing Street Performance and Innovation Unit described uranium as [PIU, 2002]:

> ". . . plentiful, easy and cheap to store, and likely to remain cheap. This means that nuclear power is essentially an indigenous form of energy."

32. Clearly, the position of the PIU would only be valid if the entire uranium resource were usable, but that is not the case. Britain has a lot of uranium in storage, but it is depleted uranium—^{238}U—left over from uranium enrichment/fuel fabrication. In order to use the other 99% of the uranium resource we would have to successfully develop fast reactors, which fission ^{239}Pu whilst at the same time "breeding" more ^{239}Pu from the unused ^{238}U. As yet, there is no commercially marketable fast breeder design, and the recent MIT study of the future of nuclear power [MIT, 2003] did not consider fast reactors to be a realistic prospect for a few decades. This is because, to date, the problems inherent in the design of fast reactors have hindered the development of a large-scale, usable prototype. The major nuclear power states—Britain, the USA, France, Germany and Japan—have all invested in fast reactor research programmes and today the only significant work on prototype designs is being carried out by India and Russia [WNA, 2005b].

Renewable Sources—Capacity vs Spatial Development

33. If fossil fuels and nuclear power have capacity problems due to the limited availability of fuel, then renewable resources should have a clear advantage. Being renewable, their energy sources are continually renewed by the natural environment. However, the limitation here is area required to intercept a sufficient "flux" of energy in order to produce enough energy to meet our demand.

34. It is often said that we only use a minute fraction of the energy that the Earth receives from the Sun each year. Whilst factually true, these statements show a clear misunderstanding of the cycling of energy through the natural environment. The energy that the Earth receives from the Sun each year creates a specific energy environment within the Earth's biosphere. If we intercept more energy from the Sun, reducing the energy reflected back into space, then the Earth will get hotter (the amount of energy radiated by the planet sets up a thermal equilibrium that determines the global temperature). Likewise, if we intercept a greater proportion of the energy that goes into the hydrological cycle, or the other climate cycles, it will affect our weather and climate.

35. The human race already uses a very large quantity of energy. The 428 exa-Joules (EJ) of energy [BP, 2005] used in 2004 represents about half of the energy that could be produced by burning all the terrestrial biomass (plant matter) produced around the globe each year in conventional power plants. The reason we can use such a large amount of energy is because fossil fuels represent solar energy that was collected for millions of years, and which has been processed using geothermal heat for tens of millions of years to produce very dense sources of fuel (oil, gas and coal). In order to utilise renewable energy sources the first obstacle we must overcome is cutting our use of energy down to a level where renewable sources are a realistic option without restricting other important activities—such as food production—because of the amount of land which must be devoted to energy production.

36. The Sun radiates a fixed amount of energy onto the Earth, which varies according to latitude. Intercepting solar energy directly using solar heat or photovoltaic (PV) systems, or indirectly using biomass, is therefore limited according to the amount of land we are able to devote to collecting the Sun's radiation. Some advocates of renewable energy believe that certain countries around the world, because of their large land area, could become "exporters" of renewable energy—principally biomass or vegetable oils. However, given the problems created by climate change, and the global erosion of the agricultural land resource [UNEP, 2002], I do not believe that this is a realistic issue.

37. The production of energy from biomass is a good example. Southern England receives, on average, 36,000 giga-Joules of energy per hectare per year (GJ/ha/yr) [OU, 2004]. Of this figure, on average, only 5% (1,836GJ/ha/yr) of this energy will actually be absorbed by the plant, and only 0.6%, or 230GJ/ha/yr, will be converted into usable biomass. Depending on the form of combustion used, the moisture content, and the amount of energy used for harvesting and transport, the net energy production might be as little as 10% of the energy contained in the biomass (23GJ/ha), which in terms of electricity is about 6.4 mega-Watt-hours per hectare per year (MWh/ha/year). Given that in 2004 the UK's power consumption was 400,000,000MWh, it would require 62.5 million hectares of land to produce the UK's electricity demand—which is about 2.5 times the UK's total land area.

38. The production of biodiesel is equally restricted. Using figures from a Defra sponsored study [Hallam, 2003], one hectare of intensively grown oilseed rape can produce 3.1 tonnes of seed, which will yield biodiesel with a calorific value of 41.4GJ/ha/yr. Assuming a fuel consumption equivalent to 45 miles per gallon, a diesel car would require 0.85 hectares of land to fuel it for the average 9,000 miles travelled each year. Consequently, producing biodiesel for the 30 million cars registered on the UK's roads would require about 25 million hectares of land, which is slightly larger than the UK's total land area.

39. Wind power, tidal power and water power are more dense sources of renewable energy, but these too are limited. However, these limitations are being made worse by the manner in which they are being developed. In order to connect economically to the national grid, and in order to maximise the return on investment, renewable energy projects are becoming far larger than they need to be. Instead of diffusely collecting energy from many sites, government policy is concentrating development, using large scale engineering, on a small number of sites. As a result these developments have received a greater level of opposition from the public.

40. Wind power is a good example of how the target of "industrial scale" energy production is wastefully using land, and creating a public backlash against renewable energy in the process. The larger the wind turbine, the further apart they must be spaced within wind farms, and consequently the lower the energy yield per hectare of land. Working theoretically, a large wind 2.3MW turbine (such as a Nordic N90 turbine) spaced five hub heights apart (an average separation distance) from other turbines has a capacity of 108 kiloWatts per hectare (kW/ha). However three 850kW turbines (such the Vestas V52) would occupy the same area of land, and even though they are 40% shorter they produce more power—111kW/ha (note, this figure includes a weighting that reflects the V52's lower height). The reason that wind farm developers are building ever larger turbines is quite simple: Whilst capital costs can be discounted over future years, maintenance costs are always at the present value. Consequently the development of fewer, larger turbines increases the power output whilst reducing maintenance costs—increasing the return on the capital invested.

41. Taking the 111kW/ha figure as a representative energy density for wind, to match the UK's major electricity generators 73,308 mega-Watts (MW) of net installed capacity [DUKES, 2005g], and assuming that the turbines generated for 30% of the time and that an additional 40% of capacity was required to charge batteries/fuel cells to provide a continuous power output, just over 3,000,000 hectares of turbines would be required—equivalent to around 13% of the UK's land area. Theoretically then, we could generate our power requirements from wind turbines. But, as noted above, electricity is less than one-fifth of the UK's total energy consumption, so this solution this would only answers a small part of the UK's energy problem—for a total solution we'd have to densely cover half the UK's land area in wind turbines.

42. The first stage in the process of developing truly sustainable energy resources within the UK would be to decentralise the national grid. This would allow a greater proportion of our energy demand to be met from local sources, which in turn allows for a greater diversity of efficient generation (eg, combined heat and power) and renewable energy sources to be developed. Such an option was outlined by the Parliamentary Office of Science and Technology in their report on UK Electricity Networks [POST, 2001]. Some campaign groups are also supporting initiatives to enable a greater decentralisation of the UK's energy supply [GPeace, 2005]. Decentralising the grid would mean that the generating capacity of individual generating plants would fall, however the greater opportunity for the development of combined heat and power systems would mean that the efficiency with which we utilise fuel sources could rise from the current 40% to 60% or higher. Such a system would also allow embedded storage systems to be employed, and this would mean that smaller and intermittent renewable energy sources could have their output buffered in order to meet the peaks in local energy demand.

43. To ensure our future energy security we should look within our own borders to meet our energy needs. Across all sources, it's possible to produce around 40% of our current energy demand from renewable energy sources. Consequently, we need to cut energy use by 60%. This is, using current technologies, achievable—for example, in the domestic sector we can look to Oxford University's recent work on energy efficient housing [OXECI, 2005]. However, when evaluating the costs of this transition, it would be wrong to use current prices as a baseline. Realistically, Peak Oil will mean that energy prices could rise 10%, year-on-year, for one or two decades—until a new equilibrium develops between the availability of energy resources and our demand for energy. For this reason we cannot value the future energy prices in terms of those today. Instead we should price various strategies in terms of certain energy and economic indicators, based at fixed points in the future, in order to provide a relative comparison.

Conclusion—The Need to Significantly Cut Energy Demand

44. The UK has an energy problem. . . we use too much. As we enter an era of declining energy we must recognise and address this fact in the shortest possible time-scale.

45. Rather than focusing on building new capacity, the Committee should investigate the development of "negative capacity", or using the phrase coined by the Rocky Mountain Institute, nega-Watts [RMI, 1990]. We face a very simple choice. We cut our energy consumption, displacing demand through renewable sources and cutting energy use, or progressively higher energy prices over the next two to three decades will cause immense damage to our national well-being.

46. Peak Oil, perhaps as soon as 2007, is going to make oil prices rise far further than their current historically high levels. Between 2020 and 2030, Peak Gas will make the overall energy situation even worse—especially if current trends continue and we are dependent upon natural gas for much of our energy requirements by that time. As a country, which is now in the process of becoming a net energy importer of oil and gas due to the peaking of our own oil and gas reserves, building more generating capacity will mean that over the coming years a greater proportion of our national wealth will flow out of the country.

47. The alternative is, logically, simple—we cut energy demand significantly in order to meet more of our requirements from within our own borders. This will be more expensive in the short-term, but unless we adopt such a course of action soon the economic damage wrought by a declining global economy, as global energy resources shrink, will make the process of transition far more unpleasant.

48. The Committee must not narrowly focus on electricity. Electricity is less than one-fifth of the UK's energy consumption, and the problems facing the generating industry today will be replicated in other sectors within a decade or so due to the effects of Peak Oil. Likewise, some of the renewable sources better suited to the domestic and commercial environment produce heat, not power. Therefore the Committee must look at measures across all energy sources that will manage energy demand.

49. Nuclear power, quite apart from the environmental and safety objections, has a fundamental limitation on its use imposed by the thermal reactor system. Expanding our nuclear capacity in order to off-set the use of fossil fuels will, if replicated around the globe, shorten the already brief lifetime of the uranium resource by the same proportion. The projections by the nuclear industry, and by inference the government's own white paper on energy, assume that fast reactors will be available to use the depleted uranium produced by the thermal reactor cycle. However (rather like fusion reactors) there is no realistic prospect that this will happen in the near future.

50. Renewable sources of energy produce less power compared to conventional energy sources because of the land area they require. However, in an era where all conventional energy sources will go into decline, there are few other options. Therefore, if we are to develop truly sustainable renewable energy sources, we must match our energy demand to the amount of power that renewable energy sources can develop.

51. Adapting to a low energy economy would require, over the course of the next 60 to 80 years, that we evolve a wholly new economic paradigm. This may sound incredible, or unachievable, but it has happened before. During the 18th Century the UK experienced a comparable change in its social and economic organisation with the coming of the Industrial Revolution (and still, today, we use the inefficient steam turbines and power generators developed during this era). This Industrial Revolution marked the transition, within a few decades, to a society that progressed through an ever-higher level of energy consumption. Cutting energy demand by 60% will require a "post-industrialisation", as we use modern technologies to cut energy demand, and decentralise many of the energy intensive systems that were built up over the course of industrialisation. In order to adapt to a contracting global energy supply over the next century, our future well-being must be linked to our capacity to use less energy.

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21 September 2005

Memorandum submitted by The Multisectoral Initiative on Potent Industrial Greenhouse Gases (MIPIGGs)

FLUORINATED GASES IN RELATION TO NUCLEAR, RENEWABLES, AND CLIMATE CHANGE

The Multisectoral Initiative on Potent Industrial Greenhouse Gases (MIPIGGs—see www.mipiggs.org) is an informal network of companies, NGOs, individual scientists and agencies who share a common concern that society should reduce and eliminate the environmental threat posed by the very potent greenhouse gases, SF6, PFCs and HFCs (f-gases).

MIPIGGs draws your attention to the scope to reduce the emissions of greenhouse gases in the UK and elsewhere, by reducing and eliminating the use of f-gases (greenhouse gases containing fluorine).

These gases are very much more powerful than CO_2—often over a thousand times more potent. Fortunately, they are easily substituted—there are many available commercialised technologies (the main applications being in air conditioning and refrigeration). Unfortunately very little is being done, and f-gas emissions are rising almost exponentially[211].

This compounds the climate change problem caused by CO_2, methane and nitrous oxide.

By 2050, a 20 year time horizon in HFCs are expected to make up 8.6% of total global warming, doing as much damage to the climate as the traffic fumes of all the worlds private cars. HFCs are building up very rapidly in the atmosphere (20% a year over the arctic[212]), reflecting pollution from many uses, most notably including car air conditioning, and commercial refrigeration.

Because they have started from a low base, f-gases have been mostly ignored in public and political debate over climate change. (Very few campaign groups focus on f-gases and the proposed draft EU Regulation on f-gases will, at most, return emissions to 1995 levels by 2020[213]). Yet by removing them from the equation, considerable leeway could be created to buy more time for action on energy and other difficult issues.

We urge your Committee to press the UK Government on this issue, and to explore with them the scope for implementing the sort of tougher policies against uses of f-gases being adopted in countries such as Denmark and Austria. Some relevant points are made below—more information is to be found at www.mipiggs.org. Excellent technical information has been done by the German, Danish and Austrian environment Ministries and Agencies and we suggest that you consider calling them to give evidence.

Within the UK, companies[214] such as Calor (until recently a manufacturer of hydrocarbon refrigerants—the business has now been sold to BOC), and Earthcare (air conditioning and refrigeration), and Wormald (fire extinguishers) should be able to supply technical information and sales case studies and data about alternatives to f-gases. Briefing material is available at our website www.mipiggs.org

Whereas building new nuclear capacity is of questionable on grounds of cost-effectiveness, creates an insoluble waste problem and is unacceptable to large parts of the public, measures to eliminate f-gases are environmentally safe, and usually have knock-on effects in reducing energy usage as they are more energy efficient than HFCs[215] (for instance in fridges and the rapidly growing sector of air conditioning).

BACKGROUND

Scientific research increasingly shows the reality of climate change caused through global warming is worse, not better, than was generally predicted. Here are two very recent examples:

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211 IPCC Assessment Report 2001 Climate Change: The Scientific Basis.
212 ENDS Daily 6 February 2004.
213 ENDS Daily—29 August 2005, Issue 1931, German EPA f-gas study.
214 For example the wide range of air conditioning, refrigeration and chilling systems sold and installed by Earthcare Products www.earthcareproducts.co.uk , and the CARE range of refrigerants www.care-refrigerants.co.uk developed by Calor Gas, the non HFC fire extinguisher range marketed by Wormald http://www.wormald.co.uk, and yellow, white and rock wool mineral insulation www.insulation-installers.co.uk
215 Hydrocarbons and other alternatives are also often more efficient and cheaper than HFCs. For example in 2004 a study of the type of refrigerant used in appliances labelled energy category A+ or A++ in the EU showed that just four out of 866 used HFCs, the vast majority using hydrocarbons instead. http://eu.greenpeace.org/issues/news.html#040715_a

— Work at MIT reveals that hurricane strengths have increased in line with warming water in the Caribbean[216].
— It has just been discovered[217] that all the UK's reductions in "carbon" (and equivalent greenhouse gas) emissions achieved through policy, have been more than wiped out by loss of carbon from warmer soils. The same phenomenon will exist in other EU States. This reality means we must do as much as is technically achievable to reduce emissions of all greenhouse gases.

The draft f-gas Regulation rests primarily on the notion of "containment". This failed with CFCs and it has been clearly demonstrated that it is failing with HFCs[218]. This summer a detailed examination[219] of the assumptions adopted by the Commission in drafting the Regulation showed that the Dutch STEK system may be allowing emissions of at least 6.9–12.7% rather than the often quoted 4.8%. If the Netherlands cannot effectively contain f-gases with such a system then it is unlikely that any EU Member State can. This means that the Regulation should be strengthened by introducing measures requiring substitution of alternative technologies with no risk of f-gases escaping. So far, it fails to require substitution for major uses such as commercial refrigeration.

There is enormous un-tapped scope to avoid this. Unlike emissions of greenhouse gases from soils for example, it is easy to use technical measures to prevent these greenhouse gas emissions[220]. Commercial lobbying by the f-gas industry has prevented this potential being taken up. Sadly, in the UK, policy does not require use of such alternatives.

The German EPA also recently reported[221] that a cut of 30% in German f-gas emissions is possible by 2020 if available substitute technologies are used (for example hydrocarbons, ammonia and water based systems in large-scale air conditioning and refrigeration). Simply applying the Regulation as drafted would only stabilise emissions of HFCs at 1995 levels, the German study showed. Substitutes exist for all f-gas uses. The Regulation needs to require substitution and introduce bans on f-gas applications.

The f-gas lobby is primarily American backed and that f-gases are actively promoted in the USA. The US EPA has even given awards for companies making HFCs on the grounds that they can substitute for CFCs (ozone depleters)—yet non-greenhouse gas alternatives exist which must be used instead if we are to protect the climate.

Austria, Denmark, Sweden and Switzerland have all adopted policies which outlaw specific uses of HFCs, PFCs and SF6. Established commercial alternatives exist for HFCs in refrigeration and air conditioning, fire extinguishing and insulation. Over 120 million domestic fridges using hydrocarbons (alternatives to HFCs) have operated successfully since 1992 but HFCs are widely used in the USA and in larger shop and office systems, due to the lobbying power of the chemical (fluorocarbon) industry.

In 2004[222] American multinationals Coca Cola and MacDonalds and Anglo-Dutch giant Unilever all took measures to adopt non-HFC technologies (mostly hydrocarbons) for chilling, cooling and air conditioning, in ice cream, restaurant, drinks and other applications. This shows that positive change is possible—regulation should require it.

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216 Increasing destructiveness of tropical cyclones over the past 30 years; Kerry Emanuel - Nature 436, 686–688 (04 Aug 2005) Letters to Editor.

Analysis by climatologist Kerry Emanuel of the Massachusetts Institute of Technology shows for the first time that major storms spinning in both the Atlantic and the Pacific since the 1970s have increased in duration and intensity by about 50%. Emanuel found that in the past three decades, Atlantic-basin hurricanes have grown more than twice as powerful, with a notably sharp upswing since 1995. The researcher links the formation of intensified storms to an increase in average ocean-surface temperature of nearly one degree Fahrenheit during the same period—due in part to climate change. If coastal populations continue to increase, Emanuel writes, it is likely to mean "a substantial increase in hurricane-related losses in the 21st century." Emanuel's is the first study to make a statistical link between global warming and stronger Atlantic storms. http://www.grist.org/news/daily/2005/08/01/4/index.html

217 [2] http://news.bbc.co.uk/go/pr/fr/-/1/hi/sci/tech/4224272.stm Warmer soils add to climate worry.

Higher UK temperatures are causing soils to "exhale" large quantities of carbon dioxide, probably accelerating global warming, scientists report. They base their assessment on a huge analysis of soil samples gathered from across England and Wales over 25 years. The team says its findings, if extended to the whole of the UK, suggest some 13 million tonnes of carbon are being lost from British soils each year.

The Cranfield University group reports its work in the journal Nature.The scientists say computer models used to forecast future climate trends will now have to be revised because the calculations on which they are based will be wide of the mark. "Our findings suggest the soil part of the equation is scarier than we had thought," Professor Guy Kirk, of Cranfield University, told journalists at the British Association's Festival of Science in Dublin, Ireland.

"The consequence is that there is more urgency about doing something—global warming will accelerate."

218 HFC containment has already failed Atlantic Consulting, www.ecosite.co.uk February 2004 report at www.mipiggs.org

219 Is STEK as good as reported? Jason Anderson Institute for European Environment Policy http://www.environmentdaily.com/docs/50615b.pdf

220 A comprehensive 248 page German study "Fluorinated greenhouse gases in products and processes—technical climate protection measures" (17/09/04) by the German Federal Environmental Agency describes the many technically and economically feasible f-gas substitution measures that are available now. A MIPIGGs summary of the report is also available (see http://www.mipiggs.org/pdfs/F-Gase_englisch17_9_04.pdf)

221 See ENDS Environment Daily—Monday 29 August 2005, Issue 1931).

222 http://www.greenpeace.org.uk/contentlookup.cfm?CFID = 1171131&CFTOKEN = 81946584&UCIDParam = 20040622143346

The new[223] (in Europe) use of HFCs in car air conditioning could be avoided by requiring use of proven CO_2-based technologies[224] or not fitting mobile air conditioning to cars. Existing mobile air conditioning uses HFC 134a. US car companies use also advocate HFC 152a, (140 times more powerful than CO_2).

In 2004, the UK Government reversed previous policy that HFCs should only be used as substitutes for CFCs, where essential, and instead allowed them in entirely new uses, such as car air conditioning.

In 2002 atmospheric levels of HFC 134a and 125 over Svalbard (Spitsbergen) were 20% higher than in 2001[225]. Another report has shown, as IPCC suggests, that HFC use leads directly to pollution, and HFCs leak as rapidly as did CFCs[226]. HFCs from mobile air conditioning (mainly cars) already has the same impact as all of Sweden's greenhouse gas emissions[227]. Over 60% of HFC emissions result from routine leaks from refrigeration and air conditioning[228].

At present governments are allowing HFCs to be used to replace uses of CFCs and HCFCs[229]. So far only about 30% of uses have been so substituted, and resulting HFC emissions comprise about 1.5% of total global warming. If all HCFCs and CFCs are replaced with HFCs, the figure will not be 1.5%, but 4.1% (the impact over 100 years), and over the critical next 20 years, 5.2%.[230]

Between 1990 and 2003 annual global sales of HFC 134a rose from 189 metric tons to 166,899[231].

I hope you find these points useful in regard to the inquiry and please don't hesitate to contact me if you require any further information.

17 September 2005

Memorandum submitted by nef (the new economics foundation)

CONTENTS

1. OUTLINE

1.1 This evidence particularly addresses aspects of inquiry issues: *B: Financial Costs and Investment Considerations.*

1.2 The evidence is organised into three sections:

3. Summary and proposed comprehensive energy path assessment grid

4. The prospects for nuclear power
   - 4.1 Historical context
   - 4.2 Current development plans
   - 4.3 The 2002 review
   - 4.4 Cost reduction through "learning and scale"
   - 4.5 Construction costs
   - 4.6 Timescale and nuclear's ability to tackle climate change
   - 4.7 Costs and hidden emissions

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[223] In Germany, 9.4% of all cars sold in 1992 were equipped with AC; in 1998 the figure was 68%, rising to a predicted 90% in 2001 (Schwarz & Leisewitz 1999 cited in Keeping cool without warming the planet: Cutting HFCs, PFCs, and SF6 in Europe Jason Anderson Climate Network Europe www.climnet.org)

[224] World's First CO_2 Air Conditioning System by Satoshi Itoh, Denso in Auto Technology 1, 2004; and, [BMW ?] and a French firm expects its CO_2 technolgy to be marketed in 2009: Valeo develops environmentally friendly R744 air conditioning system http://www.valeo.com/gb/news/news—04.20—29072004.asp. These CO_2 technologies use CO_2 recovered from the air or waste gases.

[225] ENDS Daily 6 February 2004

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[228] The high and still growing share of fluorinated greenhouse gases in overall global warming emissions—Summary of an Öko-Recherche study (including special remarks on commercial refrigeration), Frankfurt, June 2004, on behalf of Greenpeace Author: Dr. Winfried Schwarz, Frankfurt.

[229] chlorine-containing gases controlled under the Montreal Protocol of the Vienna Convention on the ozone layer.

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In addition,this evidence includes the following tables and figures:

2. **nef** (The New Economics Foundation)

2.1 **nef** (the new economics foundation) independent "think and do" tank that believes in economics as if people and the planet mattered. **nef**'s work focuses on key policy areas including energy, climate change and international financial and trade issues.

2.2 Andrew Simms is Policy Director and head of the Climate Change programme at **nef**. Andrew is a board member of The Energy and Resources Institute (TERI) Europe. His publications include several reports on climate change, globalisation and localisation, and development issues. He has been a regular contributor to the International Red Cross's annual World Disasters Report, and his book Ecological debt: the health of the planet and the wealth of nations was published in Spring 2005.

2.3 David Woodward is Director of Global and National Economies at **nef**. David has worked for the Foreign and Commonwealth Office as an economic advisor, as technical assistant to the UK Executive Director to the IMF and World Bank; research coordinator on debt for Save the Children (UK); and development economist in the Strategy Unit of the World Health Organisation.

3. Summary

Nuclear power has been promoted as a solution to climate change and an answer to energy security. On the basis of **nef**'s analysis it is neither. On the one hand, as a response to global warming it is too slow, too expensive and too limited. On the other hand, it is more of a security risk in an age of terror-related threats, than a security solution.

In spite of newspaper headlines suggesting a come-back for nuclear power, this evidence finds no substance to claims that it has an increased role to play in a flexible, safe, secure, and climate friendly energy supply system. These, in fact, are the characteristics of renewable energy, which is abundant and cheap to harvest both in the UK and globally. Successive investigations by government and parliament have come to similar conclusions. The opposite conclusion is only possible if renewable energy technologies are negatively misrepresented, and if the numerous weaknesses, high costs and unsolved problems of nuclear power are glossed over.

The Government is committed to "evidence-based policy". This alone should rule out a nuclear comeback. The limited criteria of cost and security are enough to direct the UK down the path of renewable energy. By adding further, meaningful criteria to an assessment of energy choices, such a decision is merely confirmed. It is beyond the scope of this evidence to present a fully comprehensive energy path analysis, but not beyond its scope to recommend that such an analysis be carried out. The energy assessment grid below illustrates what such an analysis should include (see Table below).

Cost and the economic return on investment are issues at the top of many people's lists. Using unadjusted figures most renewables can outperform nuclear power. Using more realistic figures for the cost of nuclear power leaves renewables easily the better choice.

Renewables are quicker to build and need less energy pumped in for every unit of power subsequently generated. Because renewables, pound for pound, also generate far more jobs than nuclear power, they contribute much more to broad based economic development both at home in the UK and abroad. Importantly, renewables leave no legacy of radioactive waste that endures in the environment for tens of thousands of years.

It is clear that a new wave of nuclear power stations could only be built with some form of large public subsidy. But given that the public purse has limited resources, the Government must make the best investment on the taxpayers' behalf. In this case, the danger is that the huge and unpredictable costs of nuclear power will crowd out vital investment into renewable energy, as it has done for decades already.

In order to re-level the economic playing field for renewables two things are needed. First the Government should remove the existing direct and indirect subsidies to nuclear power that "feather bed" its prospects. Secondly, in order that they achieve their full potential, public support to renewables should rise to match the levels historically enjoyed by nuclear power.

In a recently issued manifesto the Renewable Power Association (RPA) called for particular fiscal measures that would, it said, deliver the best value for money.[232] These include:

— Extending Enhanced Capital Allowances to all renewables.

— Reducing VAT on wood-fuel boilers and other domestic-scale renewables.

— Introducing Stamp Duty concessions for buildings with renewables.

— Enhancing tax allowances for all renewable investments.

— A Cabinet-level Energy Minister.

A private members' bill on renewable energy, introduced earlier this year by Lord Redesdale, called for all electricity suppliers to be obliged to purchase electricity from microgenerators. It went further to require local authorities to set targets for their take up and categorise certain types of microgenerator as "permitted developments", to ease their planning path at the local level.[233]

On the international stage, there is the need for an International Agency for Renewable Energy to represent the sector at the global level and to balance the already-existing equivalent nuclear institutions.

An unacknowledged benefit of microgeneration is that it puts people back in touch with where energy comes from. We have taken fossil fuels for granted for too long, and ignored the importance of living in balance with the ecosystems upon which we depend. Renewable energy is a great reminder that also offers us the chance for greater independence. It is possible that nuclear power has only survived for as long as it has because its true costs have been hidden from us, and because its waste and pollution are invisible.

The potential for a climate friendly, non-nuclear energy supply system has been acknowledged by extensive research carried out from across government, parliament, the Royal Commission on Environmental Pollution, to the wider research community and civil society. There is now an opportunity and a need to make it happen.

[232] *Renew,* Issue 155, NATTA, The Network for Alternative Technology and Technology Assessment.

[233] *Ibid.*

Energy Assessment Grid

ENERGY ASSESSMENT GRID: PROPOSED COMPREHENSIVE ENERGY PATH ASSESSMENT GRID WITH ESTIMATED, ILLUSTRATIVE SCORES FOR NUCLEAR AND WIND (0 IS THE LOWEST SCORE, 5 THE HIGHEST)

Source	*Coal*	*Oil*	*Gas*	*CHP*		*Nuclear*	*Micro/Small*	*Wind*			*Wave*	*Tidal*	*Solar*	
Factor				*chp*	*dchp*		*Hydro*	*Onshore*	*Offshore*	*Micro*			*Thermal*	*PV*
Cost						1		4	3	2				
Supply potential[1]						2		3	5	2				
Security[2]						0		5	5	5				
Climate solution[3]						1		5	5	3				
Energy gain[4]						3		5	4	3				
Waste						0		5	5	5				
Job creation						1		5	5	5				
Flexibility[5]						0		4	3	3				
Independence[6]						2		5	5	5				
Score (weighted)														

1 Considers whether the resource is renewable or not and the ease of access to the resource.

2 Considers the overall security implications of the energy technology, both vulnerability to attack, potential to contribute to wider security problems such as conflict and nuclear proliferation, as well as any negative impact on domestic civil liberties considered necessary for protection of the source/technology.

3 Considers the carbon intensity of the technology but also its potential to effect carbon savings within the timeframe considered necessary.

4 A measure of the energy return on the energy invested.

5 Considers flexibility in terms of sites for installation and supply; nuclear power's score is low because of the limited number of appropriate sites and its inflexible method of generation.

6 Considers contribution to national energy sovereignty; nuclear power's illustrative score is low because of the international nature of the industry.

4. The Prospects for Nuclear Power

A generation has grown up in Britain having forgotten how and why the future of a once optimistic nuclear energy sector became so tarnished. For that reason it is necessary to revisit the industry's journey from post war promise, to become a sector in decline, and why it is that nuclear power is now back on the political agenda. If recent events are indicative, any renewed official enthusiasm for nuclear power will face significant obstacles.

Earlier this year days after Labour Government officials seemed to be positively entertaining the prospect of new nuclear generating capacity, news emerged of a leak of 20 tonnes of plutonium and uranium dissolved in nitric acid at the Thorp reprocessing plant in Sellafield. Classified on the International Nuclear Event Scale as a "serious incident", it was a poignant reminder of the Windscale reactor fire—whose scale and impact were kept secret from the British public for 25 years—an event that led to the plant being renamed Sellafield. The contemporary leak resulted in calls from the EU Commission for tougher safety standards. Soon after, it was reported that the Nuclear Decommissioning Authority wanted Thorp to shut for good. This was due partly to the fact that it was a loss-making operation, and partly because the controversial nature of reprocessing is seen within the industry as a potential barrier to winning the argument for a new generation of reactors.[234]

4.1 *Historical context*

Discovered in the 1930s, nuclear fission was later pioneered in the 1950s by the United States, the UK, France, Canada and the former Soviet Union as a way of supplying electricity.[235]

The UK's first nuclear power station was Calder Hall in Cumbria, a Magnox gas-cooled reactor, which came on stream in 1956. Several of these aging Magnox reactors are still in operation. The design was also exported. DTI proudly cites the stations built in Italy and the one in Japan, which is still operating. They omit to mention that North Korea's current controversial nuclear programme is based on these same early generation British-designed Magnox plants.[236] France used similar technology early on then later followed the US focus on water-cooled reactors. In the 1960s Britain went on to develop advanced gas-cooled reactors before opting for pressurised water reactors (PWRs) in the 1970s.

Their development is instructive for the current debate about the potential of nuclear power to ward off climate change. A public inquiry into the UK's first PWR, Sizewell B in Suffolk, ran from January 1983 to March 1985 and it wasn't until 14 February 1995 that it began operations. Prime Minister, Margaret Thatcher, planned to build a whole series of new nuclear power plants, but as the DTI observes, "Since Sizewell B, no further nuclear reactors have been built or ordered in the UK."

When plans to privatise the electricity supply sector were announced in 1988, nuclear power was left out of the proposals. High capital costs of construction, decommissioning and waste disposal were the main reasons. But the other problem that beset the nuclear sector then and still does today was, according to the DTI, the serious "uncertainties over the costs" of financing new stations.

In 1994 the Government undertook a *Review of the Future Prospects for Nuclear Power in the UK*. After analysing the "economic and commercial viability of new nuclear power stations", it concluded that public support, or "subsidy", for building new stations would constitute a significant and unwarranted intervention in the market.

In 2000, the final explicit subsidy to nuclear power was removed and replaced with an obligation on UK energy utilities to buy 3% of power from renewable sources.[237] There are 31 operating reactors at 14 powers stations currently in the UK. See Table 1.

Table 1

POWER STATIONS IN THE UK

BNFL Magnox	*Capacity MW*	*Published Lifetime*
Calder Hall	194	2003
Chapelcross	196	2005
Sizewell A	420	2006
Dungeness A	450	2006
Oldbury	434	2008
Wylfa	980	2010

234 "Close nuclear leak plant for good says Sellafield", *The Observer,* 15 May 2005.

235 DTI (2003) Nuclear power generation and the UK industry, http://www.dti.gov.uk/energy/nuclear/technology/history.shtml (downloaded 21 Apr 2005).

236 Marquand, R (2004) "North Korea's nukes: advanced, but hidden", *The Christian Science Monitor,* 21 December 2004. Centre for Non-Proliferation Studies (CNS) at: http://www.nti.org/db/profiles/dprk/nuc/fac/reactors/NKN_F_5mwrct_GO.html

237 "British Energy planning new nuclear programme", *The Business,* 27–28 March 2005.

British Energy	*Capacity MW*	*Published lifetime*
Dungeness B	1110	2008
Hartlepool	1210	2014
Heysham 1	1150	2014
Heysham 2	1250	2023
Hinkley Point B	1220	2011
Hunterston B	1190	2011
Sizewell B	1188	2035
Torness	1250	2023

(source DTI)

The Government's Performance and Innovation Unit (PIU) published a review of UK energy policy in February 2002. It concluded that new sources of low cost, low carbon energy should be developed. It called for renewables to play a central role, and left the nuclear option open.[238]

In February 2003, the Government published its Energy White Paper *Our energy future—creating a low carbon economy*.[239] It sets energy efficiency and renewable energy as Government's priorities. The White Paper says that, "while nuclear is currently an important source of carbon free electricity [note: this is not factually correct], the current economics of nuclear power make it an unattractive option for new generating capacity and there are also important issues for nuclear waste to be resolved." Consequently and clearly ruling out the prospect of any future public subsidy, the DTI notes that, "In common with all generation options, the initiative for bringing forward proposals to construct new nuclear plant lies with the market and the generating companies".

So it was with an apparently strong contradiction that the Government came to the aid of the financially crippled nuclear sector in 2002, supporting British Energy with a £650 million credit facility. The European Commission challenged the UK Government under its rules prohibiting state aid to industry.[240]

The timescale for nuclear phase-out suggests all Magnox reactors will close by 2010 and, with some exceptions, Advanced Gas-Cooled Reactors (AGRs) by 2020. This implies nuclear power's share of generating capacity falling from its current level of 23% to 7%.[241]

In April 2005, the Government launched the Nuclear Decommissioning Authority (NDA), to manage the task of cleaning up the contamination left on the sites of the 40 nuclear reactors that have operated in the UK. Very conservatively the costs are estimated at tens of billions of pounds over the coming decades.[242] The transfer of assets and liabilities from British Nuclear Fuels (BNFL) to the NDA is considered to remove "polluter pays"-type obligations from BNFL. As the State is providing an advantage to a company, the EC considers that it falls into the category of potentially prohibited "state aid". An in-depth inquiry has been instigated.[243]

4.2 *Current development plans*

Currently there is no active programme of new nuclear build anywhere that electricity-generating markets have been liberalised.[244] In the US no new nuclear power stations have been ordered for over 25 years. In Europe, Germany, Belgium, the Netherlands and Sweden are committed to closing existing plants. Only one is being built in Western Europe in Finland. If new build were to happen, the Westinghouse Advanced Passive 1000 (AP1000) reactor is reportedly the most likely candidate.[245] A Government review of 2002 says that 20 years would be the minimum timeframe to develop a programme using this technology, ruling out any role for nuclear in cutting carbon emissions to control global warming in the period in which the growing scientific consensus dictates that action is essential.

In an attempt to escape the private sector's deep antipathy toward the economic uncertainties of nuclear power, British Energy is reported to be talking to city institutions about the possibility of private funding for a nuclear-power building programme. Contrary to past official assurances that there would be no new

238 Full report at: http://www.piu.gov.uk

239 http://www.dti.gov.uk/energy/whitepaper/index.shtml

240 DTI (2003) Nuclear power generation and the UK industry, http://www.dti.gov.uk/energy/nuclear/technology/history.shtml (downloaded 21 April 2005).

241 Evans A (2003) *The Generation Gap,* ippr: London.

242 "BNFL launches nuclear clean-up business", *Bellona,* 6 May 2004, http://www.bellona.no/en/energy/nuclear/sellafield/33726.html (downloaded 20 April 2005).

Nuclear Decommissioning Authority (2004) "Nuclear Decommissioning Authority publishes its 2005/06 Annual Plan", NDA Communications Team.

243 "UK nuclear industry is allegedly "cheating the market", 18 January 2005 www.bellona.no

244 Cabinet Office Performance and Innovation Unit (2002).

245 Evans, *op cit*.

subsidy to nuclear, the Treasury is also reportedly considering tax breaks for private companies willing to support a new-build programme. Such an approach would partly circumvent the twin barriers of the Government's reluctance to use public cash directly, and British Energy's lack of resources.[246]

British Energy is currently banned from operating any newly built stations until 2010, because of the settlement terms resulting from its brush with the European Commission after the Government's credit bail-out. According to news reports, bankers have told British Energy at London meetings that the "huge initial costs of building nuclear stations, coupled with volatility in the power market makes funding impossible" without a change of government policy.[247]

4.3 *The 2002 review*

One of the problems of dealing with the strictly economic aspects of choosing an energy path is the opaqueness of figures offered by the nuclear industry. The 2002 report by the PIU lists these reasons why the industry's figures about the costs at which it could deliver new generation should be questioned:[248]

4.4 *Cost reduction through "learning and scale"*

The nuclear industry is over-optimistic about reducing costs through "learning and scale effects":

- The former because necessarily strict regulation to do with the inherent dangers of nuclear materials, means that it is unrealistic for the industry to "learn" substantially from its mistakes, because a mistake in nuclear power terms might be disastrous.
- Even where possible "learning effects" will be less for nuclear than renewable because, "Long lead times for nuclear power mean that feedback from operating experience is slower."
- The latter "scale effects" would also be constrained because, compared to the scale benefits for renewable technologies, "The scope for economies of large-scale manufacturing of components is less."

4.5 *Construction costs*

The nuclear industry is over-optimistic about construction costs:

- It claims that it can achieve costs below the bottom of the range given in an assessment of nuclear's potential by the International Energy Agency. But such an outcome would depend on:
  - Achieving very high operating availability.
  - A series build of 10 identical reactors.
  - Short construction times; and regulatory stability.
- The technology proposed for a new series of stations is the AP 1000 which:
  - Is yet to be built anywhere in the world.
  - Carries "first-of-a-kind risks".
  - Comes at a time when no new stations have been ordered in OECD Europe since 1993.
  - Performance will be difficult to guarantee at proposed levels.

4.6 *Timescale and nuclear's ability to tackle climate change*

The earliest that new nuclear capacity could be introduced means it can't tackle climate change:

- Twenty years was considered to be the earliest that a new generation of nuclear reactors of this type could be introduced, whereas the scientific community say that action to reduce greenhouse gas emissions is urgent with the next decade.
- Given the sceptical tone of the PIU review and the clear recommendations of the recent Energy White Paper in 2003, the question the industry has to answer is, what if anything has changed in the intervening period to justify re-opening the nuclear box?

246 "British Energy planning new nuclear programme", *The Business,* 27–28 March 2005.
247 *Ibid.*
248 Cabinet Office Performance and Innovation Unit (2002), *op cit*.

4.6 *Costs and hidden emissions*

One of nuclear power's main problems is that it has proved incompatible with any kind of market system for energy. Its high, unpredictable costs and unknowable and potentially uncontainable liabilities deter investors. Its inflexible method of power generation renders the industry largely incapable of responding to changing market conditions by varying output. The bailout of British Energy in 2001 was attributed to a fluctuating market price that went below nuclear power's operating cost, and to which the sector could not respond by simply switching off reactors.[249]

Even the World Nuclear Organisation happily concedes that when the external costs of various fuel cycles are studied, the cost of wind power is up to four times cheaper than nuclear power.[250] With reference to the same methodology, however, they say that the external costs of nuclear—those not to do with immediate generating costs—are much lower than most fossil fuels. However, specialists in the measurement of ecological footprints say that the footprint of nuclear power is at least equal to many fossil fuels. Footprint analysts Best Foot Forward comment, "The losses through Chernobyl alone suggest a footprint per nuclear energy unit larger than that of fossil fuel. Life cycle studies of nuclear energy also reveal the fact that a substantial amount of pollution is produced in the production and processing of nuclear materials and the construction of power stations."[251]

According to the US-based Nuclear Information and Resource Service, the fossil fuel intensive processes involved in uranium mining, conversion, enrichment, transport and construction of power stations, mean that, "Nuclear power produces direct and indirect emissions of 73 to 230 grams of CO_2 per kWh electricity."[252]

4.7 *The problem of insurance*

The nuclear power industry is underinsured. The limited insurance it does have is effectively subsidised by public funds. The nuclear industry is unable to get commercial insurance cover and governments have had to step in, taking on the burden instead. This is a substantial, and largely hidden subsidy to the industry.[253]

In several countries the law sets a maximum liability for any nuclear facility, regardless of what the real economic, human and environmental costs of an accident will be. Under the Canadian Nuclear Liability Act the limit for an installation is CAD$75 million and is underwritten by the federal government.[254] In the United States, coverage for a "catastrophic nuclear accident" is set in law under the Price-Anderson Act of 1957 at a much larger US$9 billion, although this too has been labelled "inadequate".[255] Arguing for the industry to meet more of its own insurance costs, Senate Democrat and chair of the Senate's Transportation, Infrastructure and Nuclear Safety subcommittee Harry Reid said, during negotiations to renew legislation for the insurance programme, "We cannot allow nuclear power plants to operate without adequate insurance."[256]

The 11 September attacks on New York and Washington raised fears about the vulnerability of nuclear installations to attack. In response American Nuclear Insurers, which administers the industry's collective insurance pool, limited the industry individual operator's liability to $200 million. In the US, such a government-backed insurance programme for industry is considered unique to nuclear.

To put these figures into context, the Ukraine estimated in 1998 that, up to that point in time, it had lost between $120 and $130 billion thanks to the Chernobyl disaster over a decade earlier, whilst neighbouring Belarus estimated its economic loss at $35 billion. Of course the damage from that one incident spread much wider and, for example, still affects the hill farmers of Wales today.[257] Figures released in 2004 in response to Parliamentary questions by Labour MP Llew Smith, showed continuing damage to sheep farming in the UK from the fallout from Chernobyl.[258] In North Wales restrictions remained at 359 farms covering 53,000 hectares;[259] in west Cumbria in England, near Sellafield, nine farms were still affected covering 12,100ha;[260] in Northern Ireland, in Counties Antrim and Londonderry, 153 farms covering 8,752ha were still affected;[261] and in SW and central Scotland, 14 farms covering 16,300ha remained affected.[262]

[249] British Energy Planning new nuclear programme, *The Business,* 27–28 March 2005.

[250] World Nuclear Association (2004) *The Economics of Nuclear Power,* http://www.world-nuclear.org/info/inf02.htm (downloaded 21 April 2005).

[251] "Best Foot Forward", www.bestfootforward.com/footfaq.html

[252] Folkers, C. (August 2004), *Nuclear power can't stop climate change,* (Nuclear Information and Resource Service, Washington DC).

[253] FEASTA, "Curing global crises: Let's treat the disease and not the symptoms", http://www.feasta.org/events/debtconf/sleepwalking4.htm#panel1 (downloaded 6 Apr 05).

[254] de la Chevrotiere, N. "New insurance subsidies for nuclear industry", Bruce Centre for energy research and information, (downloaded 3 March 2005).

[255] United States Regulatory Commission, *Nuclear Insurance and Disaster Relief Funds—Fact Sheet,* (Office of Public Affairs, Washington DC).

[256] "US nuclear insurance law faces Senate fight", *Reuters,* 25 January 2002.

[257] "Neighbours count cost of Chernobyl disaster", *BBC Online,* 26 April 1998.

[258] *Renew,* Issue 153 Jan/Feb2005, NATTA, The Network for Alternative Technology and Technology Assessment.

[259] *Hansard,* 10 May 2004, column 98.

[260] *Hansard,* 11 May 2004, column 208.

[261] *Hansard,* 4 May 2004, column 1410.

[262] *Hansard,* 13 May 2004, column 488.

In terms of the international communities' ability to respond to major nuclear accidents, the Chernobyl case is instructive. A limited plan to manage the contaminated accident site was pulled together in 1996 known as the International Shelter Project. It was estimated to cost $758 million, not including the costs of actual fuel removal or the decommissioning and decontamination of the site. G7 nations pledged to contribute $300 million towards the $758 million cost, topped up by a further $37 million from 40 other countries, together making up less than half the total estimated cost.[263]

The insurance circumstances of the nuclear industry represent a double subsidy. Firstly installations are underinsured, and secondly the state ultimately picks up the bill. As the retired Royal Navy Commander Robert Green, (who navigated nuclear strike aircraft during two decades of service) observed, "No commercial insurance company has ever insured either nuclear-powered merchant ships (which were all economic failures) or electricity generation plants, because a worst-case accident, like the 1986 Chernobyl reactor explosion, cannot be ruled out."[264]

The insurance industry's deep antipathy towards the nuclear sector was underlined by a call in 2003 from Swiss Re for contracts to be rewritten and laws to be changed to explicitly remove any exposure of the insurance and reinsurance sector to the nuclear industry.[265]

4.8 *Questions of supply and cutting greenhouse gases*

People rarely consider the question of finite resources in relation to nuclear power but uranium is in limited supply. Given current nuclear output one estimate from a body representing the renewables industry suggests that uranium reserves will be depleted in around four decades.[266]

But even the International Atomic Energy Agency (IAEA), a UN body that promotes peaceful uses of nuclear power, cites known conventional, recoverable resources of uranium at 4.6 million tonnes—enough to last only another 85 years at the rate of use in 2002. It also observes "The period for which resources are sufficient decreases the more nuclear power is assumed to grow in the future."[267]

Another question is whether, even with a major building programme, nuclear power could make much difference in terms of global greenhouse gas emissions. The IAEA's 2004 review of the sector looked at two different scenarios. In the first, in which no new nuclear stations beyond those already planned get built, "Nuclear power's share of global electricity generation decreases after 2010 to 12% in 2030, compared to 16% in 2002," meaning that its relative contribution to fighting global warming falls also. However, ironically, nuclear power's potential relative contribution to reducing greenhouse emissions is even worse under the IAEA's more optimistic high-growth scenario.

This is because the model takes account of the fact that in order to pay for a major nuclear building programme there would have to be high economic growth, which would still be largely powered by even faster growth of fossil-fuel use. Hence the conclusion that under the high nuclear growth scenario "generation steadily increases by a total of 46% through 2020 and by 70% through 2030", but, "overall electricity generation increases even faster than nuclear power, causing nuclear power's share of overall electricity to decline. By 2030 the nuclear share is down to 11%".[268]

Fast-breeder reactors are meant to solve the problem of limited uranium supplies, but they require much higher energy "investments". As the UK Atomic Energy Authority wrote in 1989, "In practice, it is now not clear how [the use of fast breeders] would be achieved on an expanded global scale without encountering basic plutonium shortages, not to mention serious problems with waste disposal, power plant decommissioning and nuclear weapons proliferation."[269]

If fuel supply was not a problem there is another one. Margaret Thatcher as Prime Minister planned 10 new nuclear power stations and managed only one. In the context of declining global oil and gas production, to meet unmanaged growth in energy demand, would require an unfeasibly large programme of new build. According to one estimate between 2015 and 2040, 1,700 stations would be required.[270] Add to that the new demand to provide the energy necessary for the global economy to grow at 2% beyond 2015, and another 5,000 stations could be needed. Based on this estimate, over the 25-year period up to 2040, approximately five new stations would need to open every week. There would be significant problems in finding suitable sites outside earthquake zones and where the cooling water would not harm the marine environment, and where local opposition was not strong. Given that most stations take ten years to build, work would have to start almost immediately.[271]

263 *Fact Sheet on the Accident at the Chernobyl Nuclear Power Plant,* December 2000, US Nuclear Regulatory Commission.

264 Green, R D. (2004) "Why the nuclear-powered ship ban must stay", 17 February 2004, (Disarmament & Security Centre, Aotearoa/New Zealand).

265 Andris, D, Galley, G, Reitsma, S and Walker, R. (2003) *Nuclear risks in property insurance and limitations of insurability,* Swiss Reinsurance Company.

266 See: World Council for Renewable Energy at: http://www.world-council-for-renewable-energy.org/

267 *Nuclear Technology Review 2004,* (International Atomic Energy Agency, Vienna).

268 *Ibid.*

269 Quoted in: FEASTA, "Curing global crises" *op cit*.

270 *Ibid.*

271 *Ibid.*

Another estimate comes from the US-based Nuclear Information and Resource Service (NIRS): to meet the IAEA's high-growth scenario for nuclear power an average of 115 power stations of 1,000MW would need to be constructed annually, with a new station opening approximately every three days.[272]

A report on the *Future of Nuclear Power,* recently published by MIT said that to increase nuclear power's share from 17% of world electricity to just 19% by 2050 would mean nearly trebling nuclear capacity. Between 1,000 and 1,500 large nuclear plants would have to be built worldwide.[273]

Even a report produced in 2004 by the IAEA to mark the 50th anniversary of nuclear power conceded that nuclear power could not stop climate change. In an interview Alan McDonald, an IAEA energy analyst, admitted that, "Saying that nuclear power can solve global warming by itself is way over the top."[274]

4.9 *Security*

Global reinsurance giant Swiss Re cites three scenarios for nuclear terrorism in the post 9/11 world:[275]

(1) A radiological dispersal device, otherwise known as a "dirty bomb".

(2) Attack or sabotage on a nuclear installation.

(3) An "improvised nuclear device", either taken from military sources or "home made".

All imply long-term contamination and extremely high costs in both human and financial terms.

So far, no convincing response has been given to this key security question, which explains the nervousness of the insurance industry. There are fears that the degree of new security measures necessary to address such concerns, could, in themselves, represent a victory for terrorism and lead to a police state. There is also the problem of materials "leaking" to supply the market for state sponsored nuclear proliferation.[276]

One recent estimate put the cost to BNFL of providing security against terrorism, including armed police, at £50 million per year. This is roughly the same as the total amount recently allocated to a new wave and tidal development fund in the UK, to be spread over several years.[277]

Chernobyl demonstrated what happens when a reactor core is penetrated without first having shut down safely. Private nuclear industry calculations are understood to have shown that the effect of a plane being flown into the Intermediate Level Waste stores at Sellafield could result in 3,000 deaths within two days of the attack.[278]

With the industry arguing the case for their own renaissance in the context of climate change, there is another, ironic, potential obstacle. The challenge of finding appropriate sites for new wind farms is dwarfed by the task of choosing sites for new nuclear reactors. Given public opposition, a common official fallback position is to advocate building new reactors at existing nuclear sites. However, following the sector's much-criticised "dilute and disperse" approach to waste management, nearly all nuclear plants are to be found on the coast. But as observed in a newsletter produced by Defra, "With sea levels rising due to climate change, this does not seem to be a good location."[279]

4.10 *Waste*

Britain has over 10,000 tonnes of radioactive waste, set to increase 25-fold when current nuclear facilities are decommissioned. Most high and intermediate level waste, around 90%, is in "unconditioned form", not held in a form suitable for long-term storage.[280]

The total amount of nuclear waste in the UK, including waste generated over the next century from existing power stations and their decommissioning, is 470,000 cubic metres when conditioned and packaged—enough to fill the Royal Albert Hall five times over. The nuclear waste volumes can be divided as follows:

— High level waste—2,000 cubic metres.

— Intermediate-level waste—350,000 cubic metres.

— Low-level waste—30,000 cubic metres.

— Spent fuel—10,000 cubic metres.

[272] Folkers, *op cit*.
[273] Quoted in: *Renew,* issue 154 Mar/Apr2005 http://eeru.open.ac.uk/natta/renewonline/rol54/13.htm
[274] Lean, G. (2004) "Nuclear power can't stop climate change", *The Independent on Sunday,* 27 June 2004.
[275] Andris et al, *op cit*.
[276] 45 FEASTA, "Curing global crises" *op cit*.
[277] *Renew,* issue 154, *op cit*.
[278] Evans, *op cit*.
[279] "Energy monitor", *Renew,* quoted in *Energy, resource, environmental and sustainable Management,* May/June 2005 (defra, London).
[280] WISE/NIRS, "UK neglects its 'serious and urgent' nuclear waste problem", 17 May 2002, http://www.antenna.nl/wise/index.html?http://www.antenna.nl/wise/568/5405.html (downloaded 18 Apr 2005).

— Plutonium—4,300 cubic metres.

— Uranium—75,000 cubic metres.[281]

On average, people in Britain live only 26 miles from a major radioactive waste site, including power plants and military bases.[282]

A recently released consultation document from The Committee on Radioactive Waste Management (CORWM), based on an investigation of different options over a period of 18 months, recommended that waste should be either buried underground or stored temporarily in facilities above ground in anticipation of better technologies. No recommendation, however, is forthcoming on where these sites should be located.[283]

The high cost of waste management was a factor in another controversial government decision to do with the industry. In order to help meet waste management costs, in late 2004 the UK Government reversed a 30-year-old policy to not store foreign intermediate-level nuclear waste on British soil. But where the new waste from Japan, Germany, Italy, Spain, Sweden and Switzerland will be stored is unclear. Many observers believe that the current storage site at Drigg, near Sellafield in Cumbria is nearly full.[284]

Both sides are calling for a new debate about disposal of nuclear waste. Along with the question of security and cost, waste management remains a thorn in the industry's side. For example, the UK Government faces court action from the European Commission for safety failures and for having no reliable figure for the amount of plutonium and uranium contained in waste tanks at Sellafield. The problem goes to the heart of the technology: murky water in the tanks and radiation prevent proper inspection of the content of the holding tanks. When the problem came to light, a national newspaper commented that, "The European court of justice could in theory levy unlimited fines on the UK for failing to comply with Euratom safeguards to prevent diversion of nuclear material for military purposes."[285]

4.11 *Clarity, information and public message management*

Shortly after Margaret Thatcher became Prime Minister she announced a plan to build 10 new nuclear power stations. In spite of her extraordinary grasp on power in Britain, as mentioned above, just one was commissioned. With peculiar symmetry, shortly after Tony Blair was re-elected in 2005, a Whitehall plan was leaked, appearing to allow for a series of ten new nuclear power stations. In the event, according to former ministerial advisor Tom Burke, it turned out to be merely one of numerous options papers produced "like confetti" for incoming ministers.[286]

But the return of nuclear power to public debate didn't just happen. It has been carefully engineered. Over the course of the previous year a range of bodies representing the industry invested heavily in new staff and capacity to engage in a press and public affairs. A combination of British Energy, the Nuclear Decommissioning Agency, the UK Atomic Energy Authority (UKAEA) and the Nuclear Industry Association used a range of strategies and newly employed lobbyists to try to revive debate about the industry's prospects.[287] Even **nef** was invited to become part of the process in the build up to the political party conference season in 2005 by a public relations firm, Grayling Political Strategy, taken on by the UKAEA. In spite of such efforts, it seems the most important audience is yet to be convinced. This year only 15% of the senior management of Britain's energy utilities expected current reactors to be replaced.[288]

5. The Real Costs of Nuclear Power and Comparisons with Renewable Options

According to the PIU, British Energy (BE) and BNFL estimate the costs of nuclear generation at between 2.2 and 3.0p/kWh. Having criticised the over-optimism of many of their assumptions, PIU proposes a range of 2.2–5.0p/kWh as more realistic, with a narrower range of 3–4p.

However, this range appears too low, and unrealistically narrow for new technology that remains untested. Even if the BNFL and BE assumptions are accepted, the 2.2p/kWh figure is the lowest estimate for the *eighth* reactor to be built in a series of new build, which presupposes the construction of seven previous reactors at highest cost; and it is based on a 20-year plant lifetime. Using the PIU's standard assumptions of an 8–15% discount rate and 15-year plant lifetime, even with an optimistic view of the reduction in costs between the first and eighth units, BE and BNFL estimates imply an average cost for all eight reactors between 3.1 and 4.3p/kWh.

[281] Committee on Radioactive Waste Management (2005) *Learning from the past—Listening for the future. How should the UK manage radioactive waste?* 2nd Consultation Document, CORWM: London.

[282] BBC News, "Warning on nuclear waste disposal", 4 April 2005, http://news.bbc.co.uk/1/hi/sci/tech/4407421.stm (downloaded 18 April 2005).

[283] Committee on Radioactive Waste Management (2005) *op cit*.

[284] "In policy shift, UK says it will store nuclear waste from foreign reprocessing customers", 21 December 2004, www.bellona.no

[285] "UK faces court action for nuclear safety failings", *The Guardian,* 4 September 2004.

[286] Burke, T (2005) "Plant life", *The Guardian,* 18 May 2005.

[287] Leake, J and Box, D (2005) "The Nuclear charm offensive", *New Statesman,* 23 May 2005.

[288] Burke, *op cit*.

However, the PIU highlights reasons beyond vested interests, to believe that these figures themselves are an under-estimate. The following adjustments are based on the PIU figures for sensitivity analysis. However, since these are themselves based on an 11% cost of capital and a 20-year plant life, they are adjusted by +/−10% to correct and bring them broadly into line with the standard PIU assumptions.

First, BE/BNFL estimates of construction costs are below the lower end of the range of IEA estimates for expected construction costs of new nuclear capacity in seven OECD countries ($1,518–$2,521/kW). Based on the PIU's own sensitivity analysis, this suggests an increase in the upper end of the UK cost scale in excess of 1.1–1.3p/kWh. The estimated £100–300 million of additional "first-of-a-kind" costs excluded from the BNFL and BE figures, if spread across eight reactors, would add up to a further 4% (approximately) to construction costs, and up to 0.07p/kWh to the overall cost.

It should also be noted that these estimates are based heavily on "engineering judgements", in which the *lower limits* to the costs of producing certain types of structure are directly estimated. In other words, while the lower end of the range is a minimum, there is much greater potential for upside risk.

Past experience of nuclear power—particularly in the UK—suggests that such risks may be very considerable. Dungeness B, for example, took 23 years to complete instead of five years, resulting in a construction period longer than its productive life, while construction costs were more than 400% above the original projection. If this were repeated, it would increase the price per kWh by around 11–12p/Kh. A moderately cautious estimate of potential time and cost overruns (five years' delay and 50% cost overrun) would increase the upper end of the cost range by a further 1.5–1.8p/kWh.

Together, these considerations suggest additional costs of 0.1–3.2p/kWh, increasing the cost range to 3.2–7.5p/kWh.

BE/BNFL also assume operating availability substantially above the IEA's estimate of the current average OECD lifetime performance (75–80%). Interpreting "substantially" as a margin of 5–10%, and lowering the assumption to the IEA estimate would increase all costs (including additional costs based on the sensitivity analysis) by 5.3–11.1%. This further increases the range to 3.4–8.3p/kWh.

By comparison, if the industry estimate of 2.5–3.0p/kWh were under-estimated by the same margin as its 1995 estimate (3.5p/kWh) compared with the actual cost (6p/kWh), the true range would be 4.3–5.2p/kWh.

5.1 *Timing*

PIU suggests a planning/construction period in the order of a decade for each nuclear plant—a figure that may prove optimistic in the light of the controversy of planning applications and past experience of delays in construction. This suggests that electricity supply would come on-stream no earlier than mid-2015, even if the planning period began immediately.

However, there are a number of reasons to expect substantial further delays. Recent official briefings suggest that even an initial decision to pursue a nuclear option is far from immediately likely and possibly very far away, if it exists at all. Such an option has been, and remains highly controversial. Popular opinion towards nuclear power is roughly equally divided between supporters, opponents and undecided.[289] An added complication is the absence of a policy on nuclear waste disposal, and the finding of the Royal Commission on Energy Policy that new nuclear construction should not be permitted until this issue has been resolved to the satisfaction of the scientific community, and the public at large.

In view of these considerations, it seems unlikely that production will begin until at least 2020, and possibly well after this. This has two very important implications. First, it means that new nuclear capacity cannot contribute significantly, if at all, to the 20% reduction in carbon emissions required between now and 2020. Secondly, it means that the relevant cost comparison is not with the cost of renewable (or non-renewable) energy sources now, but in around 2020—after any cost reductions resulting from increased economies of scale and learning-curve effects in the meantime.

In fact, the delay could extend considerably further into the future. In 1981, the Monopolies and Mergers Commission (now the Competition Commission), deploring the performance of CEGB with respect to AGR plants such as Dungeness B drew the following conclusion:

> "Again with hindsight it is clear from the views we have received that work on the AGRs has been at the frontiers of technology. The implication of this is that there were many components of the AGR which could not be fully tested before full-scale operation began, nor were relationships between the variables in the design sufficiently understood even to allow simulation of certain potentially damaging conditions. Nevertheless a full-scale prototype AGR was not built before proceeding to the programme. It is the CEGB's policy not to repeat that mistake in the current proposals for the future nuclear programme."
>
> (Competition Commission, formerly the Monopolies and Mergers Commission, 1981)

Avoiding this mistake with AP1000 technology might reduce the risk of construction delays (although construction of Dungeness B took a further ten years after the completion of Hinkley Point B). However, it would delay the process by around another ten years, to 2030 or later.

[289] See MORI research at: http://www.mori.com/polls/2005/nda.shtml

5.2 *Externalities*

The PIU explicitly excludes consideration of unpriced externalities. Taking account of these could add considerably more to the economic cost of nuclear power, and to its financial cost if mechanisms were introduced to price them.

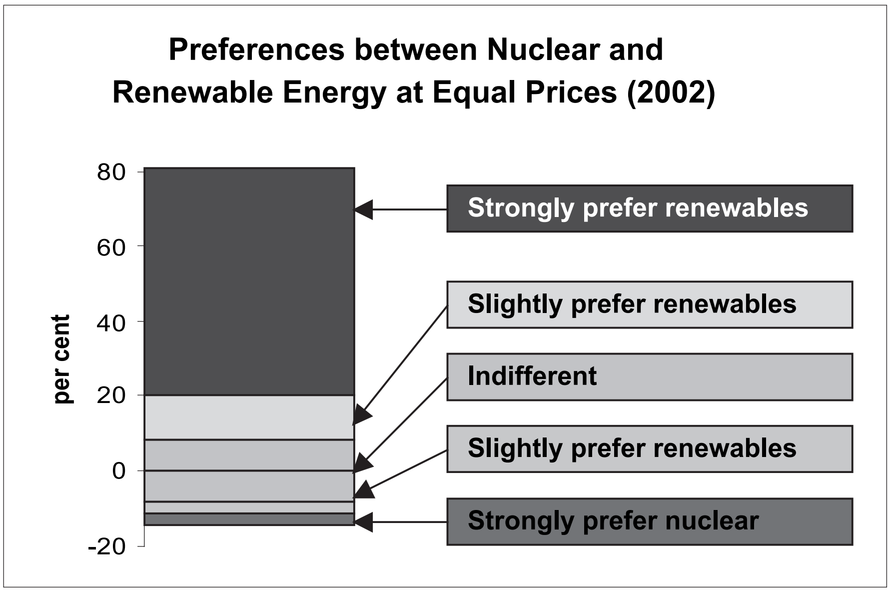
For example, there is the question of the insurance of nuclear installations, explored above. This is a cost borne largely by the State, which in the UK accepts liability for insurance costs above £140 million, and is therefore an uncounted subsidy. Secondly there is the issue that the limits set on insurance liability, where costs from major nuclear accidents are unlimited, represents a second subsidy passed onto the environment and wider community. The nuclear industry assumes that these costs are of minimal value, in which case the question remains, why should the nuclear industry not be insured at going market rates, and if the costs really are minimal why is the industry not prepared to take them on?

The risk of theft of nuclear materials, for example by terrorists, is also ignored. Given the increased level of perceived risk since 9/11, this is a serious omission. Again, it should be included in the calculations, and valued at the commercial cost of insurance against 100% liability for the damage caused. This would add significantly to costs. Additional security costs for storage and transport of inputs and waste could also increase costs significantly.

An indication of the existence of such uncompensated externalities is the public preference for renewable energy over nuclear power, excluding price effects. Asked by MORI in July 2002 about their preferences between the two, if the cost of either option were equal, 72% expressed a preference for renewables, and only 6% for nuclear (see Figure 1).

Figure 1

PREFERENCES BETWEEN NUCLEAR AND RENEWABLE ENERGY AT EQUAL PRICES (2002)



Source: MORI (2002) "Renewable Energy Wins Support From British Public"[290]

5.3 *Energy costs and learning curves*

A more positive externality arises from learning effects—the progressive reduction in costs arising from gaining experience in production. However, these effects are relatively limited in the case of nuclear power. While learning effects are typically in the order of 10–30% for each doubling of cumulative production, and 5–25% for the energy sector as a whole the figure for nuclear power is only 5.8%.[291]

There are a number of reasons for this:

— Nuclear power stations are large, one-off projects, which need to be individually designed according to local conditions. This limits the scope for learning from one case to another, even where the same technology is used.

[290] MORI (2002) "Renewable Energy Wins Support From British Public" http://www.mori.com/polls/2002/greenpeace-energy.shtml

[291] IAEA (2003) "*Guidance for the evaluation of innovative nuclear reactors and fuel cycles: Report of Phase 1A of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)*" IAEA-TECDOC-1362, June. http://www-pub.iaea.org/MTCD/publications/PDF/te_1362_web.pdf

— The large scale of nuclear power stations means that relatively few units are built; and the scope for standardisation of components is more limited than in most other productive sectors (including energy sub-sectors). The resulting short production runs for components limits the potential for economies of scale through increasing production.

— As the current cases of Iran and North Korea demonstrate, the potential for international sharing of learning is limited by security considerations, and particularly concerns about nuclear proliferation. Such concerns also limit the potential scope for use of nuclear power as an alternative to fossil fuel use globally.

— The gestation period of construction for a nuclear power station is very long—at best several years—and extended still further by an extensive planning and approval process, necessary for safety reasons. This means that, where lessons are learned which could reduce production costs, there is a considerable built-in delay before they can be put into practice.

— Learning is further delayed by the need for rigorous safety assessments of any significant changes in technology or design.

This is a critical issue. The diversification away from fossil fuels is, by nature, a very long-term process. The implications of current decisions for the future costs of non-carbon production are therefore at least as important as the effects on current energy costs. The relevant consideration, therefore, is not limited to the immediate effect on energy prices, but the long-term effect into the indefinite future of producing energy from alternative non-carbon means.

By contrast, learning effects for renewable technologies have been found to be much higher—around 18–20% for wind and PV. This reflects the more conventional nature of the production process, at least for wind and solar power, which is based on the production of a much larger number of more standardised units, with considerable scope both for learning and for economies of scale.

However, these headline figures seriously understate the scale of the differences they imply. In the case of renewable energy sources, if cost falls by 18–20% for every doubling of cumulative production, it will take an increase in cumulative production by a factor of around 10 for costs to be halved. In the case of nuclear energy, with a learning effect of 5.8%, costs would be halved only when cumulative production had been increased by a factor more than 3,000. To underline this crucial point, it means that nuclear power is 300 times less efficient at lowering its costs compared to renewables.

A further issue arising in comparing nuclear power with renewable technologies, and particularly micro-renewables, is the relative maturity of these sectors. Empirical work on learning effects shows that cost reduction is proportional to the change in cumulative production. Since nuclear power has been operating on a substantial scale for half a century, new production increases cumulative production by a relatively small amount. Thus the 5.8% learning effect is applied to a relatively small number, limiting cost reduction still further.

Most renewable technologies (except hydro), have thus far been much smaller in scale—and microrenewables still more so. As well as having much greater potential learning effects, increases in their production are therefore substantially larger relative to cumulative past production, so that these higher ratios are also applied to substantially larger numbers. The result is a much greater benefit in terms of reducing the cost of future non-carbon energy production.

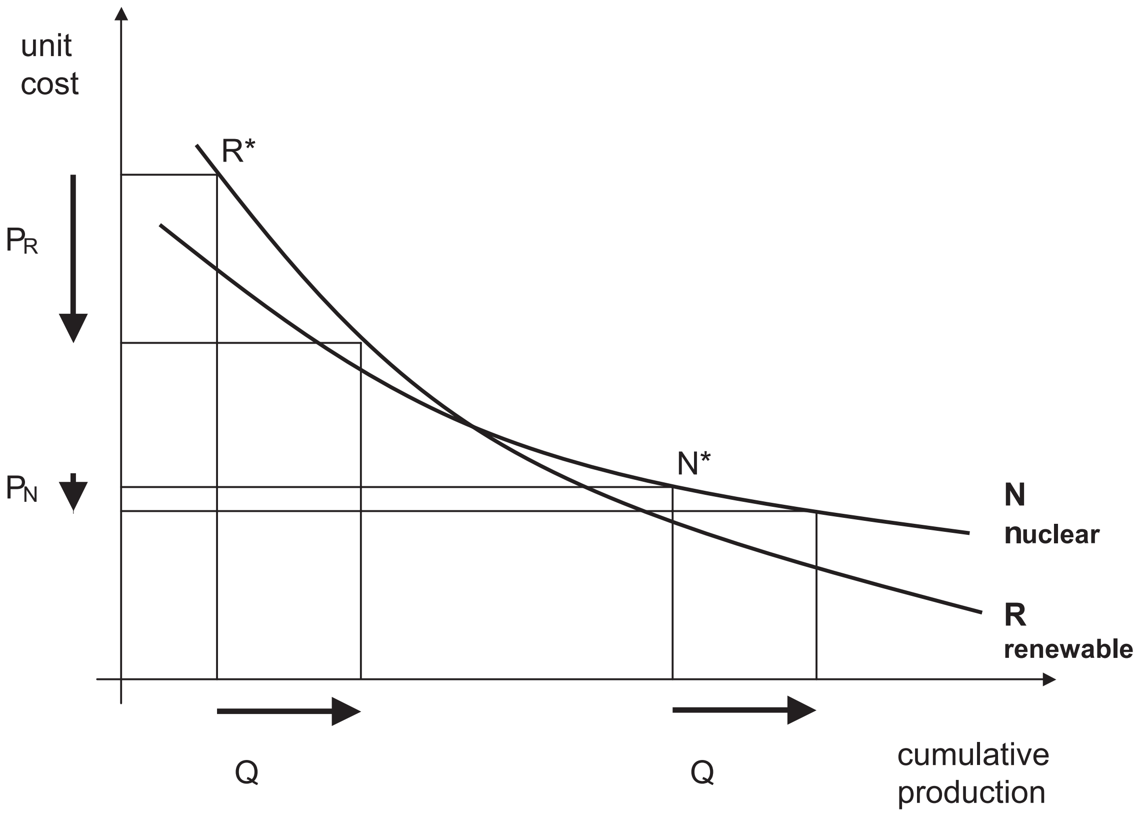
Thus there are two distinct factors, each of which makes this consideration much more positive for microrenewables than for nuclear: first, the nuclear learning curve is shallower than that for microrenewables; and secondly that nuclear is further along the curve, which becomes progressively shallower as production increases (see Figure 2).

In other words, not only would halving nuclear prices require an increase in cumulative production 300 times as great as that for wind or PV, but the much greater production to date means that it would take many times longer to increase cumulative production by a given factor for nuclear than for renewables.

Even further, increasing the production of microrenewable capacity by a factor of 10 is more than plausible; it is probable. Increasing nuclear capacity by a factor 3,000, regardless of strictly limited supplies of uranium, is highly improbable and more likely impossible.

Figure 2

LEARNING CURVE AND COST REDUCTIONS FOR NUCLEAR AND RENEWABLE ENERGY



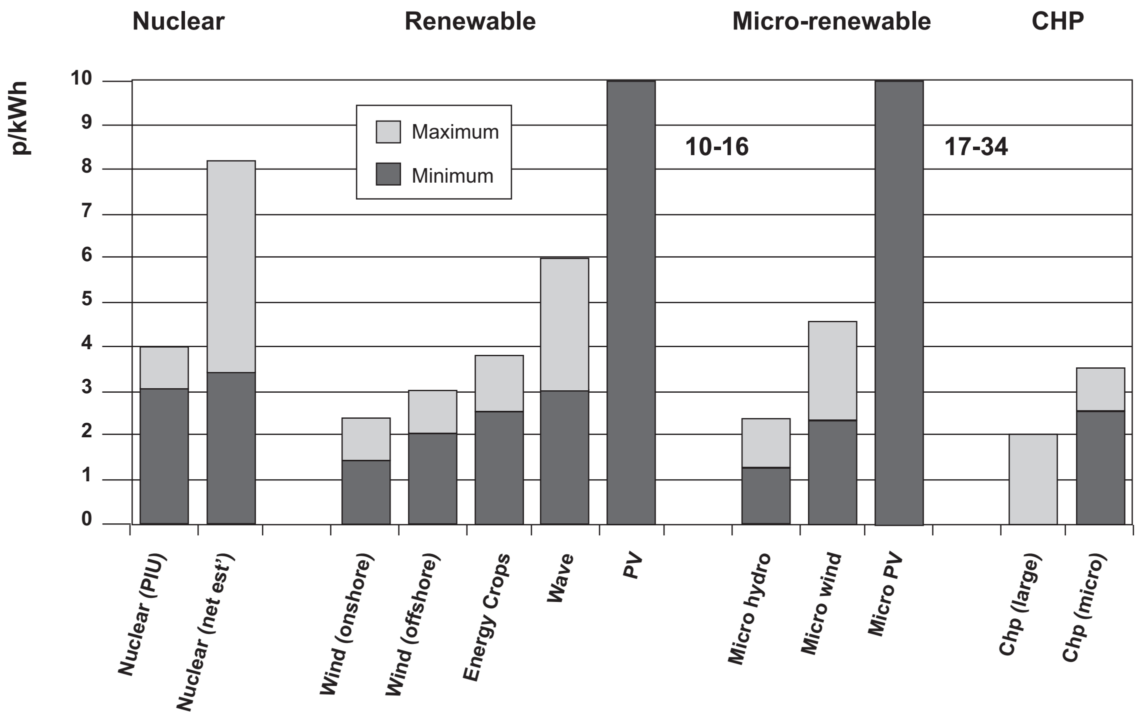
First it should be noted that the starting point for learning-curve effects, according to our calculations is that the real cost of any new nuclear generation will be much higher than the industry-quoted figures. In Figure 4 the curve marked N represents the cost of producing electricity from nuclear power at a given level of cumulative production, and R is the corresponding curve for renewables. R* and N* show the current combination of cumulative production and costs in the renewable and nuclear industries respectively. It will be noted both that the N curve slopes down more slowly than the R curve (reflecting the smaller learning effect), and that N* is further along the curve than R*, so that the slope of the curve is still shallower. The result is that if production of renewables in a given year is Q, P_R reduces the cost of production substantially; but the same production from the nuclear sector will reduce cost by a much smaller amount, P_N.

Even though our figures show that renewables already generally represent better value than nuclear on a range of criteria, there is a still further powerful argument for much greater public investment into research and development with regard to renewables and microgeneration. According to analyst Robert Williams, "When new technologies are introduced into markets, their costs tend to be higher than the costs of the technologies they would displace. Early investments are needed to 'buy down' the costs of new technologies along their experience, or learning, curves to levels at which the technologies can be widely competitive. In principle, a firm introducing a new technology should consider experience effects when deciding how much to produce and consequently to 'forward-price': that is, it should initially sell at a loss to gain market share and thereby maximize profit over the entire production period. In the real world, however, the benefits of a firm's production experience spill over to its competitors, so that the producing firm will forward-price less than the optimal amount from a societal perspective. That phenomenon provides a powerful rationale for public-sector support of technology cost buy-downs."[292]

[292] Williams, R. H. (2002) *Facilitating Widespread Deployment of Wind and Photovoltaic Technologies* (Princeton Environmental Institute, Princeton University, Princeton, N.J.), citing: Duke, R and Kammen, D. "The economics of energy market transformation programs", *The Energy Journal,* 20:15–64, 1999. http://ist-socrates.berkeley.edu/~kammen/dukekammen.pdf

Figure 3

PROJECTED ELECTRICITY GENERATION COST, 2020



Source: PIU Energy Review (2002); *DTI/ofgem (2004) Distributed Generation Coordinating Group,* PO2a Working Paper Three: The Economics Value of Micro Generation, *Technical Steering Group (except nef/ nuclear—nef estimate)*

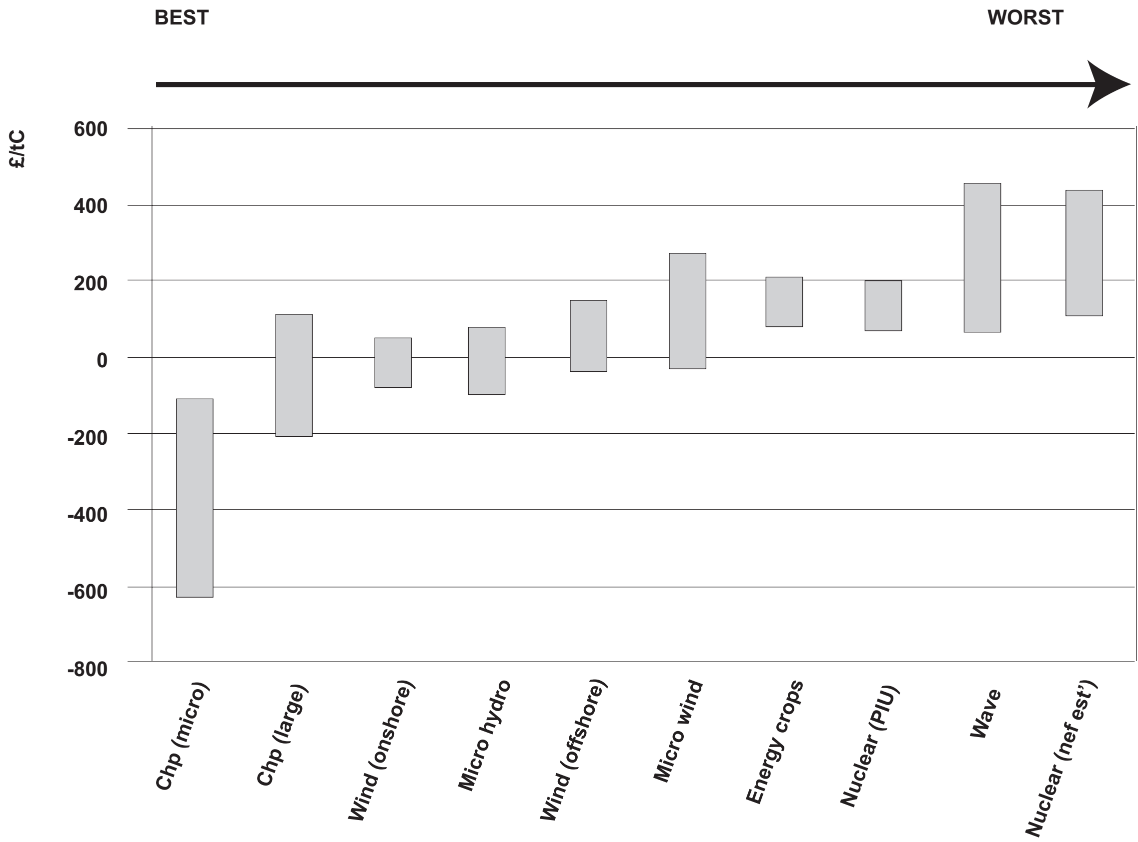
Even based on the PIU's estimate of 3–4p/kWh for nuclear power, offshore wind (2–3p/kWh) is at least as cheap, and could cost as little as half as much; and onshore wind (1.5–2.5p/kWh) is between 17% and 60% cheaper. Large CHP is also at least 33% cheaper. The cost range for nuclear energy overlaps with those for energy crops and mCHP, which may be slightly cheaper, and with wave power which may be somewhat more expensive. However, the corrected estimates for nuclear provided above suggest that it will almost certainly be substantially more expensive than any form of renewable energy with the exception of photovoltaic (which remains substantially more expensive in the UK) and possibly wave power.

Also included in Figure 3 are estimates for the cost of electricity from microrenewable energy sources. The maximum cost is that estimated by the Distributed Generation Coordinating Group Technical Steering Group in November 2004; the minimum assumes cost reductions of up to 50% by 2020 as a result of learning effects. These figures suggest that micro-hydro is likely to be one of the lowest cost sources of electricity in 2020. While the cost reduction assumption may be over-optimistic in this case, it remains highly competitive even at the maximum level (ie with no cost reduction).

The estimate cost range for micro-wind power is broadly comparable with energy crops and the PIU estimates for nuclear power (though well below our estimates for the latter). MicroPV, however, is still more expensive than larger scale PV.

Figure 4

COST OF CARBON SAVING, 2020



Source: PIU Energy Review (2002), Table 6.1 (except nef/nuclear—nef estimate; microwind/hydro—nef estimates based on P02a Working Paper Three: The Economic Value of Micro Generation, *Technical Steering Group, DTI/ofgem (2004) Distributed Generation Co-ordinating Group)*

Figure 4 shows the corresponding figures for the cost of carbon savings, in pounds per tonne (excluding PV). This suggests that mCHP saves money as well as carbon, as may large-scale CHP, onshore wind and micro-hydro. Offshore wind and micro-wind power are in the middle of the range. Nuclear power is near the upper end of the scale even on the PIU figures, equal with energy crops at £70–200/tC, and cheaper only than wave power. On our revised estimate for nuclear, the cost rises to a range broadly corresponding with that of wave power (£110–430/tC), though still cheaper than PV (£520–£1,250/tC), and considerably cheaper than micro-PV (£1,450–£3,200/tC).

Figure 5

THE ESCALATING COST OF NUCLEAR POWER (EXCLUDING INSURANCE, POLLUTION AND TERRORIST RISK)

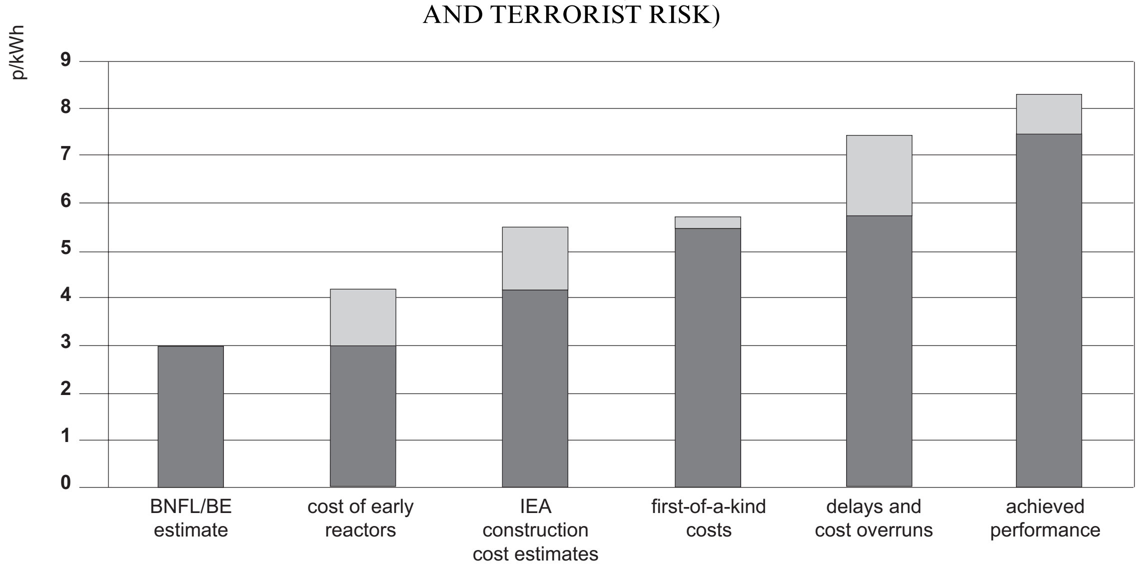


Figure 5 illustrates the effects of correcting the various sources of under-estimation of the maximum cost of nuclear power. Starting from the BNFL/BE estimate of 3p/kWh, averaging the costs of the first eight reactors adds 1.3p/kWh, as does substituting the IEA range for OECD construction costs, while "first-of-a-kind" (FOAK) costs add about 0.1p/kWh, taking the figure to 5.7p/kWh. Allowing for delays and cost-overruns could add a further 1.8p/kWh, and lowering the assumed performance to current levels 0.8p/kWh, taking the total to 8.3p/kWh—177% above the BNFL/BE figure.

Table 2

JOB CREATION IN THE ENERGY PRODUCTION INDUSTRIES

Sector	*Jobs—year/TWh (fuel production and power generation)*
Petroleum	260
Offshore oil	265
Natural gas	250
Coal	370
Nuclear	75
Wood energy	733 – 1,067
Hydro	250
Mini hydro	120
Wind	918 – 2,400
Bioenergy (ie: sugarcane)	3,711 – 5,392

Source: Goldemberg (2004)[293]

The nuclear industry is highly capital intensive and one of the least labour intensive methods of energy generation. Due to technological changes, any new cycle of nuclear power stations would employ fewer people than existing plants. Renewable energy, on the other hand, has rich potential for job creation.

The European Commission estimated that the predicted growth in the renewable energy sector would create nearly one million (900,000) new jobs by 2020, with at least 15,000 being created in the UK.[294]

30 September 2005

293 Goldemberg, *op cit.*

294 European Commission, Directorate General for Energy, "The impact of renewables on employment and economic growth (undated)".

Memorandum submitted by the Nuclear Decommissioning Authority

I read with interest about the Environmental Audit Committee's new Inquiry into Nuclear, Renewables and Climate Change.

The Nuclear Decommissioning Authority (NDA), which went live on 1 April this year, is tasked by Government to clean-up and decommission the UK's existing 20 civil nuclear sites. Our remit does not, therefore, extend to the debate around a new nuclear programme.

Nevertheless, we have recently published a major document that outlines our emerging thinking on a range of associated issues and I wanted to draw your attention to it in case it is of interest or assistance to your Inquiry. The document in question is our Draft Strategy. It is out for consultation until mid November and we must submit our final version to Government by the end of the year.

The document can be found and downloaded from our web site www.nda.gov.uk.

6 September 2005

Memorandum submitted by the Nuclear Free Local Authorities Steering Committee

Introduction

1. The NFLA Steering Committee has the support of 72 Local Authorities throughout the UK including Glasgow, Edinburgh, Leeds, Manchester and the Greater London Authority. Some of these authorities host nuclear sites, some are neighbouring authorities concerned about local economic, safety and environmental impacts of future legacy management, others are more widely dispersed and affected, for example, by nuclear transportation or historic (and potentially future) nuclear facility siting issues. All have decided to co-operate in the collective community interest in seeking to: eliminate the major production cycles that create radioactive waste, phase out nuclear generating capacity, and; ensure safe management of the radioactive waste legacy.

UK Climate Change Objectives

2. The UK is committed under the Kyoto Protocol to reducing greenhouse gas emissions by 12.5% below 1990 levels by 2008–12. We also have a national goal of a 20% reduction in carbon dioxide (CO_2) emissions below 1990 levels by 2010. In addition the Energy White Paper was intended to put the UK on a path towards a 60% cut in CO_2 emissions by 2050.

3. The table below shows one of the Government's scenarios for future energy demand detailed in Energy Paper 68 (EP68)—the Central (low prices) scenario. The projections in EP68 do not take into account policy measures, which are expected to reduce carbon emissions of 17.75 MtC by 2010, listed as additional to the baseline in the UK Climate Change Programme. The scenario also assumes no new nuclear plants will be built over the projected period.

EMISSION PROJECTIONS (AT SOURCE), MtC

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Power Stations	54.1	44.1	40.5	33.5	33.5	35.9	37.1
Refineries	5.1	5.9	5.1	6.1	6.4	6.6	6.6
Residential	21.5	21.7	22.5	22.7	23.1	23.7	24.3
Services	8.4	8.8	9.6	9.5	9.6	9.7	9.9
Industry	35.2	34.3	33.9	33.5	32.7	32.4	32.2
Road Transport	29.8	30.2	32.0	35.0	37.6	40.1	42.6
Off-road	1.6	1.5	1.3	1.3	1.4	1.4	1.4
Other transport	3.6	3.2	3.1	3.1	3.1	3.1	3.2
Total	159.3	149.6	147.8	144.9	147.5	152.9	157.3

4. We can see that power stations accounted for only around 27% of carbon emissions in 2000. Clearly, if the debate focuses on whether or not to build new nuclear stations it will ignore the fact that the UK's electricity system is responsible for only just over a quarter of UK CO_2 emissions, and nuclear power provides only around 22% of our electricity. So, as well as looking at how to reduce carbon emissions from the electricity sector, we need to look at how to provide heat more efficiently and also how to reduce emissions from other sectors such as housing and transport.

NUCLEAR CLOSURES

5. Generation from nuclear plants is declining as plants are gradually retired. By 2010 all of Britain's first generation Magnox reactors will be closed and the proportion of electricity provided by nuclear power will be down to around 17 to 18%.

6. By 2020 all but three of British Energy's stations will probably be closed with the proportion of electricity provided by nuclear generation falling to 7%. All of British Energy's nuclear stations, apart from Sizewell B, will be closed by 2023 unless they receive life extensions.

British Energy stations	*Station Type*	*Started Operation*	*Closure date for accounting purposes*	*Published Lifetime*
Dungeness B	AGR	1982	2008	2006
Hartlepool	AGR	1984	2009	2014
Heysham 1	AGR	1983	2009	2014
Hinkley B	AGR	1976	2011	2011
Hunterston B	AGR	1976	2011	2011
Heysham 2	AGR	1989	2023	2023
Torness	AGR	1989	2023	2023
Sizewell B	PWR	1995	2035	2035

7. The Government's scenarios already take into account closure of the remaining Magnox stations by 2010. Energy Paper 68 also takes into account the expected closure date for British Energy's eight nuclear power stations but assumes the company is successful in achieving life extensions for three of its stations. By 2020, even with some life extensions, only Torness, Heysham 2 and Sizewell B are likely to remain open.

8. According to the Government's First Annual Report on the Implementation of the Energy White Paper, policies which were already current when the Energy White Paper was published, should be able to reduce emissions in 2020 down to 135 MtC. The Annual Report says:

> *"To be on track for our longer-term goals, we will aim for cuts in carbon of 15–25 MtC below that level by 2020."*[295]

NUCLEAR POWER'S POTENTIAL CONTRIBUTION

9. British Energy said in its 2001 submission to the Energy Review that nuclear power was displacing around 13.5 MtC per year. The amount of CO_2 emissions displaced by nuclear power will depend on the level of emissions from an alternative fuel mix. Emissions from power stations have been going down since 1990 whilst electricity consumption has been rising. The amount of carbon produced per kWh is expected to continue to fall until 2010 despite a fall in nuclear generation. Consequently the CO_2 emissions which could potentially be displaced by a new nuclear programme will also fall. We can estimate that a new 10,000MW nuclear power programme would reduce emissions by around 6–8 MtC depending on the output.[296]

10. Putting this 6–8 MtC into perspective, it represents around 4–5% of total carbon emissions. It is, for example around half of the increase in emissions expected from the transport sector by 2020. Other policies set out in the Energy White Paper aim to reduce emissions by 15–25 MtC by 2020. By aiming for the upper end of this target the contribution from nuclear power becomes unnecessary.

	Estimated MtC reductions
Energy efficiency in households	4–6
Energy efficiency in industry, commerce and the public sector	4–6
Transport; continuing voluntary agreements on vehicles; use of biofuels for road transport	2–4
Increasing renewables	3–5
EU Carbon trading scheme	2–4
Total	15–25

[295] DTI & Defra (April 2004) First Annual Report on the Implementation of the Energy White Paper http://www.dti.gov.uk/energy/sepn/annualreport/firstannualreportfull.pdf

[296] EP 68 uses a baseline nuclear output of 66 TWh in 2010, and examines a scenario in which nuclear generated electricity is only 45TWh, and concludes that CO_2 emissions would be some 2 MtC higher than the baseline. Alternatively if the output were 74TWh, then emissions would be some 0.7 MtC lower than in the baseline ie around 1 MtC is displaced per 10TWh of nuclear output.

Lead Time

11. One of the main problems for nuclear power is that theearliest a new generation of nuclear stations could start coming on stream would be 2018–21, according to Dr Catherine Mitchell—of Warwick Business School, and a member of the Cabinet Office's energy review team.[297] This timetable assumes that everything goes well. In practice, everything rarely goes well and the earliest realistic date for delivery of power from a new UK reactor is around 2020.[298]

12. On the other hand energy efficiency improvements can be implemented now, with carbon savings beginning immediately, and up to seven times more cost effectively than building new reactors.

Do We Really Need New Nuclear Stations?

13. The danger of promoting a new generation of nuclear reactors is, as then Trade and Industry Secretary Patricia Hewitt told a meeting of Energy & Environment Ministers in London in March 2005, that it will detract from the need to give energy efficiency priority. Not only could this mean, as Gordon Brown mentioned at the same meeting, that we miss out on profitable, cost-saving measures, but could also mean, as evidence from Finland is beginning to suggest, that we end up with higher carbon emissions than we would have had without nuclear power.[299]

Finance

14. If the government decides it wants new nuclear stations then one of the main questions which will need to be answered is how new stations might be financed, what kind of government support might be necessary, and whether this support would be consistent with the market framework for energy. Nuclear power is very expensive, so the liberalised electricity market would have to be radically rearranged to get the finances to work. This will be a major concern to any non-nuclear companies operating within the current market.

15. If taxpayers' and consumers' money is going to have to be spent to drive carbon out of the economy, then we need to ensure it is spent in the most effective and environmentally sustainable way. Nuclear power is probably one of the least efficient ways of spending, so should only be countenanced after other, more cost effective methods of carbon abatement have already been implemented. Unless nuclear is the cheapest way to meet our energy needs, paying for it will actually make climate change worse. As Amory Lovins of the US Rocky Mountain Institute, explains:

> *"If we suppose pessimistically that saving a kilowatt hour costs as much as 3 cents, while generating a new nuclear kilowatt costs optimistically as little as 6 cents, delivered . . . then each 6 cents you spent on such a nuclear kilowatt hour could have bought two efficiency kilowatt hours instead. Therefore, by buying the costlier instead of the cheaper option first, you generated an additional kilowatt-hour from, say, coal that would have been avoided if you'd bought the cheapest things first".*[300]

17. Provided there are still energy efficiency gains to be made, these will almost always be a more financially effective way of spending public money than subsidising new nuclear power stations.

> "*Each dollar invested in electric efficiency displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power, without any nasty side effects," says Lovins. "If climate change is the problem, nuclear power isn't the solution. It's an expensive, one-size-fits-all technology that diverts money and time from cheaper, safer, more resilient alternatives."*[301]

18. In a letter to *The Times* on 16 September 2004, the Chief Executive of the Government's Energy Saving Trust, Philip Sellwood said:

> "*To present nuclear power as one of the main ways of combating climate change is short-sighted . . . nuclear power simply does not represent a viable option at present. Given the costs associated with nuclear power and current uncertainties surrounding the problems of dealing with nuclear waste, making the UK more energy efficient is a far safer, cheaper and more realistic solution . . ."*[302]

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[297] Catherine Mitchell, "Action Stations" *Guardian* 8 September 2004 http://society.guardian.co.uk/societyguardian/story/0,7843,1298972,00.html

[298] MacKerron, G (September 2004) "Nuclear Power and the Characteristics of Ordinariness—the Case of UK Energy Policy" NERA Economic Consulting.

[299] Pearl Marshall "Official says reviews needed before new UK nuclear built" *Nucleonics Week,* Vol 46 No 11, 17 March 2005.

[300] "Why Nuclear Power's Failure in the Marketplace is Irreversible (Fortunately for Nonproliferation and Climate Protection)" by Amory Lovins, Rocky Mountain Institute, Transcription of a presentation to the Nuclear Control Institute's 20th Anniversary Conference, "Nuclear Power and the Spread of Nuclear Weapons: Can We Have One Without the Other?" Washington, DC, 9 April 2001. www.nci.org

[301] *Guardian* 12 August 2004, "Nuclear Plants Bloom" by John Vidal, http://www.guardian.co.uk/life/feature/story/0,,1280884,00.html

[302] Letter from Philip Sellwood, Chief Executive Energy Saving Trust to *The Times* 16 September 2004 http://www.timesonline.co.uk/a££rticle/0,,59-1264441,00.html

Delivering Energy Efficiency

19. The Government's energy efficiency strategy is not ambitious and can hardly be said to represent the "step change" in energy efficiency promised in the Energy White Paper. The strategy for reducing domestic energy consumption, for example, relies mainly on requiring larger domestic energy suppliers to meet an energy saving target by encouraging customers to install energy saving measures (The Energy Efficiency Commitment). This programme, along with the Warm Front programme, which is designed to tackle fuel poverty, is producing savings, but much more could be done.

20. The Energy White Paper set out in February 2003 a programme to achieve cuts in emissions from the domestic sector of 5MtC by 2010. The subsequent Energy Efficiency Action Plan (EEAP) launched in April 2004[303] watered this down to 4.2 MtC. The Association for the Conservation of Energy (ACE) has described the new target as "wholly unacceptable",[304] and a majority of MPs signed an Early Day Motion backing the original 5MtC target.[103] The Energy Savings Trust told the Environmental Audit Committee that it does not agree with the new 4.2MtC target.

21. The Government has basically scrapped policies that could easily make up the extra 0.8MtC. For example, the Energy White Paper expected savings of 0.4MtC from increasing the uptake of A-rated household appliances. This in itself was a reduction from the 1MtC suggested by the Energy Savings Trust.[305] In the EEAP this was mysteriously dropped to 0.1MtC with no explanation. Similarly, the contribution from gas condensing boilers in the EEAP also appears to have been lowered.

22. Micro-combined-heat-and-power, or micro-CHP, can replace domestic central heating boilers. As well as generating heat for central heating and hot water, they can produce around 50% of a households electricity needs, and use less energy than the standard heating boilers of today. By 2020, 13 million central heating boilers are likely to have been replaced in the UK. If micro-CHP boilers are used instead of conventional boilers, these homes could be producing around half the electricity produced by our current nuclear programme. A number of companies in the UK are already marketing domestic micro-CHP boilers.[306] The BG Group, one of the pioneering companies, says micro-CHP could potentially achieve cuts of around 5.4MtC.[307] In drafts of the EEAP, a saving of 0.1MtC was listed for micro-CHP, but this was dropped from the final plan, despite the fact that VAT on micro-CHP has been reduced. Admittedly the plan only runs until 2010 and most micro-CHP boilers are likely to be installed between 2010 and 2020, but the deletion of this target still displays a worrying lack of ambition.

Micro-renewables

23. In addition to micro-CHP, millions of homes and offices could have their own electricity generators, such as solar roofs, and roof-top wind turbines by 2020.[308]

24. By 2020, Britain could have a very different energy system from today. The turnover of housing stock means around 3 million homes[309] will be added to the housing stock, and 200,000 or so will be removed. Much better standards of efficiency will be used in these new buildings as well as refurbished ones. Energy supply companies should become energy service companies, which can make a profit by selling less electricity and gas.

25. Most delivered energy is used in buildings. All new buildings and refurbishments should be built to a zero emission standard,[310] and new estates should incorporate district scale Combined Heat and Power (CHP) plants which will avoid the losses associated with conventional power plants which waste up to 65% of their energy by discharging hot water.

26. The Energy Efficiency Action Plan sets out how the Government intends to make additional cuts of 12MtC across the business, public and domestic sectors by 2010. Clearly by re-instating the 5MtC target for the domestic sector, as well as setting ambitious targets for the period 2010–20, and promoting micro-CHP and micro-renewables, it would be perfectly feasible to replace the carbon savings which might accrue from a replacement nuclear programme.

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303 Energy Efficiency: The Government's Plan for Action, DEFRA, April 2004 http://www.official-documents.co.uk/document/cm61/6168/6168.pdf

304 http://www.ukace.org/pubs/press/ST040426.pdf

305 http://edm.ais.co.uk/weblink/html/motion.html/EDMI—SES = 03/ref = 96

306 Evidence to the Environmental Audit Committee 19 May 2004, Q371 http://www.publications.parliament.uk/pa/cm200304/cmselect/cmenvaud/490/4051908.htm

307 See for example *Guardian*, 12 June 2003 "PowerGen markets boiler that generates electricity" by Paul Brown http://www.micropower.co.uk/content££1.cfm?pageid = 98 & Hewitt, C (2001) "Power to the People: Delivering a 21st Century Energy System" IPPR.

308 "Natural gas—meeting the UK's energy challenges". BG Group Advertisement, The Parliamentary Monitor, December 2003.

309 Paul Brown, "Home wind turbines cut bills and pollution", *Guardian* 3 May 2005, http://society.guardian.co.uk/environment/news/0,14129,1475224,00.html

310 Calculated from figures on p 3, Improving Domestic Energy Efficiency—A technical overview, background work for Energy White paper 2003. DEFRA ref no IDG/EES/WP13.

311 See http://www.zedstandards.com/

The Role of Local Authorities

27. The Government recognises climate change is one of the greatest threats to the environment that sustains our society. yet it is not yet responding to the issue as a priority. Government must take the lead, for example by making its own estate energy-efficient. Multiple measures will be required to bring about change on the appropriate scale and at the necessary speed. In particular, the role of local government in climate change mitigation has received much rhetorical championing in recent years, but the reality is that the powers and resources devolved to local government, and the assessment regime under which it works, and which dictates its priorities, are clearly not aligned to the goal of climate change mitigation. This situation requires urgent government attention.

28. Some local authorities (eg Merton London Borough Council) are beginning to adopt planning policies which promote renewable energy in developments above a certain size—requiring, for example, at least 10% of predicted energy requirements from on-site renewables such as solar energy. Local authorities have a role to play and Government needs to align planning guidance, building regulations and incentives for household energy saving and micro generation etc, with its carbon reduction targets.

Security of Supply

29. The issue of whether we are going to be too reliant on future imports of gas from unstable or unreliable supplier countries is often raised in support of the case for new nuclear stations.

30. However, the Energy White Paper concluded that relying on imports of gas "need not be a problem". Jonathan Stern, who leads a research group on gas at the Oxford Institute for Energy Studies, says the fact that gas supplies will be coming from overseas in future does not necessarily mean we will be more prone to supply disruptions. He says there is a touch of xenophobia in some of the scare stories.

31. For at least the next decade we will be importing from Norway, Belgium and the Netherlands. In the longer term there may be a need to import from Gulf Countries and Russia, but other European countries have been importing gas from Russia for 20 years with no supply disruptions. Most major disruptions to gas supplies in other countries over the past 20 years have been caused by domestic problems.

32. Stern concludes that arguments equating increased imports with a growing lack of security are not supported by international experience.

22 September 2005

Memorandum submitted by the Nuclear Industry Association

The Nuclear Industry Association (NIA) is the trade association and representative voice of Britain's civil nuclear industry. It represents over 100 companies including the operators of the nuclear power stations, those engaged in decommissioning, waste management, nuclear liabilities management and all aspects of the nuclear fuel cycle, nuclear equipment suppliers, engineering and construction firms, nuclear research organisations, and legal, financial and consultancy companies. Among NIA's members are the principal nuclear power station operators—as well as companies engaged as contractors and manufacturers in the forefront of nuclear technology.

We welcome the committee's investigation into this issue which, with the spiralling cost of electricity and the realities of climate change becoming more apparent, is both timely and valuable. Indeed a more thorough Government review of energy policy taking into account all generation sources would also be appropriate at this time. Within the context of this investigation we have confined ourselves to the questions posed by the committee and while we represent only the nuclear industry we have endeavoured to give a full set of answers.

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

Under current plans, all but one of our nuclear stations are scheduled to close by 2023 leaving only Sizewell B in operation. In addition there will be major coal fired power station closures by 2015, either under the Large Combustion Plant Directive or because of aging plant. In other words around 40% of the generating capacity projected to be required in 2020 has yet to be built.

Changes in UK mix will harm electricity supply reliability

Reliable and secure electricity supply is critical to any modern economy. Power cuts in recent years in the USA and Canada, Scandinavia and Italy amply demonstrate the particular vulnerability of even advanced industrial societies to the impact of interruptions in electricity supply. The blackout in Italy in particular highlighted the danger of over reliance on imports as it was caused by a failure in an import line combined with the reduction of supply from other countries on which Italy relies. These examples from around the industrialised world need not become reality in the UK. But as with all major infrastructure projects governments have to ensure there is sufficient clarity and incentive in the market to ensure timely investment in the electricity generating, transmission and distribution infrastructure to ensure that the impending electricity generating gap is filled.

The fabric of the UK's energy mix—in particular the electricity sector—is changing dramatically. Consumers are experiencing the impacts on their bills of record high oil and gas prices. While these commodity prices are, by their very nature, variable, the planning required to secure new generation is not. Energy and electricity generation is simply not a short-term issue. It takes 2–3 years to build a new gas plant; 1–2 years for a wind farm; 4 years for a coal plant; and 5 years for a nuclear plant. It is against this backdrop that the UK is entering a period where:

- Demand for electricity continues to grow at 1–2% per year[312].
- The UK's "dash for gas" means we are moving from 65% coal, and no gas-fired generation, in 1990 to 65% gas-fired generation, perhaps more, by 2020.
- UK oil and gas reserves are depleted. The UK has already become a net importer of gas and is forecast to import 80% of its gas by 2020.
- Government focus is on support for renewables (particularly wind power), which brings new issues of intermittency of supply into the equation which need to be managed.
- Investment is needed in the electricity grid, to maintain existing infrastructure and provide new capacity to meet the growth of renewable generation.
- The deregulation of the UK electricity market means that the emphasis of investors is now on short-term projects with rapid payback. Building of new stations has tailed off dramatically.
- There is no market driver to increase, or even to preserve, diversity within the generation portfolio or indigenous supply.
- And of course, the UK is an island; therefore, retaining the ability to meet the bulk of our own demand is essential, given the limited options for dealing with sudden supply problems by importing electricity and primary energy from our neighbours and from further afield.

Given the scale of this change—and the increasingly widespread concern about future electricity supply reliability—ensuring the UK will have electricity supplies in future as robust as they have been in the past is essential. We need to start planning now.

Nuclear and coal closing—renewables progress slow but steady

The DTI/Ofgem projections for future UK capacity, to the year 2020, show that substantial changes are expected in the generating mix:

Recent and Forecast Breakdown of UK Electricity Supply[313]

There are several reasons for the projected changes in the mix:

> All but four of the UK's nuclear fleet will potentially be closing within 10 years. This will reduce the UK's nuclear fleet from 23% of generating capacity in 2003 to 9% by 2015. If this 14% were replaced by gas fired generation then an additional 21.4 million tonnes of CO_2 (assuming it is all supplied by pipeline gas, if it were supplied by liquefied natural gas this figure would be significantly higher) would be emitted to the atmosphere and the UK would find it impossible to meet already difficult targets agreed to in global climate negotiations.

Many coal stations are expected to close between 2008 and 2015, with the introduction of the Large Combustion Plant Directive. This requires large coal-fired power plants either to have fitted equipment to remove sulphur dioxide (SO_2), nitrogen oxides (NO_x) and dust from their discharges, or else to operate for a limited number of hours (20,000 hours) over that timeframe.

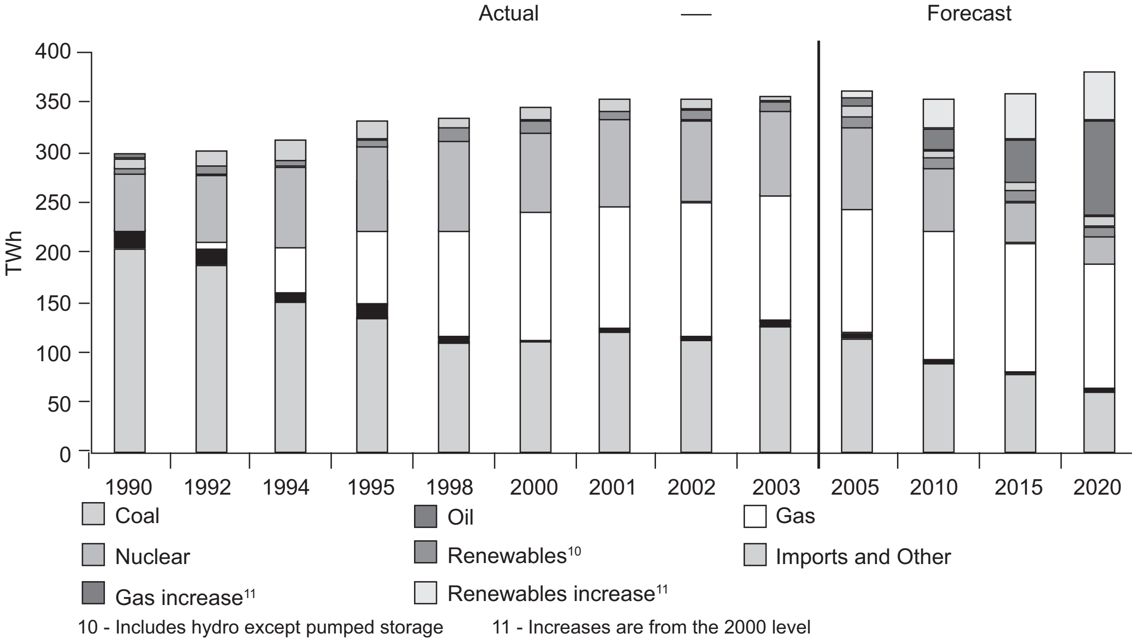
As the UK continues towards a low carbon economy, construction of renewables capacity will continue to be encouraged, but to date, although many projects are in the early stages of consideration and planning, actual deployment of renewables has been slower than expected. Recent Government projections appear to acknowledge that the 2010 target to have 10% of electricity from renewables will be missed[314], and confidence in longer-term targets being reached is therefore diminished.

312 "Digest of UK Energy Statistics 2004", eg Section 5.1.11; DTI; July 2004.

313 JESS Report; DTI/Ofgem; November 2004.

314 Parliamentary Answer from Mike O'Brien; Hansard—Column 650W; 19 October 2004.

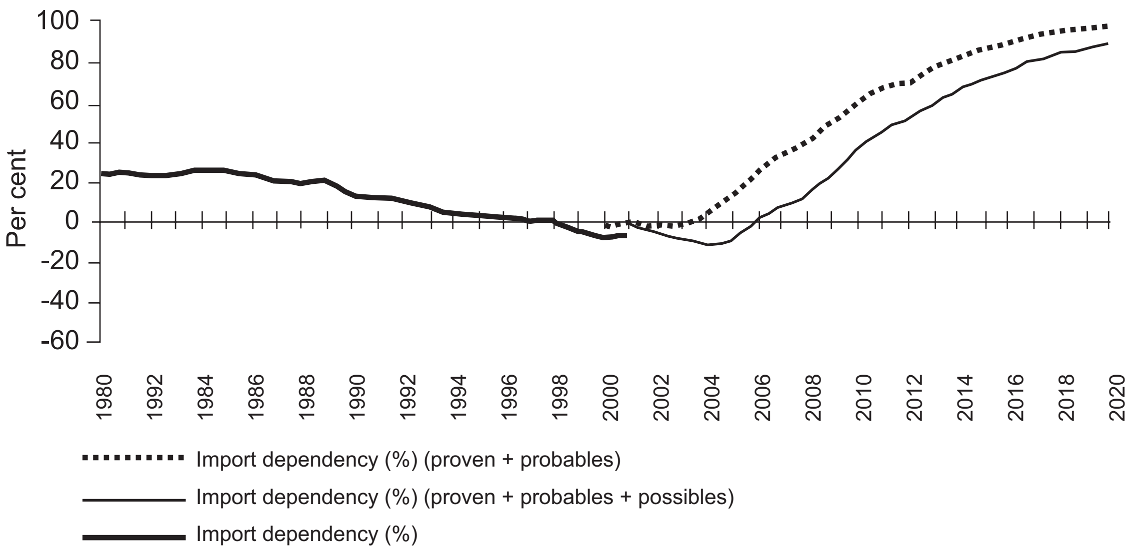
There is limited scope to increase electricity imports. Aside from the requirement to construct new interconnectors, such an approach requires confidence that the source nation will always have a surplus of power to export, even at times of peak demand in both countries. Recent experience—for instance the large-scale blackout in Italy in August 2003—shows the risks associated with this strategy.



DTI - Joint Energy Security of Supply Working Group (JESS) Fifth Report, November 2004

UK electricity sector becoming dependent on gas imports

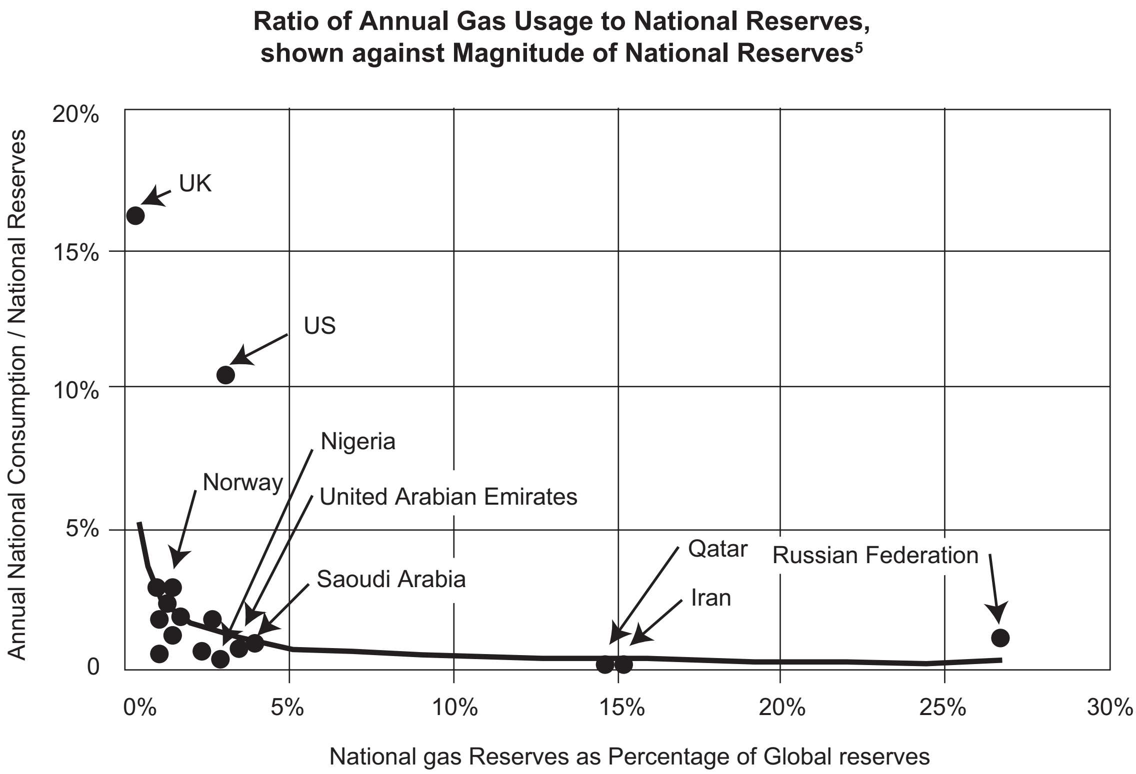
After many years of being self-sufficient in gas, the UK has now become (in 2004) a net importer (as shown on the chart below).



Recent and Projected UK Gas Import Dependency[315]

The rapid nature of this shift is illustrated in the chart below, which shows the ratio of domestic gas consumption to the scale of national gas reserves. The UK is using a greater proportion of total national gas reserves each year than any other major economy. The nation therefore faces a very steep growth in the need for imported gas.

[315] Second JESS Report; DTI/Ofgem; February 2003.



Ratio of Annual Gas Usage to National Reserves, shown against Magnitude of National Reserves[316]

One of the key ways in which security of supply can be underpinned is by ensuring that we have a balanced mix of sources of generation. It is worth noting that all the major electricity supply shocks in the UK during the 20th century were caused by over-reliance on a single energy source—in this case coal. Firstly in the early 1950s, when there was a post-war shortage of miners, and latterly in the 1970s and 1980s as a result of industrial action.

In the short term, reliable gas imports can be sourced from countries such as Norway. In the longer term however, as demand is forecast to grow across Western Europe, supplies are likely to come from countries further afield that hold the largest reserves. The bulk of the world's gas reserves are in Russia, with other significant supplies in countries such as Iran, Algeria, Saudi Arabia and Qatar. Although there is expected to be a substantial amount of gas imported as liquefied natural gas (LNG) (even though the total CO_2 emissions from this form of gas can be nearly as high as those for coal) it is anticipated that much of the gas from these countries would still have to be exported to Western Europe by means of long pipelines, passing through many countries along the way. This would require major infrastructure development in Europe, including terminals in the UK and increase the risks of potential interruption to supply.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

The economics of nuclear energy are both competitive and clear. The first generation of nuclear reactors were small, pushing the boundaries of the technologies. Around the world, second generation reactors have successfully delivered large quantities of electricity and have served to establish the industry in the mainstream energy mix. The Pressurised Water Reactor is the most widely adopted nuclear reactor technology[317] and continuous improvements in technology and performance have resulted in continuing reductions in the costs.

316 "Statistical Review of World Energy"; BP; 2004.

317 IAEA Power Reactor Information System Database—PRIS; April 2005 [215 of the world's 441 operational reactors are PWRs, compared with 90 BWRs and smaller numbers of other systems. The world's PWRs account for 206GW of installed capacity, out of a total of 367GW.]

There are a number of elements that need to be considered in determining the economics of new nuclear build: capital costs (including an understanding of "first of a kind" costs, cost benefits resulting from learning, cost of financing debt and so on); operating costs; and the costs of decommissioning and waste management. The capital and financing cost of a new nuclear plant is about 70% of the total cost of generation; the operating cost component (including fuel) is about 27%, while the decommissioning and waste management costs amount to about 4% of the total.

A number of studies[318, 319, 320, 321, 322, 323, 324] into the costs of nuclear generation make varying assumptions about the key economic parameters, the most significant of which is the assumed rate of return. At rates of between 5 and 10%, costs average only £20/MWh. However, costs can be as high as £40/MWh for rates up to 12%.

	MT (2003)	*RU (2002)*	*Chicago (2004)*	*RAE (2004)*	*DGEMP (2003)*	*Finland (2003)*	*OECD (2005)*	
Generating cost (p/ KWh)	3.9–4.0	3.9–4.0	3.1–3.6	2.26–2.44	2.0	1.7	1.3–1.9	1.8–3.0
Rates of return	11.5%	8% & 15%	12.5%	7.5%	8%	5%	5%	10%
Capital cost	$2000/ kW (£1150/ kW)	$2000/ kW (£1150/ kW)	$1500/ kW (£865/ kW)	$2000/ kW (£1150/ kW)	$1413/ kW (£990/ kW)	$1900/ kW (£1330/ kW)		$1000–$200/ kW (£610–1210/ kW)
Load factor	85%	75–80%	85%	>90%	>90%	>90%		85%
Economicilife	15 yrs	20 yrs	15 yrs	25 & 40 yrs	35–50 yrs	40 yrs		40 yrs
Construction period	5 yrs	Not identified	5–7 yrs	5 yrs	5	5 yrs		4–6 yrs

Projected costs of nuclear energy from different studies

Most recently the OECD compared generating costs for key technologies. It found nuclear generation to be competitive to coal and gas, even assuming a zero carbon cost, and significantly cheaper than alternative carbon free technologies.

318 *"The Future of Nuclear Power"*; MIT; 2003.

319 *"The Economics of Nuclear Power";* Performance and Innovation Unit Energy Review Working Paper; 2002.

320 *"The Economic Future of Nuclear Power"*; University of Chicago; 2004
[Data converted to sterling based on £1 = $1.734 (exchange rate used in RAE study)].

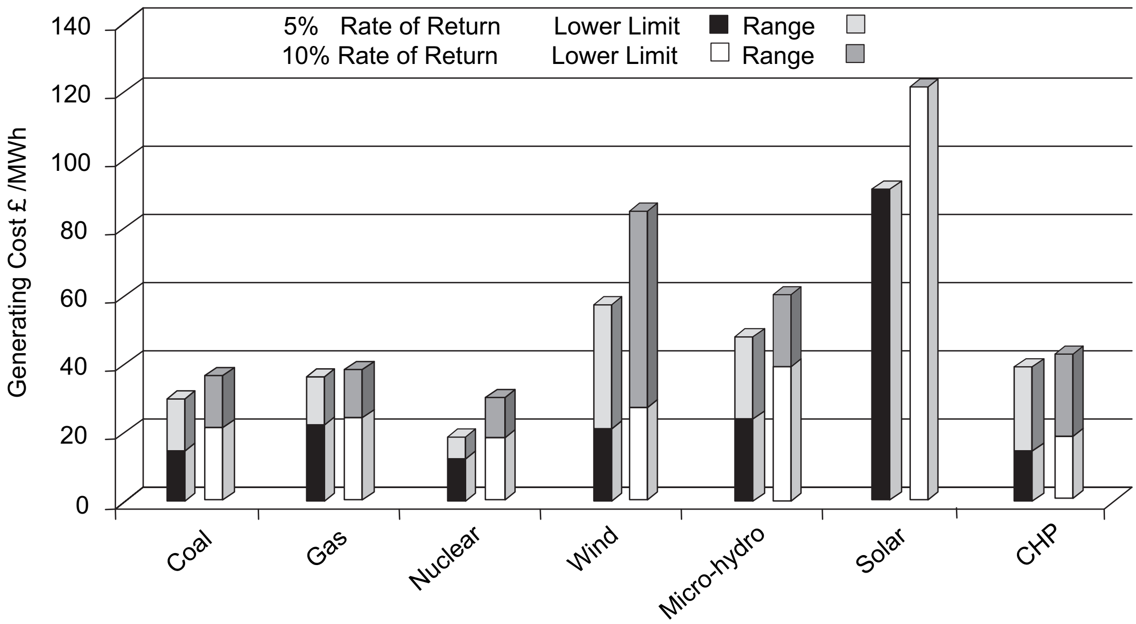
321 *"The Cost of Generating Electricity";* Royal Academy of Engineering; 2004.

322 *"Reference Costs for Power Generation"*; French Ministry of Economy, Finance & Industry; 2003
[Data converted to sterling based on 1EUR = £0.70 (Bloomberg, 10 March 2005)].

323 *"Competitiveness Comparison of the Electricity Production Alternatives";* Lappeenranta University of Technology, Finland; 2003.

324 "Projected Costs of Generating Electricity"; OECD/NEA/IEA; 2005
[Data converted to sterling based on £1 = $1.65. Data also excludes Japan and the Netherlands.

OECD analysis of power generating costs for different technologies

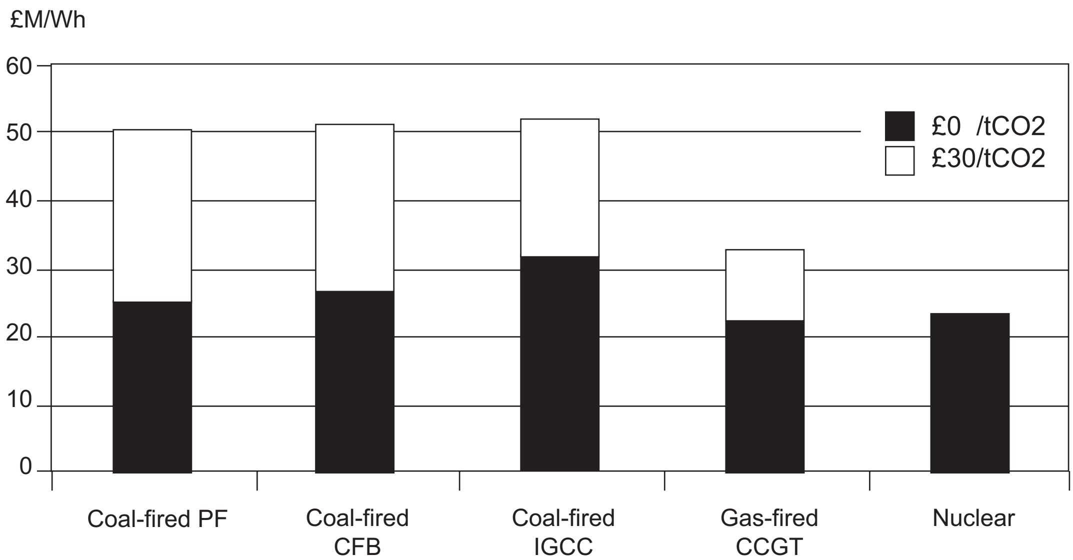


OECD analysis of power generating costs for different technologies

The OECD report confirms conclusions reached in a 2004 study by the Royal Academy of Engineering. The Academy's study is directly applicable to the UK and is based on real data, both in the UK and elsewhere. The nuclear component of the study used the data shown in the table below.

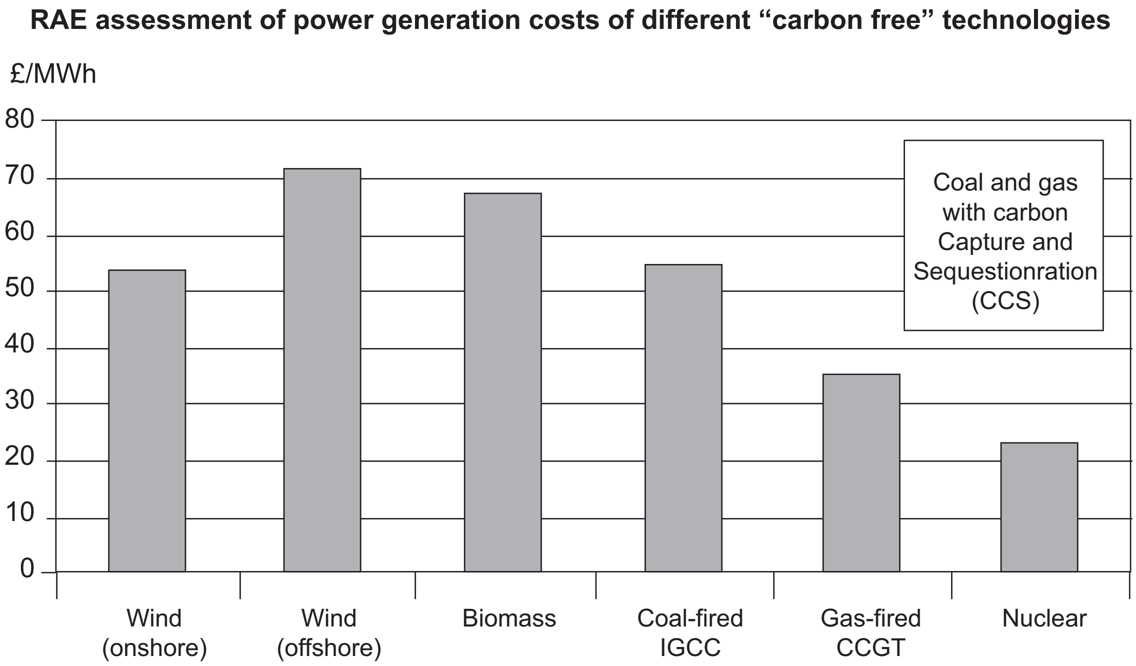
Both studies conclude that the economics of nuclear are competitive in the baseload sector even without factoring in the cost of carbon. If the price of carbon reflected the costs of climate change then the economics of new nuclear look even more favourable.

RAE assessment of power generation coast of different baseload technologies



RAE assessment of power generation costs of different baseload technologies

The RAE study also analysed 'carbon free' technologies. Its conclusions indicate nuclear is the most cost effective source to deliver large-scale electricity if reducing carbon dioxide is the only measure. Realistically, as stated earlier, industrialised nations in the 21st century should seek a balanced energy supply mix.



RAE assessment of power generation costs of different "carbon free" technologies

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

The UK nuclear industry has moved on and learned valuable lessons from the past, and by examining the experience of other countries. Past experience in the UK relates to the building of first of a kind reactors at a time when our understanding of the science and engineering challenges was rapidly evolving. Around the world, nuclear power stations are being built to time and cost. As outlined earlier, independent studies by leading institutions show low variations in costs (and much of this is directly due to the different assumptions made in the differing studies).

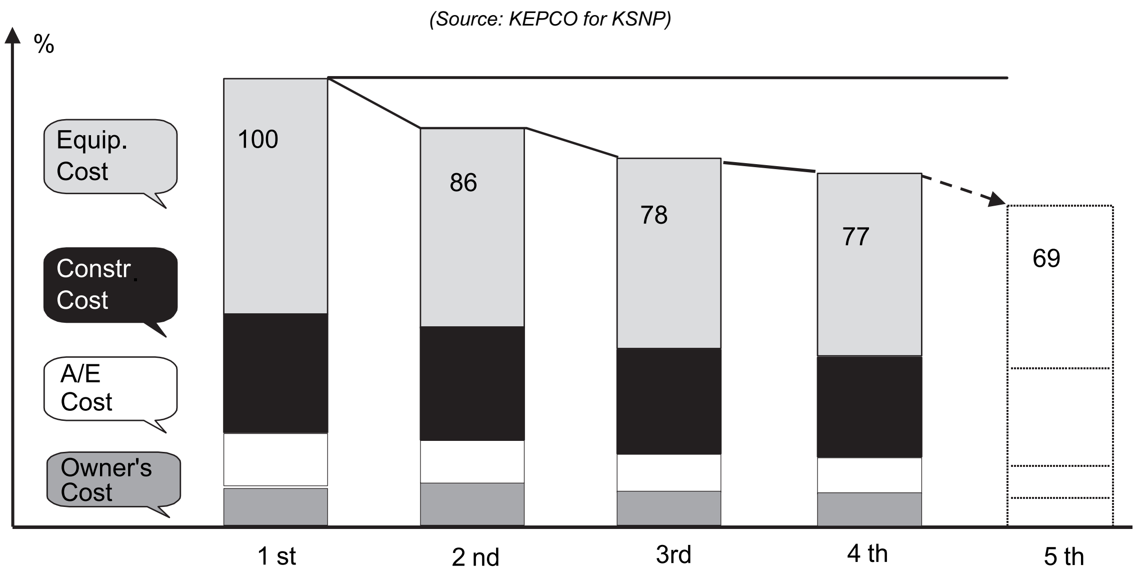
Modern approaches will help avoid past problems

Modern global construction practices and project delivery structures have evolved substantially from those which existed during the earlier part of the industry's history. The development of private finance initiatives and similar practices mean key project risks are now dealt with in a proportionate way. As a result, the industry worldwide has a track record of delivering new plants to time and budget.

New nuclear reactor construction underway abroad is based on internationally developed and standardised designs which can be readily purchased from a few global vendors. This standardised approach allows a highly optimised construction approach and facilitates the use of advanced construction techniques which together bring costs and construction timescales down. The adoption of such standardised designs is in sharp contrast to previous UK experience, where almost every station was of a substantially different design to previous ones. In addition UK reactors were often subject to re-design work during the licensing and construction phases, leading to costly and time-consuming delays.

Further improvements in delivery time and cost can be achieved through the adoption of a series build approach, where a number of reactors of identical design are constructed in the same country. This removes the requirement for the licensing process to be repeated, reducing the overall timeframe for delivery.

For example, the ongoing Westinghouse programme of reactor construction in South Korea has demonstrated impressive cost savings by constructing a series of reactor units.



Series Build Brings Successive Cost Reductions[325]

Similar excellent experience has been demonstrated by AECL, again in South Korea, as well as in Romania and China[326], where plants have been delivered to budget and either on schedule or—in some cases—up to four months early.

Analysis has been carried out[327] on the first two decades of the French nuclear build programme, which is based on a number of series of plants:

34 similar 900 MW plants
20 similar 1,300 MW plants
4 identical N4 plants.

This concluded that optimum improvements from series construction were essentially reached after a series of 10 plants (with a series of 10 identical plants delivering average capital cost savings of 35% to 55% relative to the costs of a single "first of a kind" plant).

International experience confirms confidence in ability to deliver

The evidence from other countries where nuclear is being pursued (in particular Finland and France) provides strong evidence that those nations have confidence in the ability of nuclear projects to be delivered promptly and to budget.

The Finnish model is particularly interesting. Finland has committed to building a new plant and has adopted an approach whereby risk is managed effectively. A consortium has been formed of government, constructor, operator and customers who are able to apportion risk proportionately, and are willing and able to provide certainty on the sales of electricity. They have secured positive involvement from Government, adopted an international design and have public acceptance of the need for nuclear energy. Finally they have made sure that there is a clear solution to the question of waste management.

325 "BNFL/Westinghouse AP1000—The Reactor Technology Ready Now"; BNFL submission to DTI Energy Policy Consultation; September 2002.
326 Presentation by AECL to Nuclear All Party Parliamentary Group; February 2005;
327 "The Series Effect: Impact on Capital Cost of the Standardisation of PWR Plants"; AEE/IAEE 15th Annual Conference, Tours, France; May 1992.

Insurance: UK nuclear power stations carry both material damage and liability insurance. This cover is in place for every civil nuclear site in the UK. There is a limit on the amount of insurance that operators are required to have which is currently £140 million as set in the Nuclear Installations Act, which is in turn based on the Paris convention to which most European countries, including the UK, are signatories. There is also a Vienna convention which covers countries outside Europe and has a lower insurance limit. However moves are afoot to try to move the treaties closer together (and both are moving the limits in an upwards direction). Recent updates to the Paris convention have changed the limit to €700 million and it is expected that this will be enshrined in UK legislation around the end of 2006 or early 2007. The UK insurance industry is confident that they can provide this cover on a commercial basis.

Waste: As far as waste disposal costs are concerned, NIREX has estimated costs of £0.64–0.83 million per m^3 for high level waste (HLW) (and approximately £0.04 million per m^3 for intermediate level waste (ILW)).

The UK Government could set a waste disposal levy or fee on the basis of nuclear power generated (MWh) and charge for this at the time of such generation. Most countries tend to follow this route (eg USA €0.8/MWh, Sweden €1/MWh, Japan €1/MWh and the Czech Republic €2/MWh).

To determine this fee, the government could make assumptions about the waste disposal cost, when the cost would be incurred, and the return realised on levy monies between the date of receipt and date of incurring the cost.

Security: The nuclear industry operates under very strict security procedures and gives this the highest priority. Like other industries, the nuclear industry has to pay for its own security costs.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

Renewable generation still represents a very small component of the UK's generation mix, although the Renewables Obligation envisages around 10% of renewable generation by 2010 and 15% by 2015. However in recent reports serious doubts have been expressed as to whether these targets will be met. The House of Lords Science and Technology Select Committee report on renewables[328] noted in July 2004 that it had *". . . found almost no one outside government who believed that the White Paper targets [on renewables uptake by 2010] were likely to be achieved"*

Renewables undoubtedly have the potential to contribute to the provision of low-carbon electricity. However there are also possible network problems which can be caused by having too high a proportion of generation from intermittent sources. The British Wind Energy Association itself says that these problems will start to occur once wind is producing more than 10% of our electricity. However of the renewable technologies only wind is currently in a position to produce significant quantities of extra electricity.

What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

It is almost impossible to compare efficiencies of the various technologies. Do to the extremely different nature of the technologies any attempt at comparison of efficiencies would be meaningless.

3. *What is the attitude of financial institutions to investment in different forms of generation?*

What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

Many potential financiers or finance facilitators believe new nuclear plants to be on a par with new gas fired power stations in terms of potential returns. However because of the longer build times for nuclear and the larger capital investment required parity is probably not sufficient for most investors. In particular long term pricing signals within the market, for instance by providing long-term guarantees that there will be a cost attached to carbon emissions, would provide the right climate to allow the investment to take place. The lack of a level playing field (for example, the fact that carbon free generation is only rewarded for some generators and not others) is also a deterrent to investment.

[328] *"Renewable Energy: Practicalities"*; Fourth Report by the House of Lords Science and Technology Select Committee; July 2004.

How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

No government subsidies would be required to facilitate private sector investment in nuclear new build. As stated above, because of the longer build times for nuclear and the larger capital investment required parity with returns from investment in gas fired plant is probably not sufficient for most investors.

Under an appropriate market pricing regime, and with the right arrangements for sharing risks and returns, a new generation of nuclear plant in the UK could be financed through the private sector. In this way, future nuclear build could avoid some of the pitfalls which have characterised major infrastructure projects in the past, including some previous nuclear plants. Private sector disciplines of project management and financial control will help to ensure focused and timely delivery.

A key factor in the effective delivery of nuclear plant will be the development, by Government, regulators and the industry, of the current licensing and approvals processes to ensure timely and predictable delivery of all regulatory clearances and planning consents. A clear policy for the long-term management of radioactive waste would also greatly assist in improving investor confidence by removing a degree of liability risk at the end of a station's life.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

Measures to facilitate nuclear new build by market recognition of the value of carbon free generation should also benefit the development of renewables, since they would be equal beneficiaries of the market changes. Nuclear new build should also have no direct adverse impact on renewables as these would presumably continue to be separately incentivised through existing measures such as renewable obligation certificates given that investment decisions have already been taken based on their existence. Investing in new nuclear capacity to ensure adequate low carbon generating capacity should have no impact on measures to improve demand side energy efficiency.

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

Direct Government subsidies are not required to facilitate private sector investment in nuclear new build. However, appropriate market mechanisms that recognise nuclear energy's contribution to security and diversity of supply and reducing carbon emissions will be needed to stimulate investment in new nuclear generation, and to address the lack of long-term pricing signals in the UK market and the perception of risk among investment institutions. Nuclear power delivers CO_2 free generation, security of supply and price stability.

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

A new 1GWe nuclear power station would, if displacing coal-fired generation, reduce emissions by around 7.5 million tonnes of carbon dioxide every year. If it displaced gas-fired generation, it would reduce emissions by more than 3 million tonnes of carbon dioxide each year. It would be expected to offer these reduced emissions as soon as it reached full output and through its entire operating life. The carbon emissions associated with the construction of a nuclear station are "recovered" after just six months of operation.

For example if a new build programme were to replace the one fifth of electricity currently supplied by nuclear power stations, then around 30 million tonnes of carbon dioxide each year would not be released into the earth's atmosphere (assuming that it would be displacing pipeline supplied gas fired generation). If it were displacing liquefied natural gas [LNG] then the emissions would be closer to the 75 million tonnes that coal would emit, because of the processing and transport emissions from LNG.

To put the scale of the challenge into context—the UK has a target of cutting carbon dioxide levels to 20% below 1990 levels by 2010. Yet—with just six years to go, in 2004 the reduction in emissions had only reached 4.2%, so more than three quarters of the savings still need to be made.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

Nuclear is a reliable baseload supplier with 80–90% load factors. It holds several years' fuel supply at any one time and the raw material for the fuel is readily available from stable countries. It also adds to the diversity of supply which gives increased reliability in itself. This was set out in detail in the first answer above.

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

New nuclear build would certainly be compatible with the Government's aims on security and terrorism. The security of nuclear materials, nuclear licensed sites, sensitive nuclear information and those working in the industry is overseen by the government's security regulator, the Office for Civil Nuclear Security. The office's work is overseen by Ministers who are satisfied that these facilities are sufficiently secure.

Modern nuclear power stations have large heavily reinforced containments which have been tested against the severest of impacts. They also have a number of multilayered safety systems which would require multiple damage before any danger of an off-site incident could occur and even then only if the operators took no action. In addition, all nuclear facilities have well tested emergency arrangements in place which include the possibility of instant shutdown in the event of a serious terrorist threat. They are therefore well protected against terrorist attack.

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

In terms of subsidy, renewables are the only form of generation that needs (and receives) government subsidy to exist in the current market (although coal may need it in future to incentivise new plant). Micro-generation and energy efficiency would also require government incentives to ensure take up. In terms of carbon abatement, renewables have a part to play in reducing carbon emissions, however they are not currently expanding at the rate required to meet government targets and so in order to meet the UK's climate change commitments other forms of carbon abatement will be needed. Microgeneration and energy efficiency could have an effect in reducing the increase in electricity demand, but these measures will not cause demand from the grid to fall and therefore measures will still be required on the supply side to ensure sufficient capacity is available to meet anticipated demand. Renewables help with security of supply in that they are domestic and independent of a fuel supply from overseas, but many are intermittent and require back-up conventional generation.

The Government's 2003 Energy White Paper placed the environment at the heart of energy policy with an emphasis on the development of renewable energy sources and improvements in energy efficiency as key routes towards the achievement of deep cuts in carbon emissions of 60% by 2050 to mitigate the impact of global climate change. The White Paper also signalled the Government's intention to keep the nuclear option open in recognition of nuclear energy's contribution to energy diversity and reducing carbon emissions. Investment in new nuclear stations is therefore entirely compatible with the strategy set out in the Energy White Paper.

D. Other Issues

6. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

In 1999 the DTI commissioned ETSU to investigate this for all forms of generation in order that the full life cycle carbon costs (which include construction, operation, fuel supply and decommissioning) be calculated. Their results were:

1 kWh of electricity generation produces:

Nuclear	4g CO_2
Wind	8g CO_2
Large-scale hydro	8g CO_2
Small-scale hydro	9g CO_2
Energy crops	17g CO_2
Geothermal	79g CO_2
Solar	133g CO_2
Gas	430g CO_2
Diesel	772g CO_2
Oil	818g CO_2
Coal	955g CO_2

It should also be noted that the figures for gas plants are for plant operated on North Sea pipeline supplied gas. If the gas is sourced further away then the performance will be slightly lower. However if gas plants are operated on liquefied natural gas then their performance is as bad as the best of the coal plants because of the processing and transport emissions from LNG.

7. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

The issue of finding a solution to nuclear waste is essentially a political one rather than a technical one. Countries such as Finland, Sweden and the US are putting in place technical solutions for the disposal of waste, and in doing so have addressed the essential issue of public acceptance. Likewise, ways to provide surety on the financial provisions for waste management and decommissioning have been successfully established elsewhere in the world.

More recently produced wastes are dealt with safely and effectively as they are produced, and the same will be true of any wastes from future nuclear stations. The UK, through the Nuclear Decommissioning Authority, is now addressing as its highest priority the management of those legacy wastes from the early days of nuclear experimentation and development. The historic legacy has to be dealt with, whether or not we have new generation nuclear build. Wastes associated with modern reactor designs are much smaller in volume, and are already treated and prepared for long term storage. Therefore UK historic liability provisions are not an indicator of waste management and decommissioning volumes and costs for new generation nuclear build. Furthermore, any solution put in place for dealing with legacy wastes could readily accommodate the wastes from a new generation of nuclear plants.

Therefore the actual implementation of a waste solution should not be a prerequisite for new nuclear build. However the government should ensure that the process that it has put in train delivers a publicly and technically acceptable resolution.

September 2005

Memorandum submitted by the Nuclear Information Service

1. Nuclear Power

"New Build" of nuclear power plants is unacceptable for a number of reasons. It would:

(a) take the risk of nuclear terrorism into future decades, rather than grasp an opportunity to reduce this risk;

(b) perpetuate the nuclear fuel cycle and reduce the prospect of Britain meeting its obligation under the Non-Proliferation Treaty to disarm its nuclear weapons;

(c) prevent a genuine, non-hypocritical political call for emergent nuclear states to abandon nuclear power;

(d) promote the constant risk of proliferation of weapons-grade materials and consequent risk of proliferation of nuclear weapons;

(e) encourage other, currently non-nuclear States to choose nuclear power;

(f) create further international nuclear political instability;

(g) present a permanent physical risk to workers, communities and the environment during commissioning, operation, decommissioning and decay; and

(h) prolong the problem of managing nuclear waste in a scientific and publicly acceptable form.

2. Electricity Generation

Of all the available renewable energy systems, that most overlooked as an immediately usable technology seems to me to be PV (solar) power. Every block of flats, hospital, school, university, and government institution should have a solar heated hot water system. Incentives should be available immediately to encourage the private sector to take advantage of solar power.

3. Energy Efficiency

Government policy and financial investment in public education to reduce domestic energy consumption and encourage energy efficiency is only now bringing positive results. Any promise of "new build" would send the wrong message, reversing this trend. The resulting pressure on demand, causing price rises, would impact hardest on the health and social well being of the poor, the anxious elderly and therefore, all politicians and government.

4. Safety

Accidental or deliberate release of radionuclides into the environment has been, and would always remain, the problem and responsibility of government. Clearly, if new nuclear power plants are not built, they cannot be a risk. Whereas advantages of some risks, for example, building a new bridge that could be vulnerable to sabotage, outweigh the possible harmful consequences, new nuclear build does not outweigh the cataclysmic risk of a nuclear release.

5. Security of Renewable Energy

Renewable energy brings security to Britain.

Its large-scale development can:

(a) reduce the risk of nuclear terrorism ad infinitum;

(b) create the opportunity to decommission nuclear weapons;

(c) cease international political double standards on the nuclear fuel cycle and proliferation;

(d) show integrity in international relations relating to proliferation that will go wider than the nuclear issue;

(e) take national and international responsibility for future generations;

(f) diminish nuclear risks and fears;

(g) establish a permanent supply of non-lethal energy; and

(h) contribute no hazardous waste or carbon emissions causing climate change.

6. Conclusions

(i) The comparison of points listed under Nuclear Power in 1.(a–h) above, with those under Security of Renewable Energy in 5.(a–h) show that renewable energy can completely overcome, or make a significant contribution to reducing the extreme disadvantages of building a new generation of nuclear power plants.

(ii) Nuclear power is not a financial, technical or political option for the majority world, whereas renewable energy systems would bring lasting benefit to millions of ordinary people. Britain has a responsibility to be an example and a partner.

(iii) Britain has the capacity to harness its historic manufacturing skills and invest in the development and large-scale production of equipment for the UK and export renewable energy market.

(iv) Britain is on the threshold of turning the tide away from nuclear, towards the widespread application of sustainable, clean, renewable energy.

(v) The opportunity to resist pro-nuclear pressure and go forward in another direction must not be missed. If ever politics was the art of the possible, this is it. Political vision of a safer, non-nuclear world is here; please recommend that it becomes government policy.

20 September 2005

Memorandum submitted by Nuclear Risk Insurers Ltd

Information about Nuclear Risk Insurers Ltd (NRI)

NRI is a FSA authorised insurance intermediary that acts as the UK insurance market's underwriting agent for all matters of nuclear insurance. It operates as a limited company and has a membership consisting of over 20 leading UK market property and casualty insurers from both Lloyd's and the general market, who pool their insurance capacity for nuclear risks into NRI; it is therefore commonly known as the British nuclear insurance pool. NRI then uses this capacity both to insure the nuclear sites in the UK and reciprocally to reinsure other nuclear sites around the world in association with similar entities internationally.

NRI today represents the largest single block of risk transfer insurance capacity in the world, at around £400 million ($700 million) and is also one of the oldest nuclear insurance entities in the world (founded in 1956).

Key questions posed by the enquiry of relevance to insurers

— What are the hidden costs (ie subsidies) associated with new build?

— How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalized energy markets?

- If nuclear new build required Government support on what basis would such support be justified?
- Is nuclear new build compatible with Government aims on security and terrorism within the UK and internationally?

Key Points and Recommendations of this Submission

Benefits of the international nuclear insurance market to public safety and to Government:

- Key advantages of insurers' pooling arrangements for the nuclear sector are the ability to retain a highly specialised technical ability, a comprehensive private sector post-catastrophe compensation infrastructure and a sound understanding of the special nuclear liability regimes and associated insurance products.
- Today, insurers provide about 70% of the world's nuclear site operators with both on site physical damage and financial loss insurance as well as the total amount of statutorily required off-site third party liability insurance.
- There is a strong argument, both from a political and safety perspective, which says that external scrutiny of nuclear operators by the private sector insurance market is a valuable addition to the overarching desire to optimise public safety.

Role of Government and the Question of Subsidy:

- Private sector insurance has provided the full liability and physical damage insurance requirements for the majority of nuclear plant over the past 50 years.
- International liability Conventions make the nuclear operator's liability strict and absolute and the obligation to honour "no fault" compensation is required, currently up to a financial limit per site of £140 million in the UK.
- Insurers have, since 2002, secured the help of Government in meeting the terrorism risk through a partial (and reducing) indemnity.
- In the future, the private sector will be able to provide the majority of the foreseeable expanded financial compensation requirements for a revitalised nuclear sector; the revised financial limits will be £480 million once ratification of the revised Convention occurs.

Recommendations

1. It is recommended that Government recognises the uninsurability of the prospective revision to the nuclear operator's statutory obligations with regard to environmental damage restitution and remote economic damage. (*Section 3*)

2. It is recommended that Government therefore assumes in full or at least defers imposing the ambiguous responsibilities from nuclear operators until the private financial markets are able to quantify some of the risks presented by the revised scope of the Conventions. (*Section 3*)

3. It is recommended that the existing 10 year time limitation for the insurance of nuclear liability is retained. (*Section 3*)

4. It is recommended that revised arrangements whereby Government would assume the statutory liability obligations of nuclear operators only following multiple terrorist attacks within a finite and defined period. (*Section 4*)

These recommendations are made to help ensure the continued involvement of the international private insurance market in the UK nuclear sector, thereby allowing the transfer of the majority of risk away from Government and nuclear operators for both existing and new nuclear sites.

Submission Detail

1. Benefits of the international nuclear insurance market to public safety and to Government

1.1 Private sector nuclear insurance began with the advent of civil atomic power in the UK in the 1950s. The insurance market's capacity was pooled because of the realisation that the then new nuclear industry required special insurance arrangements on account of the remote possibility of a catastrophic accident at a nuclear plant causing widespread off-site nuclear damage. Similar pooling arrangements have also been applied in many countries to other industrial risks and to natural perils such as flood.

1.2 Since the 1950s, the nuclear insurance pools have developed into centres of excellence for the understanding of nuclear risk. Key advantages of insurers pooling arrangements for the nuclear sector are the ability to retain a highly specialised technical ability, a comprehensive private sector post-catastrophe compensation infrastructure and a sound understanding of the special nuclear liability regimes and associated insurance products.

1.3 In the early days of the nuclear industry, Government lawmakers, nuclear operators and insurers worked together to draft a specific liability framework for the nuclear industry. This work ultimately lead to the creation of the "International Nuclear Conventions" which shape most national nuclear liability laws and impose strict, absolute but limited liability on the nuclear site operator with a simultaneous requirement for site operators to have in place ring-fenced funds for compensation following a nuclear accident at the site. In general, insurance is the most popular and cost effective method of meeting this financial compensation funding requirement.

International Nuclear Conventions: There are two Major Conventions—the OECD's 1960 *Paris Convention*, amended in 2004 and the UN's 1963 *Vienna Convention*, amended in 1997. Both provide the comprehensive compensation regimes for nuclear sites in the signatory states and both require financial instruments (normally insurance) to meet the compensation funding requirements.

1.4 Insurers meanwhile introduced nuclear damage exclusion clauses on all non-life insurance policies (eg motor or home owners insurance), so that all insurance capacity could be focused, through the national nuclear insurance pool, on the nuclear site operator's liability insurance. In this way, site operators can meet their legally imposed financial funding requirements through insurance and reinsurance, whilst insurers have a method of controlling exposure to a nuclear catastrophe. Without such a mechanism, insurers would not be able to offer insurance to nuclear operators because of the unknown extent of any nuclear catastrophe.

Insurance: when an insurer assumes the risk of loss from an individual or business for a premium.

Reinsurance: when an insurer seeks to insure some of his assumed risk portfolio to another insurer.

1.5 The ability to clearly quantify and control exposure has always been a vital requirement in the assessment of insurability and the nuclear liability Conventions embody both financial and temporal limits for a catastrophic nuclear accident. Currently the financial compensation limit provided per site in the UK is £140 million and the temporal limit is 10 years; both these limits are fully provided by the private insurance market.

1.6 Today, insurers provide about 70% of the world's nuclear site operators with both on site physical damage and financial loss insurance as well as the total amount of statutorily required off-site third party liability insurance. However, insurers' appetite for nuclear risk in their portfolio is limited, because of the low number of nuclear sites worldwide (about 500) and the consequent low premium volume which causes difficulties in attracting capacity to the sector.

1.7 Insurers perform regular insurance surveys on nuclear plant and good maintenance and risk management by the operator is essential if insurance is to be obtained. Failure to comply with insurers' recommendations or requirements can result in a reduction of insurance, an increase in premiums or even withdrawal of cover completely; in this case, in some countries an operator's license to operate the site could be withdrawn. Therefore there is a strong argument, both from a political and safety perspective, which says that external scrutiny of nuclear operators by the private sector insurance market is a valuable addition to the overarching desire to optimise public safety.

2. Role of Government and the Question of Subsidy

2.1 In excess of the liability compensation provided by the private insurance market, Governments or the nuclear operators step in to provide additional compensation, in some cases up to a further limit and in other cases for an unlimited amount. It is this aspect that sometimes attracts accusations of an "insurance subsidy" for the nuclear industry. However, the reality is that this secondary tier has never been required in the history of nuclear insurance and it is less likely to be required in the future as new, safer reactor designs are introduced as nuclear "new build" gathers pace. Private sector insurance has therefore provided the full liability and physical damage insurance requirements for the majority of nuclear plant over the past 50 years; whilst the only "subsidy" provided is excess compensation of the last resort—something that Governments provide to any industry or disaster with serious off-site consequences.

2.2 It should also be remembered that under the Conventions, the nuclear operator's liability is strict and he does not have to be at fault to provide compensation; this is more onerous than many liabilities and therefore better qualifies for a comprehensive regime that contemplates what is required in excess of amounts provided by insurers or the operators' balance sheets. However, the existing limits are fully matched by private insurance.

2.3 The Chernobyl accident in 1986 was not insured because the nuclear insurance pools were unwilling to offer insurance to the Soviet Union at that time; this was because of known problems with plant design, maintenance and a lack of adherence by the Soviet Union to the international Conventions. Some countries remain uninsured for similar reasons today and the insurers' technical understanding and abilities in the nuclear sector are essential to maintain a close watch on the nuclear sector in a role that complements that of most national nuclear regulators.

2.4 In the future, should the liability revisions be acceptable to the international insurance market, the private sector will be able to provide the majority of the foreseeable financial compensation requirements for a revitalised nuclear sector; the new financial limit will be €700 million (£480 million), over three times the current UK limit. New, safer reactors with a theoretical chance of a catastrophic accident of around 1 in 3 million will mean greater private sector acceptance than available today of the risks at affordable premiums.

3. Current Difficulties Caused by Amending the International Liability Conventions

3.1 The requirements of the international liability Conventions are currently satisfactorily provided for by private sector insurance, however dramatic increases in the financial or temporal compensation requirement or the scope of cover will present the insurance market with difficulties. The recent revision of the international Conventions has indeed widened scope of cover and increased the compensation requirements and these changes are now the subject of debate amongst insurers and operators alike.

3.2 Providing UK nuclear sites with the revised financial limit of £480 million itself is not likely to be a problem for insurers, but only if the scope of cover is restricted to insurable risks and the time limit remains at 10 years.

3.3 The increased scope of cover now offered by the Conventions was proposed to offer more compensation to more people in the event of a nuclear accident and, presumably, to put the state's role as "compensator of last resort" more remote; however, the likelihood is that the private insurance market's difficulties in meeting the new obligations will produce the opposite effect and insurance capacity may well slip away from the nuclear insurance market as the liabilities become less clear and more open to abuse.

3.4 In particular, the incorporation of responsibility for reinstatement of some environmental damages and the ambiguous broadening of economic damage in the Conventions present insurers with unquantifiable and therefore uninsurable risks, thereby leaving significant liabilities with nuclear operators and ultimately Government. Similar difficulties are being experienced by all insurers in the non-nuclear market since the introduction of the EU's Environmental Liability Directive which potentially imposes similarly uninsurable obligations on industrial site operators. In this case, both DEFRA and HM Treasury have recognised the fact that such undefined environmental obligations are uninsurable and it is recommended that similar recognition regarding the revised nuclear Conventions is therefore provided to nuclear operators and insurers.

3.5 If Government assumed the obligations imposed upon the operators by the ambiguous new scope of the Conventions, then no insurance would be required and a subsidy would be created. However, if this option is unacceptable to Government, at least some postponement of imposition of the obligation will be necessary until some of the risks are better understood by insurers and are therefore capable of being quantified and perhaps insured. This is the position adopted by Governments regarding the EU environmental liability directive.

4. The Special Case of Terrorism

4.1 With strict liability imposed on nuclear operators by the Conventions, it follows that compensation following acts of terrorism is also their responsibility. Recent terrorist atrocities have opened the possibility of a new dimension to the risk profile of nuclear plants—that of frequency of attacks. Hitherto, insurers have committed capacity to nuclear insurance on the basis of infrequent, but severe events; the prospect of multiple, indiscriminate terrorist attacks has added a new dynamic.

4.2 Insurers have, since 2002, secured the help of Government in meeting this new risk through a partial (and reducing) indemnity. Governments both in the UK and abroad are frequently required to provide financial assistance as a last resort for all businesses, as terrorism is often regarded as a political act and it has proved difficult to insure without the existence of numerous state-backed schemes.

4.3 Revised arrangements whereby Government would step in with supplementary financial support only following multiple terrorist attacks within a finite and defined period are recommended; this will enable the private insurance market to continue to provide capacity for infrequent events of whatever cause, but would protect the balance sheets of insurers in the event of a multiple terrorist attack of unprecedented scale.

5. Conclusions

5.1 The international private insurance market, represented by NRI in the UK, has played a key role in insuring the development of the nuclear sector for nearly 50 years at no cost to the UK taxpayer; it has also assisted with ensuring the safe and reliable operation of the nuclear sites over this time.

5.2 If the insurance market is to continue this mutually beneficial partnership with the nuclear industry, Government needs to assume some of the remote but uninsurable additional responsibilities placed upon nuclear operators by the revision of the OECD's Paris Convention on Third Party Liability.

19 September 2005

Memorandum by the Open University Energy & Environment Research Unit

PARTS A AND B

1. INTRODUCTION

1.1 *The Open University Energy and Environment Research Unit (EERU)*

The Energy and Environment Research Unit was set up in 1986 and is based in the Faculty of Technology at The Open University. The Unit undertakes research on the sustainable generation and use of energy. It also presents a course *T206 Energy for a Sustainable Future* within the Open University's undergraduate programme and supports a range of post-graduate research work. Further details of EERU and its activities can be found on its Web site: http://technology.open.ac.uk/eeru/index.htm

1.2 *Contents of Memorandum of Evidence from EERU*

Our Memorandum of Evidence to the Committee is in two parts:

Part A, "Nuclear's Inherent Insecurities", is an extensive submission in which we describe in detail our concerns about the security implications of the UK nuclear power programme and its proposed expansion.

Part B, "Non-Nuclear Sustainable Energy Futures: What Can the UK Learn from Germany?", describes the rapid progress being made in Germany in deploying renewable energy sources and improving energy efficiency. It suggests that the UK could learn a great deal from the German example.

Members of the Committee will be aware that the political situation in Germany is currently in a state of flux. Nevertheless, we believe that Germany continues to be highly-relevant as an example of what can be achieved by a Government determined to implement renewable and sustainable energy policies with vigour. Moreover, it seems unlikely that any new German Government will implement policies that would seriously jeopardize the future of its highly-successful renewable energy industry, which in 2003 had a turnover of 10 billion Euros and employed 120,000 people.

1.3 *Authors and Acknowledgements*

Part A is authored by Dr David Lowry, a visiting research fellow in EERU; part B is authored by Godfrey Boyle, Director of EERU. The authors acknowledge helpful comments received during the preparation of their memoranda from Professor David Elliott.

Memorandum from the Open University Energy & Environment Research Unit, Part A:

NUCLEAR'S INHERENT INSECURITIES

1. SELECTION OF QUESTIONS AND ANSWERS

This section of our submission attempts to provide some answers to some of the questions posed in the range of issues that constitute the remit of the Inquiry. It will address two of the subset of questions in the bullet points under Q4:

If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?

— *To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?*
— *Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?*

We also provide some guidance on two sub-questions under Q3:

What is the attitude of financial institutions to investment in different forms of generation?

— *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required?*
— *How much Government financial support would be required to facilitate private sector investment in nuclear new build?*

The first question addressed here is: Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

2. Background

"The safety and security of nuclear activities around the globe remain a key factor for the future of nuclear technology. . . The IAEA [also] has strengthened its co-operation on nuclear security issues with other international organizations, including the UN and its specialized agencies, Interpol, Europol, the Universal Postal Union and the European Commission." Statement to the 58th Regular Session of the United Nations General Assembly by IAEA Director General Dr Mohamed ElBaradei, 3 November 2003.

2.1 *Introduction*

The importance credited to nuclear safety by Dr ElBaredei in the above quotation is unsurprising. What is new and important is the coupling of safety with security.

In his speech, he went on to emphasise:

> "In light of the increasing threat of proliferation, both by States and by terrorists, one idea that may now be worth serious consideration is the advisability of limiting the processing of weapon-usable material (separated plutonium and high enriched uranium) in civilian nuclear programmes—as well as the production of new material through reprocessing and enrichment—by agreeing to restrict these operations exclusively to facilities under multinational control."

It is arguable that this is a remarkable statement coming from the director of the United Nations' agency charged with the promotion of the nuclear industry. But when we consider he made this comment barely two years after the terrorist attacks of 9/11 in the United States, it becomes more explicable.

Dr ElBaredei further pointed out that:

> "One convention that has gained increased attention recently is the 1979 Convention on the Physical Protection of Nuclear Material (CPPNM). In the past two years, 20 additional States have become party to the Convention, reflecting the importance of the international nuclear security regime."

As a result of several terrorist events in Britain in 2005, thankfully none involving radioactive materials, along with both Government ministers producing anti-terrorist initiatives, and Parliament debating their pros and cons, such as the Anti-Terrorism Act, this year has seen terrorism rise to and remain at or near the top of the public and political agenda.

The context was set In Madrid on 10 March 2005 when UN Secretary-General Kofi Annan told an international conference of some 400 anti-terror experts—meeting to mark the first anniversary of Madrid's own major terror attack on its suburban rail system a year earlier—that terrorists must be denied the means to carry out a devastating nuclear attack.

In urging UN member states to adopt the international convention on nuclear terrorism, Mr Annan made this blunt statement:

> "Nuclear terrorism is still often treated as science fiction—I wish it were." He added:
>
> "But unfortunately we live in a world of excess hazardous materials and abundant technological know-how, in which some terrorists clearly state their intention to inflict catastrophic casualties." he said.
>
> "Were such an attack to occur," he added "it would not only cause widespread death and destruction, but would stagger the world economy and thrust tens of millions of people into dire poverty."

In the same month of March 2005—but only made public six months later (see: "Pentagon Revises Nuclear Strike Plan: Strategy Includes Pre-emptive Use Against Banned Weapons", by Walter Pincus, Washington Post 11 September 2005)—an internal paper* prepared for the Pentagon's Joint Chiefs of Staff argued for consideration of the use of nuclear weapons against an enemy that is using, or "is about to use", nuclear or other WMD against US military forces or the civilian population of the United States. If put into practice, this strategy would significantly both raise the nuclear stakes, and lower the nuclear threshold.

[*US Doctrine for Joint Nuclear Operations:
http://www.globalsecurity.org/wmd/library/policy/dod/jp3_12fc2.pdf]

These high social stakes underline the importance of the need to ensure the best possible security applied to nuclear installations and materials.

2.2 *Responses to Q4*

2.2.1 Context: Nuclear Security Worldwide

Six months ago (16–18 March 2005), the World's nuclear watchdog, the United Nations' International Atomic Energy Agency (IAEA) held a timely international conference in London, co-hosted by the UK government, on "Nuclear Security: Global Directions for the Future."

It was the culmination of over three years planning, as immediately after the terrorist events of "9/11" in the United States in September 2001, the IAEA General Conference—which always meets annually in Vienna in September—requested a review of the Agency's activities relevant to preventing nuclear terrorism.

The first day of the Nuclear Security Conference reviewed the achievements and shortcomings of international efforts to strengthen nuclear security; the second day explored how the international nuclear security regime is adapting to new measures—and the IAEA role in underpinning them; the third day focused upon how the international community can reach a common understanding to better respond to the global threat of nuclear terror, detect and prevent it.

Richard Wright, the UK representative on the IAEA Board of Governors, summed the perceived situation after three days of intensive exploration by technical experts and decision-makers with words "Nuclear terrorism is one of the greatest threats to society".

The full findings of the conference are available on the IAEA web site (www.iaea.org/NewsCenter/News/PDF/conffindings0305.pdf); here we highlight some of the more pertinent of them.

> "Priorities for strengthening nuclear security include continued efforts to enhance the prevention of terrorist acts; the physical protection and accountability of nuclear and other radioactive material in nuclear and non-nuclear use, in storage and transport, throughout the life cycle, in a comprehensive and coherent manner. A graded approach should continue to be used under which more stringent controls are applied for material or activities that pose the highest risk; for example, particular attention should be given to high-enriched uranium or plutonium."

It added:

> "The fundamental principles of nuclear security include embedding a nuclear security culture throughout the organizations involved. By the coherent implementation of a nuclear security culture, staff remain vigilant of the need to maintain a high level of security. The long-term sustainability of nuclear security efforts is a primary concern. The investments made in States, through their own efforts and through assistance programmes, must be sustained in order to continue to upgrade or maintain an adequate level of security. While the level of threat may change from time to time, an effective level of nuclear security must be appropriately maintained."

This is clearly true. Later in this submission we demonstrate how, in certain respects, these principles are not being adequately met in UK practice.

A few months after the March meeting, hundreds of delegates from some 80 countries attended an IAEA conference in Vienna 4–8 July to consider and adopt amendments to the international Convention on the Physical Protection of Nuclear Material, which is a complementary regime to that controlloing nuclear terrorist threats.

The international nuclear watchdog is determined to keep vigilant, because its leadership and membership are all too aware of the negative implications for the nuclear generation industry were either a terrorist (or less likely , a wartime) attack to take place anywhere in the world against a nuclear power plant or nuclear installation, or illicitly obtained nuclear material be used in a so-called "dirty radiological bomb" in a dense urban area.

Here is a horrifying scenario painted recently by the sober finance sector magazine, *Business Week,* to mark the fourth anniversary of "9/11"

> "At 8.30 am on a Tuesday morning, as commuters converge on Manhattan, an al Qaeda operative explodes a dirty bomb outside the New York Stock Exchange. The device, while not especially powerful, contains a radioactive payload—in this case, caesium extracted from radiological equipment that was stolen from a New Jersey hospital by a sleeper working there as a lab tech.
>
> The initial blast kills only a few dozen people, but radiation is quickly dispersed by the prevailing winds. Minutes after the explosion, New York City Police officers arrive—still unaware of the real nature of the blast. But when a radiation detector in one officer's car goes wild, it becomes clear that a dirty bomb has detonated in the financial center of America's biggest city.

> Word of the explosion reverberates throughout New York. Many residents panic—despite assurances from the mayor and police chief that contamination levels would exceed government limits only in about 40 city blocks. And by 3 pm, half of Manhattan has tried to leave, clogging trains, highways, and bridges.
>
> Six months later, the financial district remains largely off-limits, and the local economy is limping along amid a cratering of business confidence, the collapse of the tourism industry, and a property market in free fall. Economists put the eventual economic losses at an astronomical $1 trillion . . ."

["New York Takes Another Hit—It has been readying itself for a dirty bomb since 9/11, but . . ." *Business Week*. 19 September 2005
http://www.businessweek.com/magazine/content/05—38/b3951012.htm]

For New York, read Paris, Tokyo, Moscow, London, Manchester, Glasgow Birmingham or any other major urban centre.

The Business Week "dirty bomb" scenario uses nuclear material stolen from a hospital, but there is real concern that such material could be illicitly obtained from commercial nuclear power installations, as UN Secretary General Kofi Annan highlighted before the Clinton Global Initiative, which ran contemporaneously (14–16 September 2005) with the UN World Summit. He stressed the dangers posed by proliferation, in giving terrorists opportunities to steal nuclear products that they could use to make so-called "dirty" bombs, which would combine radioactive material with conventional explosives in order to make bombs that could spread harmful radioactivity over a wide area.

He reinforced these concerns in his address to open the 60th General Assembly of the United Nations on 17 September 2005, when he insisted: "we face growing risks of proliferation and catastrophic terrorism . . ." www.un.org/webcast/ga/60/statements/sg050917eng.pdf)

We observe with some consternation that there is an apparent disconnect between the justifiable international concern over security threats posed by the insecurities of commercial nuclear energy sector, and the promotion of an expanded nuclear sector by the very authorities warning of the risk. It is indeed peculiar that just as policy makers were starting to face up to the real insecurities posed by existing nuclear plants and fuel cycle installations—and the transports between them—at the London and Madrid conferences, the IAEA announced at the start of March 2005 that there were: "Rising Expectations for Nuclear Electricity Production". In an official IAEA statement, issued in conjunction with publication of its Nuclear Technology Review—Update 2005, the Agency said:

> "The IAEA forecasts stronger growth in countries relying on nuclear power, projecting at least 60 more plants will come online over the next 15 years to help meet global electricity demands."

But the "Faustian bargain" infamously spoken of by former Oak Ridge National Laboratory Director Dr Alvin Weinberg in 1972 still exists. The spread of nuclear energy leads to the greater potential for the spread of nuclear weapons.

The international spread of nuclear power technology, and its concomitant spread of nuclear materials, was no accident: it was heavily promoted under the US export technology transfer initiative for "Atoms for Peace", set out in a path-breaking address to the UN General Assembly by President Dwight D Eisenhower on 8 December 1953.

In his address, in which he presaged the IAEA, Eisenhower commented:

> "My recital of atomic danger and power is necessarily stated in United States terms, for these are the only in controvertible facts that I know. I need hardly point out to this Assembly, however, that this subject is global, not merely national in character.
>
> . . . So my country's purpose is to help us move out of the dark chamber of horrors into the light, to find a way by which the minds of men, the hopes of men, the souls of men everywhere, can move forward toward peace and happiness and well being.
>
> Who can doubt, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage."

(http://www.eisenhower.utexas.edu/atoms.htm Part of the Milestone Document Series published by the National Archives & Records Administration)

Nearly 50 years later we witnessed the near inevitable outcome of this policy of nuclear promotion: a country whose director of nuclear affairs deliberately and covertly proliferated nuclear technology. This is the notorious story of Abdul Qadeer "AQ" Khan, of Pakistan.

The current US President, George W. Bush, was forced to admit the danger in a chilling speech he made on nuclear proliferation and materials controls at Fort Lesley J McNair—National Defense University, Washington, DC in February 2004:

> "In recent years, another path of proliferation has become clear, as well" said the President. "America and other nations are learning more about black-market operatives who deal in equipment and expertise related to weapons of mass destruction. These dealers are motivated by greed, or fanaticism, or both," Mr Bush warned. "They find eager customers in outlaw regimes, which pay millions for the parts and plans they need to speed up their weapons programs. And with deadly technology and expertise going on the market, there's the terrible possibility that terrorists groups could obtain the ultimate weapons they desire most."

After detailing Khan's relations with his business partner in proliferation, B S A Tahir, based in Dubai, Bush explained his new *Proliferation Security Initiative (PSI),* developed together with Australia, France and Germany, Italy and Japan, the Netherlands, Poland, Portugal, Spain and the UK, designed to intercept and interdict lethal nuclear (and other dangerous) materials in transit.

He then proposed that the work of the PSI be expanded to address more than shipments and transfers: to "take direct action against proliferation networks."

He announced the US would:

> ". . . help nations end the use of weapons-grade uranium in research reactors," and urged "more nations to contribute to these efforts."

He then pronounced:

> "The nations of the world must do all we can to secure and eliminate nuclear and chemical and biological and radiological materials."

Some may regard that as an admirable aspiration; we regard it as both practical and necessary.

The President finished by asserting:

> "Enrichment and reprocessing are not necessary for nations seeking to harness nuclear energy for peaceful purposes."

On security grounds alone, many would concur, as we do.

A few months later, (on 21 June 2004) in a Keynote Address, the IAEA Director Dr ElBaradei told a Carnegie Peace Foundation International Non-Proliferation Conference held in Washington DC that:

> "Nuclear components designed in one country could be manufactured in another, shipped through a third (which may have appeared to be a legitimate user), assembled in a fourth, and designated for eventual turnkey use in a fifth. The fact that so many companies and individuals could be involved is extremely worrying. And the fact that, in most cases, this could occur apparently without the knowledge of their own governments, clearly points to the inadequacy of national systems of oversight for sensitive equipment and technology."

He concluded: "The present system of nuclear export controls is clearly deficient."

He then argued: "First, we must tighten *controls over the export of sensitive nuclear material and technology*. . . Second, it is time that we revisit the availability and adequacy of controls provided over sensitive portions of the nuclear fuel cycle under the current non-proliferation regime . . . We should consider limitations on the production of new nuclear material through reprocessing and enrichment . . . considerable advantages—in safety, security and non-proliferation—would be gained from international cooperation in the front and the back end of the nuclear fuel cycle. Third, we should work to help countries stop using weapon-usable material (separated plutonium and high-enriched uranium (HEU)) in their civilian nuclear programmes . . ."

And he ended:

> "Fourth, we should eliminate the weapon-usable nuclear material now in existence."

Within a week (on 30 June 2004) Dr Hans Blix, Dr ElBaredei's predecessor as IAEA director-General, called for agreement on an international treaty to ban the production of weapons-grade nuclear material and prevent the spread of weapons of mass destruction (WMD). Commenting on the 15-nation WMD Commission in Vienna, which he chairs, Dr Blix said:

> "But there's also a very widespread and strong feeling on my commission that one must move on with a treaty that will prohibit all states involved from producing highly enriched uranium or plutonium, both substances that can be used in nuclear weapons."

In a *Financial Times* Op-Ed article on 2 February this year—titled "Curbing the Nuclear Threat"—Dr ElBaredei said that nations should now seriously consider a five-year moratorium on building new facilities for uranium enrichment and plutonium separation.

> "There is no compelling reason for building more of these proliferation-sensitive facilities, the nuclear industry already has more than enough capacity to fuel its power plants and research facilities," he said.
>
> [http://www.iaea.org/NewsCenter/News/2005/npt_2005.html]

One of the key events at the United nations Global summit, on 14–16 September this year, was to open for signature *the Convention for the Suppression of Acts of Nuclear Terrorism,* which emerged form the first Millennium Summit in 2000, and was adopted by the UN General Assembly on 13 April 2005. The nuclear terrorism treaty, which strengthens the global legal framework to combat the scourge, requires the extradition or prosecution of those implicated and encourages the exchange of information and inter-state cooperation. It gained its first signatories in Russian President Vladimir Putin, US President George W Bush, and French Prime Minister Dominique de Villepin. It enters into force 30 days after it is signed and ratified by at least 22 states.

In a related development at the United Nations, the UK submitted a resolution, Number 1624, to the Security Council on 14 September this year, calling for tougher controls on terrorism, including nuclear threats. It stressed that the Security Council should "call upon all States to become party, as a matter of urgency, to the international counter-terrorism Conventions and Protocols whether or not they are party to regional Conventions on the matter, and (to) give priority consideration to signing the International Convention for the Suppression of Nuclear Terrorism."

US President Bush pressed for the Security Council to approve the resolution, which called upon all nations to take steps to end the incitement of terrorist acts, and to commit countries to prosecute, and extradite, anyone seeking fissile materials or the technology for nuclear devices.

In February 2005, the UK Prime Minister's Strategy Unit advised him, in a report *Investing in Prevention—An International Strategy to Manage Risks of Instability and Improve Crisis Response,* in a section on the threats from WMDs, that:

> "Dual use nuclear, chemical or biotech programmes, which have both civilian and military applications, are a particular concern because they are more difficult to detect. Leakage of WMD technology, trafficking and further proliferation is facilitated by systemic corruption, the presence of organised criminals and terrorists, poor governance, lack of territorial control and state failure, all of which are associated with instability."
> (www.strategy.gov.uk/downloads/work_areas/countries_at_risk/report/index.htm)

In a later section (6.8.3) on the "Proliferation of Nuclear Technology", the Strategy Unit authors point out:

> "On the one hand, developing or expanding civil nuclear energy programmes is one option to meet increasing demands for energy, diversify national energy portfolios, increase energy security and reduce greenhouse gas emissions. On the other hand, such technology can be used for weapons creation . . ."

And they add:

> "The tension embodied in the verification and peaceful use provisions of the Nuclear Non-Proliferation Treaty (NPT) does not make for easy enforcement of its aims."

This problem was highlighted at the United Nations Global Summit in September 2005 by Mr Blair, when he bluntly stated, in presenting the UK counter-terrorism resolution, that:

> "The United Nations must strengthen its policy against non-proliferation; in particular, how to allow nations to develop civil nuclear power but not nuclear weapons."

Aside from the grammatical infelicity, by which the Prime Minister inadvertently appears to oppose non-proliferation, in advocating a strengthened policy "against" it , his support for the development of civil nuclear technology again demonstrates a long standing disconnect, which at once backs commercial exploitation of nuclear energy while seeking to control or indeed halt nuclear weapons proliferation.

These then are the current concerns in the international community over nuclear terrorism and security threats. This memorandum now turns to how these specifically apply to the UK.

3. Nuclear Security in the United Kingdom

For a very helpful recent analysis of the nuclear security situation in the UK, we would direct the EAC to two reports of the BNFL Stakeholder Dialogue (SHD), of which one of this memorandum's authors was a participating member, firstly on the Plutonium Working Group (PWG) and thereafter the Security Working Group (SWG), over the past five years. The final reports of both Working Groups may be accessed via the web site of the SHD coordinators, The Environment Council, at:

PWG: www.envcouncil.org.uk/docs/SWG%20Final%20Report.pdf (196 pages, published 31 March 2003)

SWG: www.envcouncil.org.uk/docs/SWG%20Final%20Report.pdf (145 pages, Published 10 December 2004)

The report of the Security Working Group summarised its

> ". . . purpose and hope [as] to contribute to the improvement of the security of BNFL's plant and activities, including in particular the transport of nuclear material, by the production of a quality review, using stakeholder dialogue, unique in this security context. The report is the fruit of rare collaborative effort on the part of a number of individuals from a variety of backgrounds with many differences in outlook. Notwithstanding that such differences in view were so divergent that in some instances they appeared to fully contradict each other, the group has produced what it considers to be a constructive and forward looking contribution to the manner in which security is provided for BNFL's activities."

The 60 recommendations generated by the group were finally grouped in seven main categories as follows:

(1) Funding and resourcing security activities.

(2) Accountability, openness and transparency of information.

(3) Establishing a mechanism for stakeholder dialogue with regard to security issues.

(4) Governance and organisational arrangements with respect to OCNS.

(5) Mechanisms for assessing threats (Design Basis Threat), the testing of security measures prescribed by an assessment, and forecasting the consequences of such threats if realised.

(6) Development and application of Security Hazard Indicator for assessment of security impact of an activity or evaluating the cost-benefit of a proposed security measure.

(7) National arrangements which fall into the remit of government.

The Security Working Group collectively agreed that "The attitude of BNFL in undertaking to implement, or to lobby for implementation of the recommendations where they lay outside their power (except where it disagrees significantly with the measure and in any such event to give reasons for such disagreement), was helpful in creating trust and enabling the process to move forward."

A number of differences on some security issues which were addressed in the course of the study remain unresolved, such as the manner of transportation of nuclear material, the risks arising from the conduct of plutonium swaps and the degree which sensitive information on nuclear materials should be made available to the public.

The SWG report in particular canvassed the difficulty of ensuring that existing licensed nuclear sites and installations—and nuclear materials in-situ and in transit—can be properly secured. This present submission examines further some of the issues canvassed in the SHD Security Working Group report.

3.1 *Contractorisation and Security Controls*

One issue looked at by the SHD SWG members was that of the vetting of site operating personnel and drivers of vehicles transporting nuclear materials between licensed nuclear sites. It was argued by some participants that the competitive contractorisation of the operational work of the Nuclear Decommissioning Authority (NDA) will undermine the ability of the UK Government's specialist nuclear security controls quango, the Office of Civil Nuclear Security (OCNS), to conduct proper vetting, as it will increase the number and dispersal of those contractors needing to be vetted.

Here are some observations in respect of security vetting from the director of the OCNS in his 2004 Annual Report:

> "Para 37. The vetting system works reasonably effectively, although it is unavoidably intrusive, time-consuming and labour-intensive. We advise foreign agencies that vetting is an essential component in nuclear security arrangements, in line with IAEA guidelines. There has been pressure in recent years to cut back numbers being vetted, but the current terrorist threat has brought about a prudent change of view.
>
> Para 38. It is sometimes claimed that a single government vetting agency could achieve greater efficiency. I doubt this. Our IOs are based close to nuclear sites. OCNS vetting staff are familiar with conditions within the industry, the hazardous nature of nuclear and radioactive material, and the work undertaken. If these close links were ever broken, the discernment of those undertaking interviews and record checks, and the understanding informing the decision-making process, would be lost.
>
> Para 39. The policy and practice of national security vetting gives full regard to the requirements of the Data Protection Act, the Freedom of Information Act, the Human Rights Act, race relations and other relevant legislation. Where appropriate, vetting information is exempt from disclosure. However, we are encountering some reluctance by employers and others interviewed to provide candid references. Despite assurances to the contrary, some worry that their identities might be disclosed on appeal and their organisations sued for defamation. I have drawn the issue to the attention of Cabinet Office officials. I have also suggested that an interdepartmental committee of vetting authorities should be re-established, to provide a forum for a regular exchange of views and the formulation of advice for central government.
>
> Companies with sensitive government contracts (List X firms) already have such a body in the Defence Industries Security Association (DISA)."

(The full OCNS third annual report is available at:
www.dti.gov.uk/energy/nuclear/safety/dcns_report3.pdf)

The Fourth Annual Report to the Energy Minister from the Director of Civil Nuclear Security on *The State of Security in the Civil Nuclear Industry,* covering the year to March 2005, was released in July 2005, and may be examined on:
www.dti.gov.uk/energy/nuclear/safety/dcns_report4.pdf.

The 2005 report informs the minister (para 14):

> "As part of a continuing programme of work since the terrorist attacks in the USA in September 2001, OCNS is reviewing, with the Nuclear Installations Inspectorate (NII) and the operators' own specialists, the security and safety measures in place to protect Vital Areas at nuclear sites, including generating stations. Vital Areas contain equipment, systems or devices, the failure of which could have serious consequences for the secure and safe operation of a nuclear site."

It concludes:

> "The programme of work is making good progress and has so far confirmed significant redundancy in all assessed systems."

But on security vetting it states (para 16d):

> "I require all individuals, both police and industry employees, who have access to facilities holding Category I nuclear material to be subject to Developed Vetting (DV) security clearance. In order to maintain his operational flexibility, the Chief Constable's Vetting Policy for the UKAEAC demanded that all UKAEAC Officers should be DV, even though a proportion did not come within my definition of requirement.
>
> With the expansion of the UKAEAC/CNC through Extended Deployment and in recognition both of the significant costs of the DV process and of OCNS' finite resources available for vetting, I welcome the Chief Constable's decision to modify his policy to allow Officers not employed on Category I nuclear sites or escort duties to be Security Cleared (SC), the level below DV. This variation will achieve significant cost savings for CNPA, ease the administrative burden for OCNS and make Officers available for front line duty faster. I have matched the Chief Constable's initiative with some well-defined guidance, giving him a commitment to 'fast-track' clearances to DV from SC should operational circumstances dictate the need."

And it adds at paragraphs 34–39:

> "OCNS provides a personnel vetting service which conforms to the requirements of Regulations 9, 17(3) and 22(3) of NISR (Nuclear Installations Security Regulations) 03, and which is applied to all permanent employees and contractors working in the civil nuclear industry. Clearances commensurate with the level of access to nuclear material and sensitive nuclear information are

granted to individuals and such clearances conform to national definitions, requirements and procedures. OCNS revalidate clearances at regular intervals according to the level granted and consider Appeals against decisions."

"35. In the year 1 April 2004 to 31 March 2005, OCNS issued a total of 12,587 clearances, of which 11,447 were for individuals who had not been vetted previously and the remaining 1,140 were revalidations. The vast majority of the new cases, 10,112, were for the lowest level of clearance, the Enhanced Basic Check (BC+), which allows unescorted access to a site. The balance of 1,335 cases represents the higher levels of clearance (Developed Vetting (DV), Security Check (SC) and the Counter Terrorist Check (CTC)) which permit access to sensitive areas of a site or access to more sensitive nuclear information. The detail is shown at Table 1 below, which includes totals recorded for 2002–03 and 2003–04 for comparison."

Table 1

SECURITY VETTING CLEARANCES GRANTED BY OCNS

Clearance Levels		*New Cases*		*Revalidations*
	2002–03	*2003–04*	*2004–05*	*2004–05*
Developed Vetting	312	435	471	279
Security Checks	753	921	863	47
Counter Terrorist Check	22	23	1	0
Enhanced Basic Check	8,381	7,742	10,112	814
TOTALS	9,468	9,121	11,447	1,140

"36. The figures confirm the trends identified in previous years which show a steady annual increase in the numbers of individuals requesting clearance. Although no one has been permitted to work on a nuclear site without the appropriate clearance or escort, absorbing the increase in tasking has been a significant challenge; OCNS has had mixed success in meeting it. Against a background of staff shortages created by retirements on the one hand and a recruitment moratorium during a major DTI downsizing exercise on the other, OCNS productivity has continued to improve from an already high base as a result of better working practices and a focused commitment by staff on the task. In spite of this, a backlog of cases built up in the last two quarters of 2004 which has yet to be addressed. At the end of the reporting period, the backlog (including arrears in revalidation cases) stood at 666 DV, 687 SC and 1600 BC+."

"37. Details of the numbers of revalidation cases processed in 2004–05 are shown in Table 2 with totals for 2002–03 and 2003–04 included for comparison."

Table 2

REVALIDATION OF SECURITY VETTING CLEARANCES

	Revalidations		
Clearance Levels	*2002–03*	*2003–04*	*2004–05*
Developed Vetting (DV)	163	186	279
Security Checks (SC)	51	101	47
Counter Terrorist Checks (CTC)	0	0	0
Enhanced Basic Checks (BC+)	2,552	3,059	814*
TOTALS	2,766	3,346	1,140

* Figure reflects policy change to treat BC+ revalidations as new cases.

"38. Although the figures in Tables 1 and 2 demonstrate the achievements of the OCNS Vetting Branch, one of my highest priorities now is to clear the backlog of vetting cases. The practical effect of the backlog on the industry amounts to delays in confirming recruitment of prospective employees or engagement of contractors, with the concomitant risk of losing them to other employment, and additional costs accruing from the need to escort individuals who do not hold the necessary clearance. In an industry where margins are so tight, this is a burden which must be reduced."

"39. I have recruited new staff to replace those who have retired and they are now coming on line. We continue to question how we manage the vetting process to identify further productivity increases and indeed, during the first quarter of 2005, significant efficiencies were achieved by treating BC+ revalidations as new cases. I have also asked all those involved in the industry to scrutinise carefully all vetting applications to ensure that clearances appropriate to individual appointments are applied for. The Chief Constable, UKAEAC's revision of his vetting policy (Subparagraph 16d above) is an example of best practice and I want to extend such initiatives.

> However, anecdotal evidence suggests that operators are requesting higher clearances than are strictly necessary, and that contractors create headroom for themselves by asking for more clearances than a project needs, and then employing individuals whose clearances arrive first. The balance of what have become unnecessary applications remain in the system, clogging it up and compounding delays."

So, although overall the DG OCNS says he is satisfied, we highlight his comment below on the implications of backlogs in vetting:

> *"The practical effect of the backlog on the industry amounts to delays in confirming recruitment of prospective employees or engagement of contractors, with the concomitant risk of losing them to other employment, and additional costs accruing from the need to escort individuals who do not hold the necessary clearance. In an industry where margins are so tight, this is a burden which must be reduced."*

We suggest that this issue should be explored with him, particularly in the context of both any new build programme, and the expansion of between nuclear installations transports that will be inevitable as the NDA begins to deliver its mission.

Security vetting concerns were confirmed when the then Cabinet office minister Douglas Alexander told the then Labour MP Llew Smith in July 2004 in a written answer that:

> "The most recent periodic review of the Government's personnel security system recommended the creation of a new official committee focussing on this area. That was accepted and that committee will work to ensure the continued effectiveness of personnel security policy and practice throughout Government, and in those organisations with which Government works in partnership." (*Hansard,* 21 July 2004 : Column 333W).

It is now known from papers released in February 2005 under the Freedom of Information Act that in the last year (2004–05) the OCNS had over 40 cases of potential security breaches under the current nuclear site management arrangements (see: www.dti.gov.uk/about/foi/documents/ocns.pdf).

The papers released under a FOIA request included the following information:

- OCNS carried out 129 pre-notified inspections in 2004. (These include the pre-notified inspections covering the last quarter of the FY 2003/4 cited in the last Annual Report);
- OCNS has carried out 15 no-notice inspections since September 2003.
- *The OCNS does not know how many security passes were lost/stolen within the nuclear industry in the past year.* OCNS states it is primarily interested in confirming that the sites have an effective pass management system as part of their security arrangements. This should include procedures for recording lost/stolen passes, disabling their access where access is automated, and periodic redesign and re-issue;
- OCNS does not expect to receive reports of individual alarms etc. where the cause has been investigated and assessed as benign. Nor are companies required to report what are essentially maintenance matters provided these have been dealt with promptly and have not significantly downgraded overall security effectiveness. We have interpreted your question broadly to mean anything out of the ordinary that the Operators drew to our attention. Therefore, not all of the incidents reported to us and noted here are of equal seriousness. None of the incidents involved theft of nuclear material or sabotage.

To address the question of what these involved, OCNS put security incidents into three broad categories:

1. Incidents that were responded to because they could indicate deliberate activity intended, for example, to steal property (including nuclear material) or information, or commit sabotage. The figures below subdivide this category into:

   (a) incidents responded to immediately and resolved immediately;

   (b) incidents responded to immediately and later resolved; and

   (c) incidents responded to immediately that were deliberate attempts to by-pass security measures.

2. Security equipment or procedural failures identified by normal management arrangements or by inspection/audit. Compensatory/corrective measures were taken to ensure maintenance of overall security standards.

3. Failure of security leading to unacceptable or undesirable consequences.

[The numbers and description are gathered together in Annex 1 to the FOIA release]

A key part of the OCNS mission is to identify and characterize threats. This is how OCNS director highlights "Threat Assessments" in the latest OCNS annual report:

> "11. It is vital, given the potentially serious consequences of any criminal or malevolent activity directed against civil nuclear sites or material, or proliferation sensitive technology, that security measures are designed to counter realistic threats. Effort must not be wasted on ineffective security precautions. Accurate, timely intelligence is essential. Information on the methods, capabilities and intentions of terrorist groups and other potential adversaries enables security measures to be

put in place. Though rarely specific enough to identify in advance when and where attacks might take place, intelligence reporting often does indicate when the threat has increased, to enable contingency measures to be activated in response, such as extra patrols or searching. Intelligence may also indicate when more labour-intensive security measures can be scaled back, to avoid over-extending staff and undermining morale."

"12. I am pleased to record that the provision of intelligence has improved markedly over the past six years. When I took over as Director, little intelligence was received, due to DCNSy's anomalous position within the UKAEA, as well as resource problems inhibiting liaison. To begin with, I had to rely on personal contacts to overcome these difficulties. The transfer to the Department and the provision of additional staff has remedied these deficiencies. We now receive all relevant intelligence, not just about nuclear, radiological and related threats (CBRN), but also providing a broader context. Most reports are sent to OCNS electronically via an encrypted data link. We are consulted by the intelligence agencies about our particular intelligence requirements and our advice is sought about the interpretation to be drawn from raw material. We are also able to provide digests and threat assessments to the operating companies, based on this material, for circulation to Board members, security managers, contractors and members of staff."

"13. The decision by the Government, which I mentioned in last year's report, to establish the Joint Terrorism Analysis Centre (JTAC) has, as expected, substantially enhanced the quality, scope and focus of intelligence reporting on the terrorist threat. JTAC has developed remarkably quickly into a most effective organisation. I am a member of the JTAC Oversight Board and OCNS functions as a participating organisation. As well as receiving intelligence, we provide JTAC with insights into nuclear security issues to aid reporting on these topics. This year, JTAC staff have received briefings from OCNS and attended training courses with managers from the operating companies. Visits to nuclear sites are being arranged. However, to derive full advantage from this link with JTAC, one of our two INFOSEC Inspectors is having to devote much of his time to the work, reading and disseminating material received and liaising with JTAC analysts based in London. For this reason, we aim to recruit a third INFOSEC Inspector to support both functions. Other, larger participating agencies provide teams of analysts to JTAC on secondment."

"14. I mentioned in my previous reports the procedures we use to assess medium term security threats, incorporated in a key planning document known as the Design Basis Threat (DBT). The document is based on the intelligence we receive about the motives, intentions and capabilities of terrorist groups and other potential adversaries. It is designed to provide a definitive statement of the possible scale and methods of attack that could be faced at civil nuclear sites, or when nuclear material is being transported. The DBT also takes account of the availability of countermeasures and contingency arrangements provided by the police, the MOD and other agencies. It makes clear which forms of possible attack the nuclear operating companies are expected to guard against, which types of attack remain the responsibility of the Government and whether, in the latter case, the companies are required to take mitigating or preventative measures."

"15. The DBT provides the basis for the design, implementation and management of security measures by the civil nuclear companies. It is also used by OCNS to develop or revise model security standards and guidance, evaluate site, transport and computer security plans prepared by the operators, and to monitor compliance. The companies subject to regulation have supported this approach because it provides a clear, rational basis for security planning, resource management and quality control. Furthermore, the approach is regarded by the IAEA as best practice and has been adopted by other foreign regulatory authorities."

He ends by stating: *"For security reasons, the DBT is classified SECRET and no further details can be published."*

A 140-page study prepared for MPs and Peers by the Parliamentary Office of Science and Technology (POST), published in July 2004, on *Assessing the Risk of Terrorist Attacks on Nuclear Facilities,* carries a short section (4.5) on the UK DBT. It states:

"**The Design Basis Threat**

Official information on the potential scale and methods of terrorist attack at civilian nuclear facilities is contained within a document known as the Design Basis Threat (DBT) as recommended by the IAEA (Box 3–2). The contents of the DBT, drawn up by OCNS, are secret, although OCNS mentions two possibilities which are now included: the possibility that terrorists might *use vehicles loaded with explosives to crash through perimeter defences,* and *the threat that terrorists who were prepared to kill themselves or risk discovery might attempt to penetrate into* [certain sensitive areas inside sites] *to detonate explosives.* 61 The DBT makes clear which forms of possible attack the nuclear operating companies are expected to guard against and which remain the responsibility of the government, and whether, in the latter case, companies are still required to take mitigating or preventative measures.

"Different countries publish varying amounts of detail about the Design Basis Threat. There is more publicly available information on the US DBT than most other countries. Some of these are listed in Box 4–1, to illustrate the kinds of attack contemplated by authorities, although this provides no indication of the contents of the UK DBT."

The POST report is an excellent overview, which may be insufficiently known to Parliamentarians. We recommend the EAC invite its primary author, Dr Chandrika Nath, to provide oral evidence to explain, and perhaps update, her findings.

It may also be instructive for the EAC to look at how details of the DBT is classified, or otherwise, elsewhere.

3.2 *The United States Case*

In the United States, following the terrorist events of September 11, 2001, a review of nuclear security was conducted by the regulatory authorities. The following is part of the text of the Nuclear Regulatory Commission (NRC) press release issued on 21 September 2001 under the headline:

"NRC REACTS TO TERRORIST ATTACKS"

The press release said:

> "In light of the recent terrorist attacks, US Nuclear Regulatory Commission officials and staff have been working around the clock to ensure adequate protection of nuclear power plants and nuclear fuel facilities. This has involved close coordination with the Federal Bureau of Investigation, other intelligence and law enforcement agencies, NRC licensees, and military, state and local authorities."
>
> "Immediately after the attacks, the NRC advised nuclear power plants to go to the highest level of security, which they promptly did. The NRC has advised its licensees to maintain heightened security. The agency continues to monitor the situation, and is prepared to make any adjustments to security measures as may be deemed appropriate."
>
> "In view of the recent unprecedented events, Chairman Richard A Meserve, with the full support of the Commission, has directed the staff to review the NRC's security regulations and procedures."

On 29 April 2003 the NRC announced changes being made in the DBT. The text read in part:

> "The NRC, after extensive deliberation and interaction with stakeholders, has approved changes to the design basis threat (DBT). The Commission believes that the DBT represents the largest reasonable threat against which a regulated private guard force should be expected to defend under existing law . . . In addition, the Commission has approved the issuance of two other Orders to nuclear plants . . . to further enhance protection of public health and safety, as well as the common defense and security."
>
> "These Orders, in combination with the recently-issued Order in the area of access authorization, enhance the already strong defense capability at these sites using three interdependent elements directed to best protect the public, with the appropriate resources placed at the right places. These elements are:
>
> — the revised Design Basis Threat and associated defensive capabilities derived from previous measures that the Commission directed;
>
> — tighter work hour control and more robust training requirements for security personnel, to increase their capability to respond to threats; and
>
> — enhanced access authorization controls to ensure all plant personnel with access to critical areas have had the most rigorous background checks permitted by law.
>
> "The Order that imposes revisions to the Design Basis Threat requires power plants to implement additional protective actions to protect against sabotage by terrorists and other adversaries. The details of the design basis threat are safeguards information pursuant to Section 147 of the Atomic Energy Act and will not be released to the public. This Order builds on the changes made by the Commission's 25 February 2002 Order. The Commission believes that this DBT represents the largest reasonable threat against which a regulated private security force should be expected to

> defend under existing law. (emphasis added) It was arrived at after extensive deliberation and interaction with cleared stakeholders from other Federal agencies, State governments and industry."
>
> "Under NRC regulations, power reactor licensees must ensure that the physical protection plan for each site is designed and implemented to provide high assurance in defending against the DBT to ensure adequate protection of public health and safety and common defense and security. Extensive changes in those physical protection plans will now be made and submitted to NRC for approval."
>
> "The second Order describes additional measures related to security force personnel fitness for duty and security force work hours. It is to ensure that excessive work hours do not challenge the ability of nuclear power plant security forces to remain vigilant and effectively perform their duties in protecting the plants . . . The NRC developed this unclassified Order through a public process . . ."
>
> "The third Order describes additional requirements related to the development and application of an enhanced training and qualification program for armed security personnel at power reactor facilities. These additional measures include security drills and exercises appropriate for the protective strategies and capabilities required to protect the nuclear power plants against sabotage by an assaulting force. This Order requires more frequent firearms training and qualification under a broader range of conditions consistent with site-specific protective strategies. The details of the enhanced training requirements are safeguards information, and will not be released to the public. As with the DBT Order, the Commission solicited comments on a draft training Order from cleared stakeholders, including security personnel and took those comments under consideration in reaching its final decision."

[As a matter of public fact, the Orders were challenged in the United States Court of Appeals for the District of Columbia Circuit by the NGOs Public Citizen, Inc and San Luis Obispo Mothers for Peace, in a suit brought on 30 June 2003. The full text is on the NRC website at: http://www.nrc.gov/reading-rm/doc-collections/news/2003/03-053.html]

The disclosures over the sensitivities and changes in the US—following its post "9/11" review— are the subject of a special analysis by one of our authors, and are appended as Annex 1 to this memorandum. This analysis clearly demonstrates that a sensible, detailed discussion on the DBT can be held in open session.

We would recommend the EAC invite before them both the director and deputy director of the OCNS to examine how they advise decision makers and ministers on the comparative risk from the hazards posed by breaches of security at nuclear installations.

We find it hard to understand why, despite the fact that the US Nuclear Regulatory Commission has found it possible—post 9/11, in a country, the United States, deeply wounded by the terrorist actions on its own soil—to put many details into the public domain on changes in the US DBT, such details still remain classified, and hence beyond independent critical appraisal, in the UK.

Some MPs have made efforts to discover the background to the UK DBT. The then Energy minister Brian Wilson told MPs in a written reply three years ago:

> "I cannot add to the information about the key planning document known as the design basis threat (DBT) which the Director of the Civil Nuclear Security referred to in his recent annual report on the 'State of Security in the Civil Nuclear Industry and the Effectiveness of Security Regulation', placed in the Libraries of the House on 11 June 2002. The assessment is classified and no further details can be published. The Director of Civil Nuclear Security assures himself that a site operator's ability to protect against the DBT is adequate and is tested. (Official Report, 26 June 2002: Column 892W)."

In July 2004, a question was put to the DTI energy minister on the DBT, asking which organisations provided information used by the Office for Civil Nuclear Security (OCNS) to construct its design basis threat (DBT) for plants and operations of civil nuclear companies; and whether the OCNS shares information on the United Kingdom DBT with its United States counterpart.

The then Energy minister Stephen Timms replied:

> "The Design Basis Threat is a planning tool that draws principally on assessments produced by the Security Service and the Joint Terrorism Analysis Centre (JTAC), of which OCNS is a member. OCNS discusses the processes involved in the production and use of a Design Basis Threat with many member states of the International Atomic Energy Agency, including the United States, but does not exchange analyses or conclusions that are protectively marked." (Official Report, 16 July 2004: Column 1383W).

This is a matter we would recommend is explored further by the EAC.

3.3 *BNFL Material Unaccounted For (MUF) Problem Highlights Nuclear Materials Accountancy Difficulties*

Another issue that is central to nuclear materials security is: how reliable is the accountancy procedure?

In February 2005 BNFL admitted that nearly 30 kilogrammes of plutonium remained "unaccounted for" in its annual nuclear materials stocktake. *The Times* newspaper reported it as its front page lead story.

The Whitehaven News, Sellafield's local newspaper, in its 24 February 2005 edition reported a BNFL spokesperson as saying that, in fact, the IAEA sets standards on these uncertainties "at 1% of the total Sellafield throughput but the latest figures represent only around 0.5% of this."

BNFL had issued a statement on 17 February which boldly stated in part that:

> "Euratom, the European regulator with responsibility for this issue, has accepted all inventories as satisfactory".

Further investigation demonstrated that this brief comment was not comprehensive, and hid an unresolved problem, viz that Euratom, the European Unions' nuclear watchdog regulator, remained in dispute with BNFL over the application of safeguards at Sellafield. Indeed, DTI energy minister Mike O'Brien stated in a written parliamentary answer to MPs:

> "BNFL and the [DTI] Safeguards Office are currently in discussion with the European Commission to resolve measurement issues that have been identified in certain aspects of nuclear material accountancy at Sellafield." (Official Report, 25 February 2005: Column 888W).

The important fact to recognise is not that the percentage uncertainty is less than 0.5%, but the actual quantity of the plutonium—a potent nuclear explosive material—is around 30 kilogrammes. With the IAEA's "significant quantity" to trigger security concerns of this nuclear material being 8 kilogrammes, this means that more than three times that amount (around 10 nuclear bombs' worth) was not accounted for.

This problem is not one of safety, but security, safeguards and materials accountancy. 100,000 kilogrammes of reprocessed plutonium is currently stockpiled at Sellafield. The fact that such a large surplus of this potent nuclear explosive remains without a long-term management solution remains an awkward political problem for ministers. And it also puts the inability of BNFL, Sellafield's operators, to account for 30 kilogrammes into context.

This incident was given a context in May 2005, when the Guardian newspaper (9 May) revealed that some 83 m^3 of radioactive liquors, containing up to 200 kilogrammes of plutonium, had been leaking from a section called the "feed clarification cell" inside Thorp, Sellafield's most modern reprocessing plant, operated by the British Nuclear Group (BNG), part of BNFL. The Nuclear Decommissioning Authority, owners of Thorp, subsequently issued a Media Statement on 27 May, recording it had taken receipt of an internal report of the incident from the British Nuclear Group board of inquiry.

The Energy Minister informed Parliament in written answer, issued in September 2005, that his predecessor, as the minister responsible, had first been informed of the leak on 21 April. (Official Report, 12 September 2005: Columns 2269–70W).

The Energy Minister had earlier informed Parliament in a written answer on 15 June what was known about the accident, in that:

> "the results of BNGSL's investigation suggests that the pipe may have started to fail in August 2004 and that complete failure of the pipe may have occurred in mid-January 2005. Opportunities such as cell sampling and level measurements were missed which would have shown that material was escaping to secondary containment." (Official Report,15 June 2005: Column 413W).

The Energy Minister revealed in his answer this September that:

> "The special report (dated 10 May 2005) on this incident, as required under Article 14 of Commission Regulation 302/2005, was forwarded to the Commission's DG Transport and Energy Directorate H by the UK Safeguards Office on 13 May 2005. However, this official notification had been preceded by verbal notification to the Commission of accounting discrepancies in THORP during a routine inspection on 29 March 2005. When it became clear that the discrepancies were due to a leak, the Commission were informed on 21 April 2005. Further details were provided to Commission inspectors on the Sellafield site during the week beginning 25 April 2005."

He added that while there is no formal requirement to notify the International Atomic Energy Agency: "the UK made a statement at the Board of Governors in Vienna during the week of 13 June 2005. The UK Safeguards Office has been kept informed of all related discussions between the British Nuclear Group Sellafield Limited, including participating in a meeting held at the DG TREN offices in Luxembourg on 16 June 2005." (Official Report, 12 September 2005: Columns 2269–70W)

For a hair-raising account of how major problems can occur in even relatively new nuclear plants handling nuclear materials, the final report of the Board of Enquiry makes for chilling reading, (http://www.britishnucleargroup.com/pdf/2765_1.pdf) which we would recommend to the EAC, not least because the BNG's parent, BNFL, is often touted as a possible future builder/operator of new nuclear power plants.

This was an accident that created environmental safety and potentially nuclear security problems. But there assuredly are bigger nuclear terrorist threats. At the 7th Irish and UK Local Authorities Standing Conference on Nuclear Hazards, held in Drogheda, County Louth, Ireland, on 10–11 March 2005, specialist consultant Dr Gordon Thompson, of the Institute for Resource and Security Studies, Cambridge, Massachusetts, presented a chilling paper on the theme: "Are Nuclear Installations Terrorist Targets?"

He pointed out that in the US the Government has published a design of a cruise-missile warhead intended to penetrate rock or concrete. He reported that the warhead has a diameter of 71 cm, a length of 72 cm, and a total mass of 410 kg; when tested in 2002, it created a hole of 25 cm diameter in tough rock to a depth of 5.9 m; that one means of carrying such a device would be a general-aviation aircraft; and that a Beechcraft King Air 90 will carry a payload of up to 990 kg at a speed of up to 460 km/hr; a used King Air 90 can be purchased for US$0.4–1.0 million.

In other words, a viable platform of attack is well within the budgets of international terrorists. The vulnerabilities are manifold: spent fuel stores, high activity radioactive waste liquor storage tanks; long-term immobilised radioactive waste stores; and nuclear reactor containment at Magnox reactors.

Dr Thompson provided the following typologies of vulnerability:

Mode of Attack	*Characteristics*	*Defenses at a US Plant*
Commando-style attack	— Could involve heavy weapons and sophisticated tactics. — Successful attack would require substantial planning and resources.	Alarms, fences and lightly-armed guards, with offsite backup
Land-vehicle bomb	— Readily obtainable. — Highly destructive if detonated at target.	Vehicle barriers at entry points to Protected Area
Anti-tank missile	— Readily obtainable. — Highly destructive at point of impact.	None if missile launched from offsite
Commercial aircraft	— More difficult to obtain than pre-9/11. — Can destroy larger, softer targets.	None
Explosive-laden smaller aircraft	— Readily obtainable. — Can destroy smaller, harder targets.	None
10-kilotonne nuclear weapon	— Difficult to obtain. — Assured destruction if detonated at target.	None

We record that it was Dr Thompson's memorandum to the Defence Select Committee, in January 2002, that led to the Defence Committee making a recommendation that the terrorist threat to nuclear installations be conducted by POST, resulting in the POST report to which reference was made above. The EAC may find it useful to invite Dr Thompson, who has since been used as a security consultant by the Committee on Radioactive Waste Management (CoRWM), to give further oral details on his concerns over insecurities at UK nuclear installations.

3.4 *Cyber insecurity*

Another vulnerabity of nuclear plants is cyber insecurity. An article by Kevin Poulsen of *Security Focus* (8 March 2005) reported that two companies that make digital systems for nuclear power plants have come out against a US Government proposal that would attach cyber security standards to plant safety systems.

The 15-page proposal, introduced in December 2004 by the US Nuclear Regulatory Commission, would rewrite the NRC's "Criteria for Use of Computers in Safety Systems of Nuclear Power Plants." The current version, written in 1996, is three pages long and makes no mention of security.

The NRC plan expands existing reliability requirements for digital safety systems and, as the article states:

> "infuses security standards into every stage of a system's lifecycle, from drawing board to retirement."

So far, industry reaction has been less than glowing. Capri Technology, a small California firm that builds specialised systems and software for nuclear plants, calls the regulations "premature", and says the proposal could deter plant operators from installing new digital safety systems entirely.

"The NRC tries to promote the use of digital technology in the nuclear power industry on the one hand, but then over-prescribes what is needed when a digital safety system is proposed," wrote company president William Petrick, in comments filed with the commission. An industry veteran, Petrick advocates withdrawing the proposal until the NRC and industry experts can agree on a more effective cyber security strategy.

Framatome, a French company that develops and builds nuclear plants from the ground up, had a similar response. The company argued in its comments that the NRC is painting with too broad a brush—for example, by applying the same security standards to software running on a general purpose computer, and to firmware embedded in a chip.

Cyber security "is sufficiently important and complex to merit a more considered set of guidance," Framatone has argued. "A significant joint effort should be undertaken to publish comprehensive cyber security guidance that covers present and planned uses of software in nuclear plants", the company asserts.

In 2004 the IAEA itself warned of growing international concern about the potential for cyber attacks against nuclear facilities, and said it was finalizing new security guidelines of its own. No successful targeted attacks against plants have been publicly reported, but in 2003 the "Slammer" worm penetrated a private computer network at Ohio's idle Davis-Besse nuclear plant and disabled a safety monitoring system for nearly five hours. The worm entered the plant network through an interconnected contractor's network, bypassing Davis-Besse's firewall.

(http://www.theregister.co.uk/2005/03/08/nuclear_cyber_security/)

We recommend that the EAC invite before it suitable witnesses to explain the vulnerabilities posed by cyber-threats to nuclear plants.

3.5 *Parliamentary scrutiny of nuclear security issues*

Several pointed questions have been raised in Parliament in the past year over nuclear security, including concerns over potential threats to nuclear installations from aircraft.

Defence minister Adam Ingram said in response to a question in April 2004 asking the Secretary of State for Defence if he would list each near-miss incident involving RAF aircraft and United Kingdom nuclear installations reported to his Department in each year since 2000 that:

> "Restricted areas for aircraft have existed around nuclear facilities for many years. In the aftermath of 9/11 the Civil Aviation Authority (CAA) revisited this policy, issuing an amendment to Article 85 of the Air Navigation Order, and now major nuclear installations have a restricted area of two nautical mile radius."
>
> "The number of alleged breaches of restricted areas involving RAF aircraft and United Kingdom nuclear installations reported to the Ministry of Defence in each year since 2000 is detailed in the following table. The Ministry of Defence, Defence Flying Complaints Investigation Team carried out investigations on each occasion and concluded that five of these were found to have infringed restricted areas. I will shortly place copies of all reports of the investigations in the Library, with all personal data redacted in accordance with the Data Protection Act 1998."

	Total number of complaints	*Total confirmed breach*	*Under investigation*
2000	6	—	—
2001	19	—	—
2002	18	3	—
2003	11	1	—
2004 (up to 31 March 2004)	3	1	1

(Official Report, 27 April 2004 : Column 874W)

Mr Ingram later told MPs that:

> "Both Royal Air Force and United States Air Force aircraft operate with the same restrictions in respect of overflights of nuclear installations and residential areas. Nuclear installations are to be avoided by a radius of two nautical miles from a fixed centre-point or a height of 2,000 ft, by all types of aircraft. In respect of 'residential areas' we grant avoidances in the United Kingdom military low-flying system to towns with a population of 10,000 or more, as well as everything within certain major avoidance areas. Towns granted avoidances are to be overflown at not less than 1,000 ft by helicopters, and not less than 2,000 ft by fixed wing aircraft." (Official Report, 25 May 2004 : Column 1617W)

We know from an earlier parliamentary answer to the now retired Labour MP Llew Smith that a "near-hit" incident reported on 4 April 2002 involved a helicopter landing in the grounds of the BNFL nuclear installation at Berkeley, Gloucestershire. It turned out to be a Canadian military helicopter on a joint military exercise. But what if it had been a group of international terrorists? The plant management did not know.

It was reported in several newspapers (*The Observer*, *Sunday Express*) on 11 September 2005 that armed police would henceforth be routinely deployed to guard nuclear plants: "Armed police drafted in to protect nuclear plants from terror attack", was one headline.

> "Armed police have been introduced at two nuclear power stations in Suffolk, it was confirmed yesterday. Civil Nuclear Constabulary officers have been drafted in to patrol. Security at the sites of BNG's Sizewell A and British Energy's Sizewell B plants near Leiston has been reviewed, along with other plants throughout the country, following both the 9/11 attacks and the London bombings in July. Sizewell B director Mark Gorry revealed to a Sizewell stakeholders group meeting that the move was intended to boost confidence and act as a deterrent. In January 2003, 30 Greenpeace campaigners scaled the dome containing the pressurised water reactor at the Sizewell B plant. They said the protest was to highlight the station's poor security and vulnerability to attack."

We recommend that Greenpeace be invited, along with officials from the British Nuclear Group and British Energy, to explore the current robustness of security at UK nuclear plants

Independent Commentary on Nuclear Security Risks

The following disturbing statements were included in an exhibition hosted by BNFL at its Sellafield site, prepared by the Science Museum.

> "A nuclear device could be the ultimate weapon for a terrorist, but fortunately, such devices are very difficult and expensive to build. Although the UK government does not allow plutonium from civil nuclear reactors to be used in the UK's nuclear weapons, some people are worried about terrorists getting hold of plutonium illegally. By reprocessing and by transporting MOX fuel, which contains plutonium, all over the world, we are increasing the risk of plutonium proliferation."
>
> "Some people believe that as reprocessing separates reactor-grade plutonium from spent fuel it increases the terrorist risk and should therefore be stopped. Leaving the material as spent fuel is often considered safer as it is less attractive to terrorists who would have to separate the plutonium from the fuel themselves—a long and difficult process. But terrorists could still use the spent fuel, with out separating out the plutonium, to make a 'dirty bomb'".
>
> "The Irish Government, environmental groups, and organisations opposed to nuclear proliferation have all expressed opposition to the opening of the MOX fuel manufacturing plant at Sellafield. The case put forward against MOX fuel manufacture includes, but is not confined to, the risk of plutonium proliferation, the possibility of slightly increased radioactive discharges, and economic arguments based upon the apparent lack of customer orders for the new fuel."
>
> "Civil nuclear plants have to meet certain national standards of security and design to protect them against sabotage and terrorist attacks. But the attacks of 11 September 2001 forced many people to reassess the lengths that terrorists might go to."
>
> "The high-level liquid waste that comes from reprocessing is stored in constantly cooled tanks at Sellafield. These tanks represent one of the world's most hazardous concentrations of long-lived radioactive material and are, therefore, a prime terrorist target. An attack on these tanks, similar to the one in New York in September 2001, could have extremely serious consequences for much of the UK and Ireland."

We found these observations alarming, but not alarmist. All of these statements were to be found at the web site for *Sparking Reaction* at:
www.sparkingreaction.com/home.shtml.

The web site, and exhibition, has now been closed.

We recommend representatives of the Science Museum be invited before the EAC to give evidence on the basis of these commentaries.

As part of the Government's evolving counter-terrorist legislation, the Home Secretary published a new draft Terrorism Bill on 15 September which includes a section on combating nuclear terrorism. The relevant clauses are reproduced at Annex 2. At the time of preparation of this submission, there was insufficient detail about these clauses to allow comment to be made.

Our judgement is that far from enhancing energy security of supply, the further deployment of nuclear technology would undermine security in the UK, and should be avoided. The second part of this submission demonstrates that "the lights can be kept on" by a range of decentralised and dispersed renewable energy technologies, none of which suffer the insecurities of nuclear power.

4. Responses to EAC's Question 3

Q3 *What is the attitude of financial institutions to investment in different forms of generation?*

— *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required?*

4.1 *Introduction*

EERU does not pretend to expertise in nuclear financing. However,the authors of this memorandum attended an international expert seminar on the future prospects for new UK nuclear energy development, hosted by the Ditchley Foundation at Ditchley Park in June 2005, where the matter was keenly explored. The rules of reportage covering the event ("Chatham House Rules") preclude specific reporting of the remarks and observations of participants. We are, however, able to report that amongst those engaged were representatives from merchant bankers NM Rothschild & Sons, investment specialists Spirent, legal and business advisors Eversheds, and project management specialists CH2M Hill International.

4.2 *Risk*

The key issue for prospective future investment in new nuclear power capacity is risk.

This was addressed in an open forum roundtable discussion at the World Nuclear Association's Annual Symposium, held in London 8–9 September 2005.

The participants from the investment sector comprised the following: Roger Ewart-Smith, Managing director, Rothschild (UK), William Oulton, Managing Director, FTSE4Good, William Vereker, Managing Director, Lehman Bros, (UK).

In response to questions asking how investment banks considering investing in new nuclear power plants in the UK would factor into their risk assessment the implications of a terrorist attack on any other nuclear installation in the UK, or abroad, during the planning, construction or commissioning phase of any nuclear plant they might fund, the following replies were given:

Mr Ewart-Smith of Rothschild said that the private sector cannot easily take the risk in such circumstances. Mr Vereker of Lehman Brothers said there would need to be protection measures built in to secure their investment.

Therefore it is apparent that risk arising from terrorist actions could prove an impossible hurdle for the full funding of new nuclear plants, if the reactions of these two senior investment bankers specialising in energy investment are a good guide.

According to a report in *The Business* newspaper ("Rothschild Champions Nuclear Joint Venture", 26 June 2005): "NM Rothschild, the London merchant bank, is leading an initiative to finance, build and manage Britain's next generation of nuclear power stations. It plans to create a jointly-owned nuclear power company, provisionally named 'New Nuclear', that could raise funds and manage the nuclear-build programme."

The article went on to record "*The Business* has learned that Rothschild has drawn up the plan on behalf of its client, state nuclear group BNFL, which is looking at ways in which a UK nuclear revival could be funded by the private sector. Rothschild's is proposing instead that a minimum of three of the UK's six utilities take stakes in New Nuclear. The three main contenders would be the UK arms of Eon, RWE and Electricite de France (EdF), whose European parent companies already operate nuclear power stations. Scottish and Southern Energy, Scottish Power and Centrica could also take stakes, although they could settle for long-term power purchase agreements instead."

It quotes an unnamed source from one of the UK power utilities as saying "Rothschild's are very keen to get back into nuclear."

Brian Count, who has recently retired as chief executive of RWE's UK arm is reported to have said of the scheme: "It's credible; it has merit. The issue is one of spreading the political risks."

This article is one of several to appear in the Sunday business press, and is typical of "kite flying" or "dipping one's toes in the water", to test the temperature. The assertions reported need to be tested with witnesses.

We would thus recommend that witnesses from Rothschild, Eon, RWE and Electricite de France be invited to give evidence before the EAC.

On the same Sunday, *The Sunday Times* ("Taxpayers 'will pay billions' for nuclear plants," 26 June 2005) reported that a "new generation of nuclear power stations could be built only if the government is prepared to put billions of pounds of public money into the project." This was the conclusion of a leading economic think tank, Oxera, in a report issued on 27 June.

Oxera estimated that replacing the current nuclear power stations would likely cost about £8.6 billion, from which it thinks industry could expect a return on its equity of just 11%. "Our figures do not indicate there would be enough of an incentive for industry to finance a new nuclear programme," said Oxera director Derek Holt.

We would concur with the Oxera conclusions, and recommend that the EAC invite Oxera to present evidence to the Committee.

We note that in the House of Commons at Trade and Industry question time on 23 June 2005, the Trade and Industry Secretary Alan Johnson told MPs, in response to a request for a statement on the future of nuclear power in the UK, that:

> "The 2003 energy White Paper set out the Government's energy policy on all sources, which obviously includes nuclear energy as well as fossil fuels and renewables. The Department keeps progress against the White Paper goals under review, through, for example, the work of the Joint Energy Security of Supply Working Group and the publication of the second annual report on the White Paper."

And in response to a supplementary question asking how many new nuclear power stations would this country need to maintain a 20% contribution, Mr Johnson added:

> "I understand the point made by the hon. Gentleman, who has long been a proponent of new-build nuclear energy. I come to this question with what could be called clean-slate technology, as I am neither pro nor anti-nuclear. I feel very strongly that the 2003 energy White Paper got it about right when it said that at some point in the future "new . . . build might be necessary . . . to meet our carbon targets.That is still the case. There are issues around cost and waste which, as the hon Gentleman well knows, are difficult issues. The Prime Minister has said that we need to make a decision on new build in this Parliament. We intend to do so, but we intend to take a measured look at all the issues across the energy field and ensure that our decisions, if they involve nuclear new build, meet the obligations that we agreed in 2003 for further consultation and another White Paper."
>
> (Official Report, 23 June 2005: Column 929–30)

At present, this would appear to remain the situation. *We would thus recommend the Trade and Industry secretary, his energy minister Mr Wicks, and the Director General of Energy at the DTI, Ms Joan MacNaughton, be invited to give the committee further details on departmental thinking on prospective financing of new electricity generation technologies.*

Annex 1

Shortly after the NRC Orders were issued, Joseph S Mahaley, Director of the US Department of Energy's Office of Security, testified before a session of the House of Representatives' Subcommittee on National Security, Emerging Threats, and International Relations of the Committee on Government Reform, held on 24 June 2003.

He told the Representatives that the 2003 DoE Design Basis Threat Policy is predicated on the information contained in the Defense Intelligence Agency, "Postulated Threat: to US Nuclear Weapons Facilities and other Selected Strategic Facilities," dated January 2003, also referred to as the Postulated Threat Statement.

> "The Postulated Threat Statement details relevant threat information about postulated adversary team sizes, characteristics, capabilities and applicability to national security assets. The Postulated Threat Statement is based on intelligence information detailing actual terrorist attacks and the equipment and tactics utilized in the attacks, expert judgments regarding stated terrorist intentions and the ability of the terrorist to execute the stated objectives, and postulated capabilities based on the latest knowledge concerning terrorist activities."
>
> "Prior to 11 September 2001, attacks in New York and Washington, the Department of Energy, in August 2001, requested that the intelligence community prepare an update to the 1994 Postulated Threat Statement. Although the 1994 Postulated Threat Statement was designed to be a 10-year document, we believed at that time that changes in international politics, emerging technologies and increases in worldwide terrorism required a reassessment. The National Intelligence Coordinating Committee assigned the primary responsibility for updating the Postulated Threat Statement to the Defense Intelligence Agency."
>
> "The events of 11 September 2001, delayed the Postulated Threat Statement update effort due to reallocation of critical assets. However, the requested Postulated Threat Statement update was fully underway by January 2002. The primary entities collaborating on the revision to the Postulated Threat Statement were: the Defense Intelligence Agency, the Department of the Navy,

the Department of the Army, the Department of the Air Force, the Nuclear Regulatory Commission, the Federal Bureau of Investigation, the Central Intelligence Agency, and the Department of Energy."

"The Department of Energy's Office of Security began revising the DoE Design Basis Threat Policy in October 2001. Our work on the revised DoE Design Basis Threat Policy was carried out in parallel with the work on the updated Postulated Threat Statement to reduce the amount of time that would be required to issue a final DoE Design Basis Threat Policy upon completion of the Postulated Threat Statement. After the release of the final Postulated Threat Statement in January 2003, we made final revisions to the Departmental Design Basis Threat Policy. The Policy was then coordinated within the Department of Energy, including the National Nuclear Security Administration. The revised Policy was approved by the Deputy Secretary of Energy on 20 May 2003."

"The new Design Basis Threat Policy will provide managers an improved threat policy document to plan, resource, and execute vital safeguards and security programs. In addition to updated threat information, the revised Design Basis Threat Policy includes a significant enhancement over prior policies—the use of the 'graded threat concept'. The graded threat concept considers and accounts for factors such as consequences of a malevolent event, the attractiveness of the asset, the ability of an adversary to accomplish a given objective with an asset, and the resources required by an adversary to accomplish a given objective."

"The graded threat approach includes the establishment of 'Threat Levels' for Departmental facilities and associated 'Protection Strategies' based on the assets located at a given facility. The Design Basis Threat Policy separates 'Threat Levels' into two distinct categories. One category of 'Threat Levels' covers theft, disruption of mission, and espionage and foreign intelligence collection, and the second category—of 'Sabotage Threat Levels'—covers radiological, chemical, and biological sabotage."

"Five 'Threat Levels' are established for theft, disruption of mission, and espionage and foreign intelligence collection: Threat Level 1 (the highest)—for facilities that receive, use, process, store, transport, or test Category IA assets (ie, nuclear weapons, nuclear test devices, or completed nuclear assemblies) through Threat Level 5 (the lowest)—for facilities that are only required to maintain minimum safeguards accountability or security operations (ie, small office activities, tenants in large office buildings, or small isolated research or test facilities that do not possess quantities of special nuclear material)."

"Four 'Sabotage Threat Levels' are established for radiological, chemical, and biological sabotage. Sabotage Threat Level 1 (the highest) through Level 4 (the lowest) are set for facilities, buildings, or operations that process, store or transport radiological, chemical, and biological materials by the degree to which these materials, if dispersed, would result in acute dose effects at the site boundary."

"Immediately following the events of 11 September 2001, the Department implemented measures to augment safeguards and security for the most critical Departmental assets. The recently revised Department of Energy Design Basis Threat Policy incorporates those measures and, in some cases, sets a higher standard for the protection of Departmental assets."

"The revised Design Basis Threat Policy is effective immediately and will be implemented over the next several years. Actions to augment existing safeguards and security programs for those facilities and assets that are considered the highest security policy will be undertaken as soon as practicable."

No such detail of the British DBT has been placed before MPs by anyone in a position of authority to know.

On the same day as the above testimony, the US Government Accountability Office issued a report entitled Nuclear Security: DoE Faces Security Challenges in the Post September 11, 2001, Environment, (GAO-03-896TNI).

The GAO reviewed how effectively the National Nuclear Security Administration (NNSA)—a separately organised agency within US Department of Energy (DoE)—manages its safeguards and security programme, including how it oversees contractor security operations. GAO also reviewed DoE and NNSA's response to the terrorist attacks of 11 September 2001. In this regard, GAO examined: DoE and NNSA's immediate response to 11 September; DoE's efforts to develop a new Design Basis Threat, a classified document that identifies the potential size and capabilities of the terrorist forces that DoE and NNSA sites must be prepared to defend against; and the challenges DoE and NNSA face in meeting the requirements of the new Design Basis Threat.

The USGAO was able to use unclassified material to provide three case studies of US military nuclear installations or security regimes—at the Rocky Flats former nuclear warhead production plant, outside Denver, Colorado; the Technical Area-18 (TA-18) at the Los Alamos Nuclear Laboratory in New Mexico; and the Transportation Security Division, which travels the United States interstate highways.

To our knowledge, no analysis independent of the nuclear security regulator has been conducted of the UK DBT, because the details of the DBT remain confidential. Here is one comment made by the USGAO on the US DBT:

> "The number and capabilities of the terrorists involved in the September 11 attacks rendered obsolete DoE's Design Basis Threat, last issued in 1999. However, DoE's effort to develop and issue a new Design Basis Threat took almost two years; it was issued in May 2003. This effort was slowed by, among other things, disagreements over the size of the potential terrorist group that might attack a DoE or NNSA facility. Successfully addressing the increased threats will take time and resources, as well as new ways of doing business, sound management, and leadership. Currently, DoE does not have a reliable estimate of the cost to fully protect DoE and NNSA facilities."

Moreover, the US National Academy of Sciences was given a detailed assessment—in public session—on the "Vulnerability of Spent Fuel Pools and the Design Basis Threat", by Peter D H Stockton (a former Special Assistant on nuclear security for US Energy Secretary Bill Richardson, now senior investigator for the Project On Government Oversight [POGO]) on 10 May 2004.

He said on the Design Basis Threat (DBT):

> "The Postulated Threat is a document created by the Defense Intelligence Agency—in conjunction with the US intelligence community. It indicates a significant threat against nuclear facilities in terms of numbers of adversaries, lethality of weapons and size of truck bombs. This document should be the basis for the size of the DBT."

Amongst the proposals made by POGO were some on a Possible Solution to Threat from Aircraft:

> "Barrage balloons, similar to those used in World War II, lofted around the perimeter of a nuclear plant site would likely divert an oncoming plane, and would not be prohibitively expensive."

It is also on public record (TCNC Newsletter 3–4 July/August 2003) that a Workshop on Korea-USA Design Basis Threat (DBT) was held at INTEC of KAERI in Daejeon from 30 June to 2 July 2003, in which around 50 participants from MOST, KAERI, National Police Agency, KHNP, KEPCO, KNFC, KOPEC, and other competent authorities participated. The lecturers of the workshop were experts from the US Government's Sandia National Laboratories (SNL) in the US.

Annex 2

The Draft Terrorism bill, dated 13 September 2005, made public 15 September 2005, contains the following sections:

"**10 Trespassing etc on Civil Nuclear Sites**

(1) The Serious Organised Crime and Police Act 2005 (c 15) is amended as follows.
(2) In subsection (1) of each of sections 128 and 129 (trespassing etc on a designated site in England and Wales or Northern Ireland or in Scotland), for designated insert protected.
(3) After section 128(1) (sites in England and Wales and Northern Ireland) insert.
(1A) In this section protected site means.
(a) a civil nuclear site; or
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11
(b) a designated site.
(1B) In this section civil nuclear site means.
(a) any premises in respect of which a nuclear site licence (within the meaning of the Nuclear Installations Act 1965) is for the time being in force; and
(b) so much of any premises of which premises falling within paragraph (a) form a part as lies between.
(i) the edge of the premises in respect of which the licence is in force; and
(ii) the outer perimeter of the protection provided for those premises.
(1C) For this purpose.
(a) the outer perimeter of the protection provided for any premises is the line of the outermost fence provided for the protection of those premises; and
(b) the line of such a fence shall be treated as including what would, assuming every gateway in the fence to be closed, be the line the gate in each of those gateways.
(4) After section 129(1) (sites in Scotland) insert.
(1A) In this section protected Scottish site means.
(a) a civil nuclear site in Scotland; or
(b) a designated Scottish site.
(1B) In this section civil nuclear site means.

(a) any premises in respect of which a nuclear site licence (within the meaning of the Nuclear Installations Act 1965) is for the time being in force; and
(b) so much of any premises of which premises falling within paragraph (a) form a part as lies between.
(i) the edge of the premises in respect of which the licence is in force; and
(ii) the outer perimeter of the protection provided for those premises.
(1C) For this purpose.
(a) the outer perimeter of the protection provided for any premises is the line of the outermost fence provided for the protection of those premises, and
(b) the line of such a fence shall be treated as including what would, assuming every gateway in the fence to be closed, be the line of the gate in each of those gateways.

12 Maximum penalty for certain offences relating to nuclear material
(1) In section 2 of the Nuclear Material (Offences) Act 1983 (c 18) (offences involving preparatory acts and threats), for subsection (5) substitute.
(5) A person guilty of an offence under this section shall be liable, on conviction on indictment, to imprisonment for life.
(2) Subsection (1) does not apply to offences committed before the commencement of this section.

(Text at http://www.homeoffice.gov.uk/docs4/Print-02C.PDF)

Part B

NON-NUCLEAR SUSTAINABLE ENERGY FUTURES: WHAT CAN THE UK LEARN FROM GERMANY?

In the UK, a vociferous minority have recently been arguing that we must re-open the nuclear energy option. Renewables and energy efficiency, they say, cannot make a big enough contribution to achieving the 60% cuts in fossil-fuel carbon emissions that will be needed by mid-century to avert catastrophic climate change.

Yet Germany, a larger and wealthier nation than Britain, with higher electricity consumption and a higher proportion of nuclear power but with poorer fossil and renewable energy resources, is on-course to phase-out nuclear energy by 2020, is phasing-in renewable energy many times faster than the UK and has detailed plans to cut its emissions by not just 60% but 80% by 2050.

In 2003–04, Britain's renewable energy sources, as the Table below shows, contributed only 1.3% of the country's primary energy and 3.5% of its electricity. By contrast, renewables in Germany contributed some 3% of primary energy and 7.9% of electricity in 2003—more than twice as much as in the UK.

Table 1

GERMANY AND THE UK: SELECTED COMPARISONS

	Germany	*United Kingdom*
Gross Domestic Product (GDP) (2003)	$2,270 billion	$1,666 billion
GDP per person	$27,550	$27,630
Population	82.4 million	60.3 million
Land area	349,000 sq km	242,000 sq km
Population density (persons per hectare)	2.4	2.5
Annual electricity demand (TWh) (2003) (1 Terawatt-hour (TWh) = 1 billion kWh)	506 TWh	338 TWh
Annual electricity use per person, kWh (kilowatt-hours)	6140 kWh	5578 kWh
Percentage of Electricity from Nuclear (2003)	28.8%	22.7%
Percentage of Electricity from Renewables (2003)	7.9%	3.5%
Percentage of Primary Energy from Renewables (2003)	3%	1.%
Capacity of wind power installed (2004)	16,600 megawatts	880 megawatts
Number of Photovoltaic Roofs & Capacity (2003)	>100,000 410 megawatts	<1000 5.9 megawatts

How do Germany's and Britain's plans for the rest of this decade and beyond compare?

The UK Government in its 2003 White Paper on energy (DTI, 2003) emphasized the role of renewables, combined heat and power and energy efficiency in enabling the UK to meet its Kyoto treaty commitment to cut greenhouse gas emissions (mainly carbon dioxide, but including other gases) by 12.5% by 2012. No new nuclear power stations would be built, though the option of doing so in future was left open. By the end of 2004, the UK had reached its Kyoto target—though there are concerns that emissions may rise again in future years. Through the Renewables Obligation the Government plans to increase the proportion of renewable electricity to 10% by 2010 and to 20% by 2020. It has also pledged to go beyond Kyoto and cut emissions of the principal greenhouse gas, CO_2, by 20% by 2012.

Germany's renewable electricity targets are similar: 12.5% by 2010 and 20% by 2020. But by 2010 it also aims to achieve a 10% contribution of renewables to primary energy. Germany's Kyoto target is for a 21% cut in greenhouse gas emissions. By 2004, it had reached 19%.

The rate of growth in Germany's renewable energy supplies has been astonishing. Between 1998 and 2003 the contribution of biomass energy doubled, wind power capacity quadrupled and the number of solar photovoltaic roofs increased six-fold (see Figures 1a, 1b and 1c below). By 2003–04, as Table 1 above demonstrates, Germany's installed wind and solar photovoltaic capacities were respectively 19 and 70 times as great as those of the UK. (BMU, 2004)

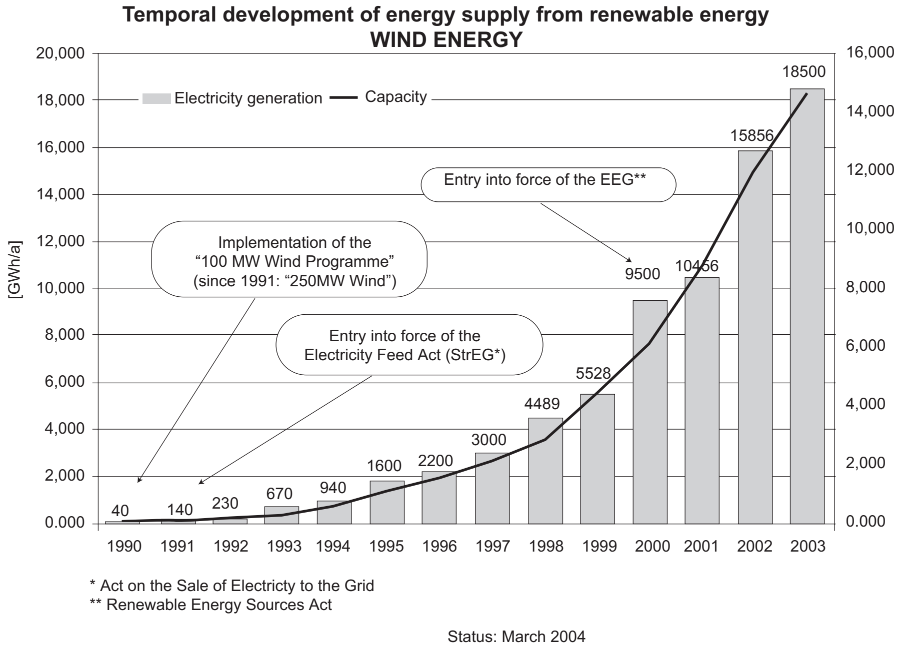

Figure 1a: Growth in Wind Electricity Generation and Installed Capacity in Germany, 1990–2003. *Source:* BMU, 2004a

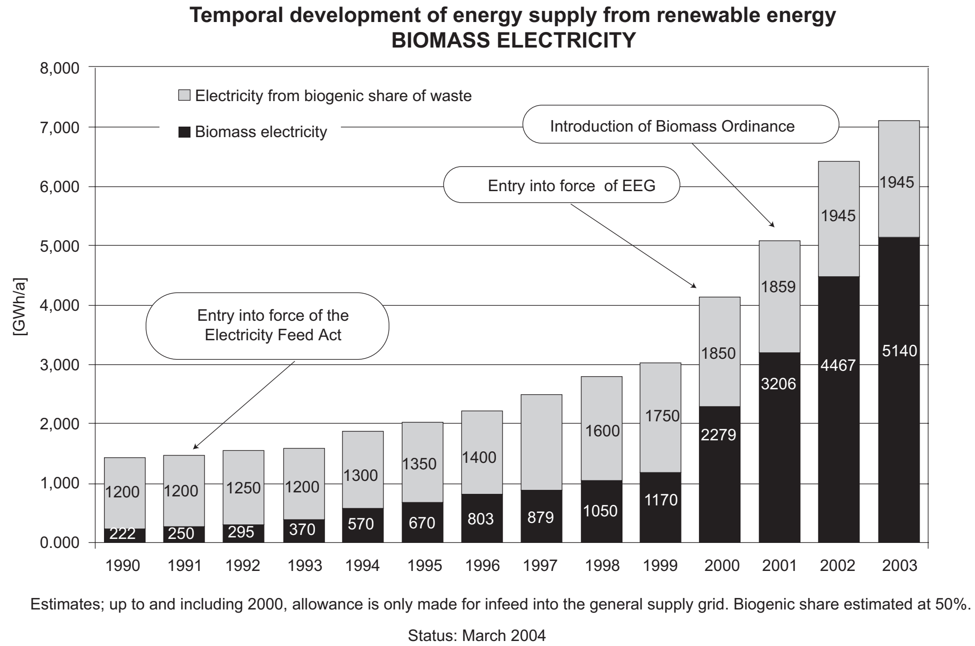

Figure 1b: Growth in Biomass Electricity Generation in Germany, 1990–2003. *Source:* BMU, 2004a

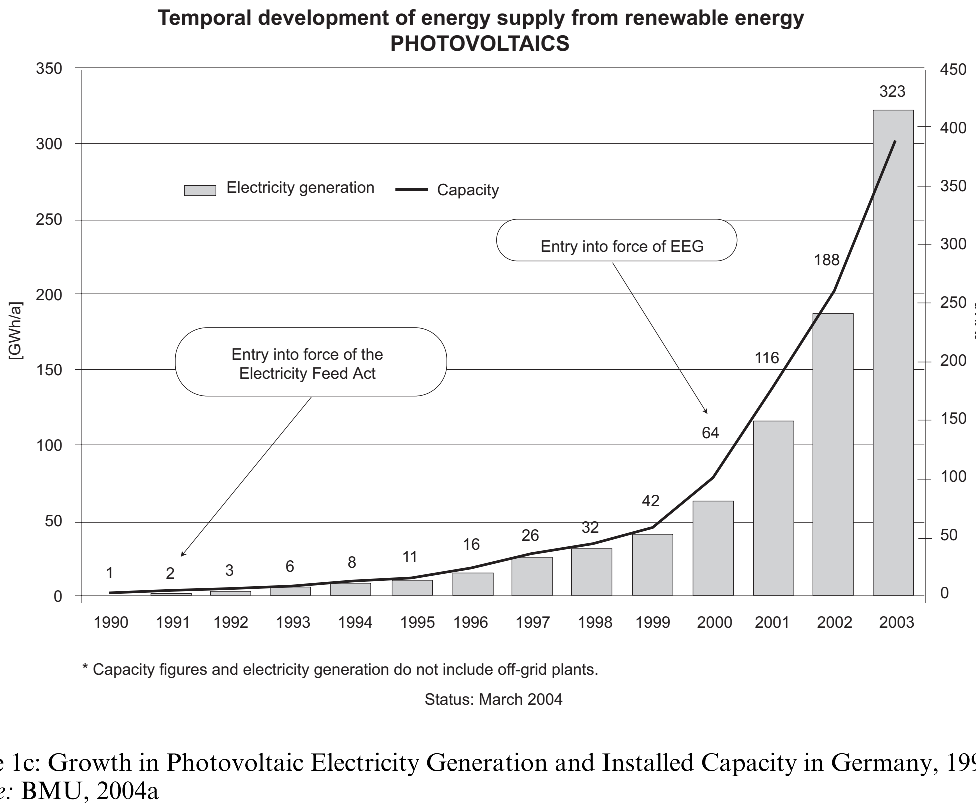

Figure 1c: Growth in Photovoltaic Electricity Generation and Installed Capacity in Germany, 1990–2003. *Source:* BMU, 2004a

Premium prices are paid for renewable power under Germany's Renewable Energy Sources Act, but the additional costs are modest, one Euro per month per household, and are added to electricity bills, not paid through taxes. The prices are different for each technology and the subsidy system is quite sophisticated. For example, each year the price paid for electricity from new photovoltaic installations falls by 5%, giving solar manufacturers a strong incentive to reduce prices as the size of their market expands. But the premium prices are guaranteed for 20 years, giving confidence to investors.

Not surprisingly, the renewable energy sector in Germany is booming. In 2003 it had a turnover of 10 billion Euros and employed 120,000 people. Long-term, investment is predicted to reach 18–20 billion Euros per year, and by 2020 the number of jobs is expected to reach 400,000. (Trittin, 2004).

Alongside measures to promote renewables, Germany has also been strongly encouraging more efficient use of energy, though such measures as incentives for combined heat and power generation and increasingly stringent regulations on the energy performance of buildings.

Germany's ambitious plans for the rest of this century are described in great detail in the Environment Ministry's 2004 report *Ecologically-Optimised Extension of Renewable Energy Utilisation in Germany* (BMU, 2004). By 2050, the report envisages primary energy use falling to around half the current level, despite continuing economic growth and rising prosperity, due to major improvements in energy efficiency and increasing use of combined heat and power plants. By then, renewables should be supplying 65% of the nation's electricity, 45% of its heat and 30% of its transport fuel. Nuclear power will have been phased out three decades ago and fossil fuel use reduced to around 20% of current levels. This "ecologically-optimised" energy system will allow Germany to achieve an 80% cut in greenhouse gas emissions, making a major contribution to international efforts to mitigate climate change, and setting an example to other wealthy nations.

So why has renewable energy, and wind energy in particular, progressed so slowly in the UK? To a considerable extent, this has been due to widespread misconceptions about the nature of wind power, its costs and its effects on the environment and the electricity system. The recent publication of *Wind Power in the UK,* a comprehensive, peer-reviewed report on the subject by the Government's Sustainable Development Commission (SDC, 2005) is therefore greatly to be welcomed.

Among the report's conclusions are that wind power is already relatively cheap, with on-shore wind currently costing around 3.2 p/kWh and offshore some 5.5 p/kWh. These costs should reduce to around 1.5–2.0 p/kWh and 2.0–3.0 p/kWh by 2020. By 2010, some 7.5% of UK electricity could come from roughly 4,000 MW of on-shore turbines and another 4,000 MW of off-shore capacity. Moreover, contrary to some other reports—in particular the 2004 report of the Royal Academy of Engineering (RAE, 2004)—the additional reserve and balancing power requirements of wind power are not onerous. By 2020, some 20% of UK electricity could come from wind at a very modest additional cost of some 0.17 p/kWh. These conclusions are very similar to those of the German energy agency DENA, which in 2005 reported that it would be quite feasible for some 20% of Germany's electricity to come from wind by 2020, that the requirement for additional reserve power and new power lines would be modest, and that the additional cost to householders would be only 0.5 eurocents per kWh (DENA, 2005).

The development of wind power on-shore in the UK has been also partially hindered by the fact that under the Renewables Obligation (and its predecessor, the Non-Fossil Fuel Obligation) there are strong financial incentives to developers to seek the windiest sites, which are often the most visually conspicuous and therefore most likely to be opposed by local amenity groups.

A further problem is that the value of the Renewables Obligation Certificates (ROCs) earned by producers of renewable power is determined by market forces and can go down as well as up in future years. This is a disincentive to investors, unlike the situation in Germany where investors know they will be paid a fixed price for their electricity for 20 years. However, on a more positive note, the new planning guidelines recently issued to Local Authorities have resulted in a higher rate of planning approvals for on-shore wind farms in the last year or so.

Though several UK offshore wind farms have now been built, offshore wind progress has recently slowed, partly as a result of mergers among the large Utilities funding such projects, and partly because most firms are reluctant to bear all the risks of being a pioneer in this new and very demanding environment, preferring to wait and learn from others' mistakes. The capital grants offered by the DTI to offshore wind projects do not seem to be sufficient to compensate firms for the very considerable initial risks involved ı though few doubt that in the long term offshore wind will be a highly successful and profitable area of operation. (Harrison, 2005; Massy, 2005; Milborrow & Moller, 2005).

So how can the UK accelerate its progress in renewable energy and energy efficiency?

1. For new supply technologies, what is needed is more and "smarter" support, with higher levels of funding for technologies at earlier stages of maturity, such as offshore wave, tidal and wind, biofuelled electricity and photovoltaics. The DTI has recently introduced some promising innovative support mechanisms, with wave and tidal being given a mixture of capital grants and fixed price support, in addition to the value of ROCs. (for details, see Renew 2005 and http://www.gnn.gov.uk/environment/detail.asp?ReleaseID = 143807&NewsAreaID = 2&NavigatedFromDepartment = False)

2. More community involvement in local renewable energy projects would help to gain improved acceptance. For example, priority could be given in planning rules and grant funding to projects with a proportion of local ownership.

3. Although renewable electricity is important, electricity provides less than 20% of UK delivered energy, so incentives to increase the renewable proportion of energy used in heating and in transport are urgently needed.

4. Efficient energy use in buildings, industry and transport needs to be encouraged by a mixture of incentives for efficiency and penalties for inefficiency, backed up by increasingly stringent regulatory measures.

5. The UK needs to accept that energy is currently too cheap, and that higher energy costs will encourage more efficient use (though with appropriate measures to protect low-income consumers).

6. The enormous purchasing power of Government, at both local and national level, could be used to greater effect to stimulate the market for low- and zero-carbon goods and services.

7. There should be scope for low interest loans (since Governments can borrow much more cheaply than the private sector) to assist investment in renewable and sustainable energy projects—perhaps though public-private partnerships, with Government funding some of the investment at low interest rates and the private sector funding the rest at higher rates of return.

8. And finally, we in the Universities are very conscious of the need for education and training for the many thousands of specialists who will be required to design, build and maintain the sustainable energy infrastructure of the 21st century. We also need a major programme of public education to enable non-specialists to be better informed on key issues.

To conclude, Germany's successful track record and its policies for future decades demonstrate that it is entirely possible to deploy renewables and improve energy efficiency fast. And its "ecologically optimised" scenario for 2050 shows in detail how an 80% cut in CO_2 emissions by 2050 can be achieved without nuclear power. This scenario, incidentally, is very similar to the UK Royal Commission on Environmental Pollution's scenario number four for 2050, which entailed a 47% cut in primary energy use, with energy mainly supplied by renewables (plus a much-reduced fossil fuel contribution) and no contribution from nuclear power (RCEP, 2000).

A new nuclear programme for the UK is undesirable because it would in practice (if not in theory) starve renewables of investment and send the wrong signals to investors and to other countries.

In short, the 2003 White Paper strategy remains broadly correct, but the UK Government needs to make a much stronger commitment to renewables and energy efficiency in the coming decades, along German lines, if its ambitious and laudable CO_2 reduction targets for 2050 are to be achieved.

Godfrey Boyle is Director of the Energy & Environment Research Unit at The Open University and editor and co-author of *Renewable Energy: Power for a Sustainable Future* (Oxford University Press, 2004) and *Energy Systems and Sustainability* (Oxford University Press, 2003).

An abbreviated version of this text was published in *Science in Parliament,* Journal of the Parliamentary and Scientific Committee, Summer 2005 (Boyle, 2005), as a synopsis of the author's contribution to the Committee's debate on "The Nuclear Option", held at Westminster on 13 June 2005.

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21 September 2005

Memorandum submitted by John R Parry

In response to your request for comments from the public concerning new electricity generating capacity, I would like to make the following observations.

I have been witness to the spoliation of the Lake District by the erection of wind farms in the vicinity of Grizebeck and Haverigg. I note that most of them no longer work. In my view, the insistence of their manufacturer's in constructing them of bright white materials, presumably to advertise their presence, was an act of ecological vandalism.

I have also watched with incredulity as large business concerns have been granted permission to construct gas-fired power stations and to run them on low-price North and Irish Sea gas. I note that the price of gas to domestic consumers is scheduled to rise this year—the figure of 40% has been mentioned. As a domestic consumer, I have to ask myself "what's that all about?" It seems to me that the policy is insane.

I have been associated with the nuclear industry for the last 25 years, and I know there are drawbacks to nuclear power. However, I would submit that these are as nothing compared to living, as I did through my formative years, downwind of a coal-fired power station (in my case it was Agecroft north of Manchester). The health of generations of people living in Prestwich was blighted by the outpouring of filth from the stack, the top of which was level with the borough less than a mile away.

There are problems with nuclear waste, but I would submit that modern recycling and encapsulation methods can overcome these. The Nirex deep deposit project encountered considerable local opposition, but my feeling is that that was caused by "not in my back yard" syndrome. If the proposition had been to put the entrance to the tunnel within the boundaries of Sellafield, rather than in a thriving local village, the local opposition would have been minimal.

There have always been reservations concerning nuclear power associated with the "base load" problem. If you build sufficient nuclear power stations to take up the maximum load on the electricity grid, you are faced with the problem of shedding the difference between the maximum and minimum loads during quiet periods, nuclear power stations not being amenable to being switched on and off as required. May I suggest that sufficient nuclear power stations be built to exceed the maximum load. During the off-peak periods the excess capacity can be used to power desalination plants to compensate for the water shortages anticipated due to global warming, and in addition, the desalinated water can be electrolysed to provide a copious supply of hydrogen. This could then be used to power our motor vehicles—a totally "carbon free" solution to the pollution caused by our motor traffic.

In conclusion, I am delighted that the problems of electricity supply are at last to be addressed, and would urge you to act rapidly and boldly to provide a long-term solution to the whole problem, which has been shamefully ignored for the last 20 years.

29 July 2005

Memorandum submitted by Paul Payne CEng, CEnv, MIChemE

Introduction

1. The Environmental Audit Committee has invited the submission of views to this inquiry from members of the public. The views expressed herein are my own, and do not represent any organisation to which I am affiliated or employed by.

2. Professionally, I am a chemical engineer with Chartered Engineer and Chartered Environmentalist status. I have worked in the chemical and nuclear industries for 26 years, mainly in the areas of effluent and waste management (including back end nuclear fuel cycle). I have made submissions to various regulator, UK government and EU consultations on aspects of energy policy, the nuclear industry and sustainable development.

3. My overarching view is that the development and deployment of sustainable renewable energy sources is imperative, but this must replace existing fossil fuel capacity, not (as the Energy White Paper implies) retiring nuclear capacity. Furthermore, increased nuclear capacity is not an option: it is a necessity. Nuclear capacity should be increased in order to meet what should be an increasing demand for electricity from all sectors, and to replace existing fossil fuel capacity at the earliest opportunity.

Summary

4. In order to adequately address climate change, electricity demand needs to grow as direct use of fossil fuels is significantly reduced in all sectors.

5. In addition, the use of fossil fuels for electricity generation needs to be minimised.

6. Therefore there is a need for deployment of significant new carbon free generating capacity, which necessitates new nuclear build alongside new renewable build.

7. The use of historic cost performance as a yardstick for new nuclear led the Energy White Paper to incorrect conclusions regarding nuclear new build.

8. Building a new fleet of nuclear power stations would not pose any serious additional threat from terrorism or proliferation.

9. Technical solutions to legacy nuclear waste disposal exist now: new nuclear build should not be delayed whilst the political implementation of these solutions is debated.

Energy Supply Shortfall

10. Climate change is affected by all fossil fuel use, not just electricity generation. It is therefore imperative that the transport sector addresses significant reduction in the use of oil based fuels, and not by replacement with gas. Direct use of gas for heating and similar uses also needs to be targeted for significant reduction. In both cases, this will increase the need for electricity generating capacity as petrol and diesel transport systems and gas fired domestic and space heating systems become electrified. In the event that hydrogen fuel cells can be safely implemented to replace petrol and diesel for cars, this will further add to the required generating capacity.

11. Future generating capacity projections must be revised to allow for these increased requirements. Financial and regulatory measures should be instigated to encourage and implement significant reduction in fossil fuel usage in all sectors.

12. This will have the effect of increasing electricity demand whilst reducing generating capacity. As the only practicable sustainable means of closing the shortfall, new nuclear capacity is required alongside optimised deployment of renewable generating capacity.

Costs

13. In considering comparative costs of differing technologies, the energy white paper was at best flawed (and at worst, deliberately biased to achieve a preconceived answer) in that the cost of new renewable capacity was taken to be at the lower end of its cost range, whereas nuclear was taken to be at the higher end.

14. With the exception of wind turbines, renewables are generally immature, emerging technologies. It is therefore unrealistic at this point in time to assume that they can be delivered at the lowest projected cost. As with all emerging technologies, it is most likely, at least initially, that deployment will come in at the high end of the cost range. Initial deployment would be concurrent with, if not later than, the requirement for nuclear new build.

15. Conversely, nuclear is a mature, established technology. Use of the high range cost was justified by past experience. It is unrealistic to base predictions of nuclear new build costs on historic projects. The Magnox and AGR fleets were all built as one off, virtually prototype designs and in an era when project management was a discipline in its infancy and just about every public sector project experienced significant cost and programme overruns. Current advances in project management, financial control and accountability, coupled with mature technology and the benefits of multiple build would ensure greatly improved cost and programme performance in delivering new nuclear build compared to past projects.

16. In any event, both renewable and nuclear build are required to fill the shortfall resulting from retiring nuclear and fossil generating capacity coupled with increasing electricity demand.

Strategic Benefits

17. The primary strategic benefits of new nuclear build may be summarised as:

Security of supply

18. The scenario presented in the Energy White Paper where around 75% of UK energy supply relies on imported gas poses a realistic threat to security of supply. This arises both from potential changes in political alignment or stability of the states possessing the reserves, or through whose territory the pipelines run, and from vulnerability to terrorist action of large, unprotectable soft targets. Interruption or loss of supply would impact on the UK within days at most, and potentially within hours. Since nuclear plant is only refuelled intermittently at long intervals, interruption to uranium supply could take in excess of 12 months to impact on generating capacity, providing ample opportunity to arrange alternative supply or diversified capacity.

Substantial reduction in greenhouse gas generation and other environmental impacts

19. Continued mass use of carbon rich fossil fuels for electricity generation, heating and transport will continue to discharge unacceptable and potentially dangerous levels of greenhouse gases into the environment. As well as Kyoto obligations, UK is also bound by the OSPAR convention to seek to avoid future use of such fuels where clean alternatives. Annex 1 presents this argument.

20. Fossil fuel extraction processes release toxic substances in to the environment, including heavy metals and fugitive hydrocarbon emissions. Maritime accidents also continue to result in periodic heavy pollution of coasts and their fragile ecosystems.

21. For these reasons, it is environmentally unacceptable to implement an energy policy which does not, at its core, seek to significantly reduce the use of fossil fuels.

22. Nuclear generating plant discharges virtually nothing directly to the environment during operation and only relatively small quantities of stable, well contained solid waste.

Improved safety due to significant reduction in extraction, transportation and storage of hazardous fossil fuels

23. Extraction and processing of fossil fuels into a useable condition is a hazardous business. Globally, major fires and explosions still result in frequent loss of life and significant economic damage. By contrast, 50 years of commercial nuclear generation has only seen one (Chernobyl) serious accident resulting in loss of life and significant release of radioactive material to the environment.

Reliability of baseload generating capacity

24. It is widely recognised that the major renewable energy source (wind) is not sufficiently reliable to provide baseload capacity without excessive redundant capacity across the country (with the attendant cost and environmental penalties of providing such). Given the unacceptability of fossil fuel generation, outlined above, and the immaturity of most other renewables, nuclear is the only available option to provide reliable baseload generation. Nuclear reactors consistently operate at high availability and high load factors.

25. Additional strategic benefits would also arise from new nuclear build:

- medium term employment and economic stability around the selected sites. These are generally in rural areas where the input of well paid technological jobs is of great value to the community;
- UK plc would be able to maintain and demonstrate a sound technology base from which to grow the economy;
- expansion of the nuclear generating base would enable the UK to re-enter the international arena for research in to fast reactor technology. The addition of fast reactors would dramatically improve the sustainability of the nuclear fuel cycle and convert the existing stockpile of depleted uranium into a valuable commodity.

Other Issues

Legacy wastes

26. Many people confuse the issue of legacy wastes, ie those currently in existence and arising from initial development of the nuclear fuel cycle and of weapons, with future new build. These issues are clearly distinct and must be considered separately. It is incumbent on the Government to promote and defend this dissociation to the public and the Media.

27. Legacy waste stocks are unique in that most of the activities which generated those wastes happened in the past or will continue to happen only until the remaining Magnox and AGR fleets are closed and decommissioned. Much of the older wastes have arisen or are stored in conditions which would not arise under current practises or with current reactor technology.

28. The technology to retrieve and process legacy wastes safely into stable forms, and to dispose of them, exists. What is needed is the political will to select a disposal route and to robustly present that to the public and the Media.

29. Whilst it is imperative that a disposal route is decided for legacy wastes, this should not be allowed to impact on the decision for new build. Sizewell B was successfully divorced from the legacy wastes issue; there is no reason why, given the political will, that new build could not also be so divorced.

Future waste from new build

30. What is apparent is that nuclear waste arisings from the postulated new build will be significantly lower in volume than from past reactor designs. Advances in fuel performance have dramatically reduced waste arisings. Light water reactors use significantly less raw material to build (and therefore to potentially become contaminated or activated) than gas graphite reactors.

31. It is, however, incumbent on the Government and the generating companies to determine a firm fuel and waste disposal strategy to cover realistic lifetime arisings of radioactive waste (spent fuel and other arisings) prior to proceeding to new build. As well as providing political capital and allaying any public concerns, this would enable more accurate financial provision for waste disposal and decommissioning, which then needs to be built into the electricity pricing structure. (The same would also be true for fossil capacity: hitherto, waste disposal has been by free dumping into the environment and with redundant buildings left standing. Continued future use needs to incorporate waste capture and disposal, plus decommissioning costs.)

Security

32. Two major concerns cited against new nuclear build are acts of terrorism and proliferation due to the availability of plutonium.

33. Of necessity, nuclear plant is physically robust and therefore relatively hardened against terrorist attack. It is, perhaps, a sad fact of life that terrorists target what they can, and use what they can. Experience has shown that there are far easier, more effective, higher profile terrorist targets in the country than nuclear installations. There are also many ways to contaminate large areas and render them at least temporarily uninhabitable, other than the use of nuclear material. The terrorist threat is therefore no more significant with nuclear plant than without it.

34. UK has now over 50 years experience of operating a nuclear fuel cycle (almost 50 years commercially) and transportation, processing and storage of plutonium. A significant proportion of that time has seen regular active terrorism across mainland Britain. Whilst there is clearly no room for complacency, it has been demonstrated that the UK has the necessary will and capability to continue to do this without risk of proliferation or loss of plutonium to terrorists.

35. Indeed, the use of MOX fuel in a fleet of thermal nuclear reactors could consume more plutonium than it generated, providing a net reduction in the UK plutonium stockpile.

Conclusion

36. In order to adequately address climate change, electricity demand needs to grow as direct use of fossil fuels is significantly reduced in all sectors. such phase out includes the electricity generating sector. Therefore, UK will see rising electricity demand with falling capacity as older nuclear and dirty fossil fuel capacity is retired.

37. The use of historic cost performance as a yardstick for nuclear projects led the Energy White Paper to incorrect conclusions regarding nuclear new build. In addition, the question of providing disposal routes for legacy nuclear wastes has been allowed to become an obstacle, when in fact legacy wastes have no real relevance or comparison to new wastes arising from new build. Technical solutions to legacy nuclear waste disposal exist now: new nuclear build should not be delayed whilst the political implementation of these solutions is debated.

38. Building a new fleet of nuclear power stations would not pose any serious additional threat from terrorism or proliferation.

39. As such, there is a need for deployment of significant new carbon free generating capacity, which necessitates new nuclear build alongside new renewable build.

Annex 1

OSPAR OBLIGATION TO IMPLEMENT PRACTICABLE ALTERNATIVES TO FOSSIL FUELS

A1.1 *Citing the OSPAR convention Article 2 clause 1 requires: (emphasis added for clarity)*

The Contracting Parties shall, in accordance with the provisions of the Convention, take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. To this end Contracting Parties shall, individually and jointly, adopt programmes and measures and shall harmonise their policies and strategies.

A1.2 *"Pollution" is defined in Article 1 "d" as:*

"Pollution" means the introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea.

A1.3 Releases of carbon dioxide from the burning of fossil fuels is widely accepted to be causing global warming by enhancing the "greenhouse effect". These releases are therefore indirectly introducing energy into the maritime area caused by man:

- The results of this introduction of energy are widely accepted to include:
  - increased sea temperatures, resulting in:
    - harm to marine ecosystems;
    - possible harm to living resources;
    - rise in sea level, giving rise to flooding of low coastlands, and hence damage to amenities;
    - change in weather patterns resulting in hazard to human health (including loss of life in high winds), harm to living resources and damage to amenities.

A1.4 *Whilst this scenario is not proven, Article 2 clause 2 requires that:*

The Contracting Parties shall apply: the precautionary principle, by virtue of which preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship between the inputs and the effects.

A1.5 *Article 2 clause 3 stipulates that:*

In implementing the Convention, Contracting Parties shall adopt programmes and measures which contain, where appropriate, time-limits for their completion and which take full account of the use of the latest technological developments and practices designed to prevent and eliminate pollution fully. To this end they shall: taking into account the criteria set forth in Annex 1, define with respect to programmes and measures the application of, *inter alia,*

- best available techniques;
- best environmental practice;
- including, where appropriate, clean technology;
- in carrying out such programmes and measures, ensure the application of best available techniques and best environmental practice as so defined, including, where appropriate, clean technology.

A1.6 There is nothing in this clause which supports the view that it is alright to continue building and operating power stations or road vehicles which discharge greenhouse gases on the grounds that there is no practicable technology to abate the discharge. Rather, the clause does support the view that alternative technologies should be implemented instead.

A1.7 Taking this, for example, into the arena of transport policy, it would be incumbent on the contracting party to implement policies where diesel locomotives were replaced with electric locomotives using electricity generated by non-fossil means.

A1.8 *Further, Article 4 requires:*

The Contracting Parties shall apply the measures they adopt in such a way as to prevent an increase in pollution of the sea outside the maritime area or in other parts of the environment.

A1.9 Thus, implementation of such measures as the sequestration and storage of carbon dioxide released from burning fossil fuels in underground reservoirs or deep ocean, which would result in the pollution of those parts of the environment, is not allowable under OSPAR.

A1.10 *Thus, in summary*

A1.11 The OSPAR convention requires that Contracting Parties shall take all reasonable steps to prevent and eliminate the release of greenhouse gases (in general) including carbon dioxide released from the use of fossil fuels (coal, gas, petrol and other oil derivatives), and shall individually and jointly adopt measures to implement this.

A1.12 The convention further requires that steps and measures implemented are not limited to arguments that back end abatement technologies are not practicable: rather it is required to compare current greenhouse gas producing technologies with alternative technologies.

A1.13 The convention precludes the implementation of back end clean up measures which transfer the pollution from the OSPAR maritime area to any other maritime area or any other sector of the environment.

13 September 2005

Memorandum submitted by Anthony Powell

1. I'm taking the energy industry as a whole, because it all emits CO_2 and CO_2 is what were trying to cut. My submission relates to the first part of your question 2: What are the main investment options for electricity generating capacity?

2. The cheapest option is to cut demand. Substitute air travel for rail and coach; promote the UK for our holidays. Cut car weights and the need for them. Reduce speed limits, thereby also encouraging other transport modes. Introduce Domestic Energy Quotas (like Domestic Tradable Quotas, but use them when paying for any energy—fossil or renewable—and any non-local travel). All new buildings should be low or zero carbon. Bring Carbon Trading to all businesses. Encourage local sustainability in order to reduce transport needs.

3. That should knock a serious hole in our energy consumption. We might stand a chance of meeting the rest from renewable sources.

4. Starting with information from the DTI leaflet "UK Energy Flows 2001":

Sector	*2001 use, mtoe*	*My proposed % cut*	*Reduced usage, mtoe*	*Notes*
Transport	54.9	80%	11	25% of transport was air travel—mostly replaced by rail. No unnecessary car journeys, lower max speed, low-weight, fuel efficient vehicles, local sustainability.
Domestic	48.6	50%	24.3	Zero-energy new-build and multi-family homes. Education and energy efficient appliances. Don't forget washing lines—some current housing types can't have them.
Industry including iron and steel	35.1	50%	17	Less consumer and industry waste; better, longer-lasting products; recycling encouraged by zero-waste policies and levelling of exchange rates.
Power Station conversion losses	56.7	75%	14.2	Would be 50% supplying the 50% more efficient industrial and domestic sectors, but factor in proportion of non-thermal renewables. Increased efficiency of fossil stations countered by CO_2 sequestration costs.
Energy industry use and distribution losses	20.2	70%	6	Lower demand means less losses. Contribution from embedded supply.
Non-energy use	10.9	100%	0	Use of renewable feedstocks
Total	226.4		72.5	68% reduction!

5. The Energy Review, under its Global Sustainability scenario, assumed for 2050 an energy use of about 150 mtoe of which 50 mtoe was renewables, the rest gas and oil. The above table shows it can be done with less gas and oil—but either needs the concerted effort of the whole Team UK. Domestic Energy Quotas could get everyone on board.

6. After cutting needless activities and employing energy efficiency, we should look at renewable energy. Passive solar, heat pumps and wood-burning are perhaps the most cost effective small-scale, especially when designed into buildings. Other technologies are best left for larger schemes, not micro-generation: probably locally owned rather than large-scale controversial. Rooftop PV will be more economic if many rooftops feed into a common grid access.

7. Next option is clean fossil fuel, and last resort (as I fear the terrorist risk, and would hate to pass on radioactive material onto future generations) nuclear.

21 September 2005

Memorandum submitted by Dr J A Pritchard, JAP Consultancy Services

The Inquiry raises a number of issues on which I would like to comment.

The first point to bring out is the scale of the problem. Nuclear power has been contributing some 20% of the electricity supply in this country.

Within the next 20 years or so virtually all of the operating nuclear power stations will have reached the end of their lives. Since there is little sign of a reduction in the rate of increase in the demand for electricity (despite better insulation etc) we will be faced not only with replacing that 20% loss but supplying the increase in demand anticipated in that timescale. At the same time we are committed to reducing our carbon dioxide emissions according to the Kyoto agreement.

Are renewables the answer? There is a great deal of talk about wind turbines, particularly from "green" groups but again the scale needs to be addressed. A single nuclear power station typically generates 1000 megawatts of electricity. The largest of the wind turbines generates (assuming the wind continues to blow at the correct speed) some 5 megawatts. Simple mathematics tells us then that at least 200 (400 ft tall!!) wind turbines are required just to replace the output from one nuclear power station. Is this an environmentally acceptable, let alone practicable solution?

Nuclear waste is an important issue but , again, there is much confusion in the minds of the public. There is a world of difference between waste stored at Sellafield, arising from reprocessing of nuclear fuel, and that accumulated on the nuclear station sites. The High Level Waste at Sellafield accounts for 95% of the total radioactivity of UK waste, but only 0.5% of the total volume. The Intermediate Level Waste on power station sites represents just 5% of the total UK radioactivity. Technology for dealing with the High Level Waste is available (immobilisation by glassification) and is being applied. This process should be accelerated to minimise stocks of liquid waste. The most effective way of dealing with the Intermediate Level Waste remains to be agreed but immobilisation (by grout encapsulation) is also an option here. Generally the disposal of nuclear waste is an issue which must be resolved whether there is a future nuclear generation programme or not. However, the construction of new nuclear power plant on existing sites would obviate the need for complete removal of all waste and reversion to a green field site and the associated high cost. There is a strong need for joined up thinking here.

There is no point in the Nuclear Decommissioning Agency pursuing a rapid decommissioning and clean-up policy, investing large resources in removing services and converting closed power stations to green field sites for the Government to then announce support for a new nuclear build programme with common sense dictating building on existing sites.

Construction of nuclear power stations is capital intensive with a long lead time to revenue return. With the present uncertainty on Government policy on treatment and disposal of waste, and therefore uncertain "back-end" costs, it is unlikely that private investors would wish to commit funds to nuclear build without some subsidy or Government support.

However, nuclear power is currently the only large scale electricity generation process which does not involve combustion of hydrocarbons with the associated emission of carbon dioxide to the environment. It is capable of making a substantial contribution to our environmental release commitments, therefore, and should be included in a sensible generation mix. So-called renewables can also play their part in reducing greenhouse gas emissions but it is likely to remain a relatively small contribution.

Nevertheless they are receiving vast sums in subsidies. The same arguments that are used to subsidise renewables could be applied to providing some form of incentive to new nuclear build. Given the relatively long lead time for nuclear construction, this decision should be reached sooner rather than later. An early decision is also required to ensure that a nuclear build capability remains within the UK.

15 September 2005

Memorandum submitted by Prospect

INTRODUCTION

1. Prospect is a trade union representing 105,000 scientific, technical, managerial and specialist staff in the Civil Service and related bodies and major companies. In the energy sector, we represent scientists, engineers and other professional specialist staff in the nuclear and radioactive waste management industries, the wider electricity supply industry and, increasingly, also in the gas industry. Our members are engaged in operational and technical management, research and development and the establishment and monitoring of safety standards, environmentally and in the workplace. Other members are directly involved in a range of sectors and functions for which environmental issues are of significant professional concern. We are fortunate in being able to draw on this broad range of knowledge and expertise to inform our views.

2. Key points of our response are summarised below, followed by Prospect's answers to the specific questions posed by the Select Committee. Finally, we also highlight particular concerns relating to the future supply of jobs and skills across the energy sector. It is worth emphasising that our responses focus on the

energy sector because the Select committee's inquiry does. However, it is clearly the case that an effective climate change strategy requires action on a much more front, and not least in the road and air transport sectors where emissions continue to rise steeply.

SUMMARY OF KEY POINTS

The Extent of the Generation Gap

- The trajectory of UK electricity forecasts exist in the context of an inexorable rise in global demand. The generating capacity to meet this demand continues to undergo significant change with the impending retirement of nuclear and coal plants and the uncertain but policy driven arrival of renewables.
- In aggregate around 75% of existing plant of all types will require replacement over the next decade or so. It is important to provide for the capabilities of different generation sources and combinations of sources to meet differing needs.
- If renewables or other generation sources do not fill the short fall, and given the expectation of rising demand, then the capacity margin will diminish to level where continuity of supply will become a high profile issue. The adverse social, economic and political consequences of reaching a point where customers face load shedding due to capacity shortfalls should be self evident.

Financial Costs and Investment Considerations

- The 2004 study by the Royal Academy of Engineering into the comparative costs of energy generation found that nuclear was closely competitive with CCGT plants, and cheaper than all other options.
- A nuclear new build programme would take around 10 years including licensing, tendering and construction. (There is no reason why the design licensing process could not proceed in parallel with political/national debate about new nuclear build, leaving final approval subject to Parliamentary decision.
- Pay back periods for nuclear construction will be longer than for other energy sources. However it is important that costings are done on an equivalent basis, taking account of back end costs and discount factors. Prospect believes that whole-life costs should also take account of environmental and efficiency criteria eg energy units generated and carbon emissions.
- Coal-fired generation should be safeguarded in the interests of supply security and for its contribution to environmental objectives[329]. Realising the full potential of clean coal will require investment in research, development and demonstration.
- A policy framework must be created whereby market participants are incentivised such that they do not simply choose generation new build options on rate of return considerations and can accommodate shareholder value pressures with broader energy policy aims.
- The technologies for nuclear decommissioning are well understood and whole-life costs compare favourably with any other form of generation. Costs would be further reduced if Britain pursued a long-term nuclear programme, like France. New nuclear build is a long-term investment and needs a stable electricity market against which this investment can be judged. The current market and the lack of long-term Government commitment do not provide this.
- Crucially compared with the current nuclear waste legacy, 60 years of operation of eight AP1000s would only produce a 10% increase in high and intermediate level waste and a 5% increase in low level waste.[330] However Prospect believes that an upfront, clearly defined resolution of all waste issues, legacy and from a new nuclear fleet, is a prerequisite to assuage public fears that arise on both cost and safety grounds.
- Further, to aid a rational consideration of costs between different generation sources comparisons must factor in all aspects of the source being viable. For example the need to hold conventional reserve available to meet the inherent intermittency of wind generation needs to be translated to a unit cost. There are well-researched problems with the ability of wind turbines to replace existing nuclear, coal or gas generation. These are the size of wind farms and their impact on visual amenity; system stability consequences of increased reliance on wind generation and wind farm availability.

[329] In June 2002 the then Energy Minister recognised the importance of clean-coal technology both domestically and in terms of its export potential. "Probably the best thing we could do globally for the environment is to make sure that clean coal is used in countries that are heavily dependent on coal and in most cases on old and dirty technology".

[330] NIREX: Radioactive Wastes in the UK; A summary of the 2001 inventory, October 2002, and supporting documents.

— Prospect believes that there is a continuing role for both nuclear and renewables and that an even-handed approach must be applied to assessing the costs and benefits of each energy source. The Inter-Departmental Analysts Group report published by the DTI shows this to be essential if the UK is to come anywhere near close to meeting the Royal commission on Environmental Pollution (RCEP) targets for CO_2 emissions.

— The challenge for any participant is to justify commitment to new generation without a sustained period of higher trading prices. Of course such conditions will draw fire from large users and the domestic market and could weaken faith in market solutions.

— Inevitably nuclear new build involves greater initial commitment of capital and returns that are in the longer term. In our opinion apparently unique nuclear risks can be addressed by a combination of a policy framework that values the carbon free generation from nuclear stations, the early adoption of a politically and technically acceptable solution to waste, a long term commitment to a new fleet of stations based on a "standard" design, and a more streamlined planning process. In other words a stable regime in which costs, timescales and returns can be clearly calculated. However we must make the observation that energy shortfall and environmental improvement are strategic questions for the country as a whole and should not depend purely upon the risk perspective of the financial markets. These are issues that the Government has itself recognised through incentivising investment in renewables despite the significant costs of doing so.

— It is also worth noting that the greatest challenges for transmission and distribution will arise from any move to large-scale generation from renewable sources. In particular, it is evident that a major expansion of distributed generation would have a dramatic impact requiring solutions to a range of engineering issues associated with distributed generation. There are major implications for construction and may also be environmental implications, especially if power lines are required from remote locations to population centres and grid connections are not local. It is conceivable that transmission issues could be the limiting factor on renewable development in some areas.

Strategic Benefits

— Despite good early progress, UK carbon dioxide emissions are now higher than they were a decade ago. Eight AP1000 reactors would generate the equivalent of the current 25% nuclear contribution, so by 2020 we could have recovered the situation of 25% of electricity generation being CO_2 emission free, reliable, with fuel from stable sources and cost effective. If this is coupled with say, 10–20% from renewables and 20% CCGT generation, plus contributions from micro-generation, energy efficiency measures and changes to transport fuels, we may stand a chance of meeting the Government CO_2 emission targets. Nuclear power could also be used to power hydrogen plants to power fuel cells and reduce some of the transport generated CO_2 emissions.

— Worldwide demand for gas, in common with all fuels and many other commodities, looks set to rise sharply over the medium term. This is largely driven by the fact that major economies such as China and India are experiencing rapid economic growth, with the associated rise in energy demand. UK electricity security is projected to go from being the best in the G8 to the worst within two decades.

— The nuclear option should not be considered as an alternative, but as part of a balanced energy mix. All forms of generation have drawbacks. For nuclear public and political acceptability, coupled with long construction times and problems of design changes have been historical burdens. But new technology is available; designs licensed eg in the USA and Finland; efficiency is improved and costs reduced for construction and operation.

Other Issues

— Prospect is concerned that however good the CoRWM process is, proposals may well falter at implementation phase due to lack of public, political or financial support. The key challenges at this stage are societal, not technical, and in Prospect's view responsibility lies with the current generation to take the steps necessary for creating the framework for safe, environmentally sound and publicly acceptable radioactive waste management. We believe that the implementation of a long-term waste management facility should start as soon as possible to minimise the burden put on future generations.

— Although of underlying importance to future sustainable energy generation, the implications for jobs and skills are not explicitly addressed in the inquiry questions. For all energy sources investment needs to be assessed both against the positive contribution to achievement of the climate change targets adopted by the Government and a wider range of sustainability principles.

— The nuclear industry plays a key role in the UK economy, employing 40,000 directly and supporting many additional jobs. Many of these are skilled jobs in areas where these are scarce, and future nuclear build would offer opportunities to maintain and grow the role played by the industry in this respect.

- — We are aware of work being undertaken on labour and skills requirements by the Cogent and Energy and Utility Skills Sector Skills Councils, and consider that this should be published for debate and action. Sector skills agreements must be genuinely forward looking, developed in partnership and delivered by means of a joined up approach at local, regional and national level.
- — Transition to a low carbon economy will also have implications for the wider skills base, in particular to maximise the benefits and minimise the costs of change in energy intensive sectors. The approach taken must be forward looking and provide time and support for adjustment not, as in the past, based on post-hoc packages of assistance to deal with the consequences of regional dislocation. It must also focus strongly on quality of employment. Transitional skills strategies must provide support for well-qualified staff at all organisational levels as well as for lower skilled employees who may lack a portable or adaptable skills base.

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

3. The trajectory of UK electricity forecasts exist in the context of an inexorable rise in global demand, with some commentators suggesting that world demand may rise by 75% over the next two decades.[331] UK demand has risen steadily by 1–2% per year and in our opinion whilst energy efficiency measures may moderate growth rate, demand will continue to rise.

4. The generating capacity to meet this demand continues to undergo significant change with the impending retirement of nuclear and coal plants and the uncertain but policy driven arrival of renewables. The DTI analysis is a convenient starting point for an assessment of the consequences of the change in generation pattern[332]:

2020 Projections of Electricity Generation, Base Case

Gas: 68%
Coal: 13%
Renewables: 11%
Nuclear: 7%

2020 Projections of Electricity Generation, Carbon Savings Model

Gas: 59%
Renewables: 25%
Nuclear: 9%
Coal: 7%

5. Nuclear currently provides about 25%. The prospective rundown of nuclear capacity that may be impacted or accelerated by the NDA is as follows[333]:

2005	22%
2008	18%
2012	13%
2013	8%
2023	Less than 3%
2035	0

6. In aggregate around 75% of existing plant of all types will require replacement over the next decade or so. Projections will depend on progress with the introduction of renewables and what decisions are made on replacement capacity for the nuclear power stations that will close once they reach the end of their operating lives. It is important to provide for the capabilities of different generation sources and combinations of sources to meet differing needs. For example CCGT stations give good, fast reaction capacity, including as back up for intermittent renewable sources, whereas nuclear is best suited as base-load generation.

7. If renewables or other generation sources do not fill the short fall, and given the expectation of rising demand, then the capacity margin will diminish to level where continuity of supply will become a high profile issue. The adverse social, economic and political consequences of reaching a point where customers face load shedding due to capacity shortfalls should be self evident.

[331] The Nuclear Communications Network Feature no 12 13/9/05.
[332] DTI Energy White Paper.
[333] Derived from British Nuclear Energy Society data. These figures do not take account of the recently announced life extension to Dungeness B power station.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?*

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

8. The 2004 study by the Royal Academy of Engineering into the comparative costs of energy generation found that nuclear was closely competitive with CCGT plants, and cheaper than all other options. However, these conclusions were based on a gas price forecast of 23 pence per therm compared to current forward prices in excess of 55 pence per therm.[334]

9. International price forecasts are difficult to interpret on a consistent basis due to nation-specific variables, such as cost of fossil fuels in a particular region or availability of high quality renewable resources. Nuclear does have the advantage in this regard that uranium is both in plentiful and secure supply and constitutes a small proportion of total generating costs.

10. For nuclear the "build time" will roughly be:

- Three years to licence the design and obtain the regulators endorsement of site and design. (There is no reason why the design licensing process could not proceed in parallel with political/national debate about new nuclear build, leaving final approval subject to Parliamentary decision.
- Two years to conduct the tender process, obtain financial backing and place a contract.
- Five years for construction.

This 10-year process assumes that no extensive enquires or policy changes impact timescales to delay the process.

11. Pay back periods for nuclear construction will be longer than for other energy sources. However it is important that costings are done on an equivalent basis, taking account of back end costs and discount factors. Prospect believes that whole-life costs should also take account of environmental and efficiency criteria eg energy units generated and carbon emissions.

12. Prospect has consistently argued that coal-fired generation should be safeguarded in the interests of supply security and that it also has a contribution to make to environmental objectives[335]. Realising the full potential of clean coal will require a range of measures which, in our view, should include immediate provision within the UK's National Allocation Plan under the EU Emissions Trading Scheme for fitting, and retro-fitting, Supercritical and Flue Gas Desulphurisation (FGD) technologies. Retrofitting allows innovative technologies to be proven in shorter timescales and at less risk and cost than on complete new plants. Looking ahead, expansion of the UK programme of clean coal R&D should facilitate full examination of the range of clean coal technologies, including integrated gasification combined cycle (IGCC), carbon capture and storage and next generation technologies including integrated gasification fuel cells and hydrogen from coal. For example, one of the key issues that needs to be resolved before IGCC technology can be offered commercially is reliability, requiring further work on system integration, gas clean-up and consistent gas turbine performance. It is certainly the case that market risk aversion is currently being compounded by uncertainties surrounding the future of the Large Combustion Plant directive and EU Emissions Trading Scheme. Innovative practice therefore needs to be supported through demonstration of state-of-the-art plant, which in turn provides references for other potential customers at home and abroad. The Advance Power Generation Technology Forum has recommended funding of £10–20 million pa for clean coal research, development and demonstration. We think that this is likely to be at the lower end of support required to make a significant impact.

13. In our opinion the UK Government will also need to recognise that reliance on pure market solutions for the generating mix means that achievement of emissions targets is unlikely and supply margins will be increasingly at risk. Government intervention designed to ensure fuel source balance and to stimulate progress on environmental objectives does not require the abandonment of the market in its entirety. But it must mean the creation of a policy framework where market participants are incentivised such that they do not simply choose generation new build options on rate of return considerations and can accommodate shareholder value pressures with broader energy policy aims.

[334] The Costs of Generating Electricity—Royal Academy of Engineering (2004).

[335] In June 2002 the then Energy Minister recognised the importance of clean-coal technology both domestically and in terms of its export potential. "Probably the best thing we could do globally for the environment is to make sure that clean coal is used in countries that are heavily dependent on coal and in most cases on old and dirty technology".

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

14. Prospect believes that there is a continuing role for both nuclear and renewables. Indeed, the report of the Inter-Departmental Analysts' Group published by the DTI shows this to be essential if the UK is to come anywhere near to meeting the RCEP targets for reducing CO_2 emissions. An even-handed approach must be applied to assessing the costs and benefits of each energy source.

15. It is important to assess the technology as presently understood and at the current stage of development; far too often when comparing technologies the comparison has been done against what may be possible instead of the known situation (a well known statement was "electricity too cheap to meter" at the start of the nuclear age).

16. The technologies for nuclear decommissioning are well understood and whole-life costs compare favourably with any other form of generation. Costs would be further reduced if Britain pursued a long-term nuclear programme, like France. New nuclear build is a long-term investment and needs a stable electricity market against which this investment can be judged. The current market and the lack of long-term Government commitment do not provide this. Not surprisingly the Finnish decision to construct the new Olkiluoto-3 plant is cited as an illustration of how a combination of political consensus built on public confidence and proven design can lead to new build as part of a balanced fuel source policy.

17. With respect to new nuclear build the robustness of estimates should be sound, and it is unrealistic to make comparisons with past experience. In the past the UK's nuclear fleet has not been built to a standard design, whereas the AP1000 has been approved and licensed in the USA in the past year which should give confidence to recent estimates.

18. Additionally the AP1000, compared to conventional PWRs, uses 50% fewer valves, 35% fewer pumps, 80% less pipe and 85% less cable, within an overall seismic building volume of 45% less. This means that construction and commissioning should be far less complicated so, in addition to cost savings on materials and the shortening of time-scales, maintenance will be simplified and reliability increased. Equally a modern reactor will have ease of decommissioning built into the design, unlike previous generations of reactors. The design of the next generation of stations is also allied to improvement in construction techniques using modular approaches that facilitates off site testing prior to assembly at site. Essentially standardisation offers economies not previously available when reengineering and bespoke solutions contributed to cost overruns.

19. Crucially compared with the current nuclear waste legacy, 60 years of operation of 8 AP1000s would only produce a 10% increase in high and intermediate level waste and a 5% increase in low level waste.[336] However Prospect believes that an upfront, clearly defined resolution of all waste issues, legacy and from a new nuclear fleet, is a prerequisite to assuage public fears that arise on both cost and safety grounds.

20. Whilst supporting a policy that produces a genuine balance between generating sources there are particular "level playing field" issues that currently disadvantage the nuclear industry:

- Unlike its carbon-based competitors, the industry has to capture, handle and store all its waste. Thus there are no currently hidden costs associated with nuclear waste. It is totally inappropriate therefore, that attempts to "internalise" the carbon-based "externalities" using taxation and emissions trading should exclude the only large non-CO_2 producing technology currently available. This means that the industry will pay for part of the CO_2 waste management costs as well as its own.
- The industry has a highly disproportionate level of regulatory costs, including the essential and wholly supported costs of safety regulation.
- National licensing systems mean that good and properly licensed designs have to be re-licensed at considerable extra cost before they can be re-used.
- The current system for planning inquiries means that they can last for very long periods of time, with resultant delays and uncertainties that may discourage investment plans.
- The impact of economic regulation on the price of capital is particularly problematic in so highly capital intensive an industry.

21. There are in addition a number of emerging nuclear technologies that the energy market is not structured to support:

- New generating technologies are emerging that are "intrinsically safe". (The AP1000 already has features which are inherently safe). This means that safety systems depend passively on the physics of the reactor, not actively on the equipment, human designers or operators.
- In the longer term, the use of thorium may replace a uranium-based cycle.

[336] NIREX: Radioactive Wastes in the UK; A summary of the 2001 inventory, October 2002, and supporting documents.

22. Further, to aid a rational consideration of costs between different generation sources comparisons must factor in all aspects of the source being viable. For example the need to hold conventional reserve available to meet the inherent intermittency of wind generation needs to be translated to a unit cost.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

23. The CO_2 reduction targets set by the Royal Commission on Environmental Pollution (RCEP) pose a major challenge. Most scenarios posed by the RCEP involve a nuclear element and the one most clearly founded on proven technology rests to a very large degree on nuclear capability.

24. Prospect believes that there is a continuing role for both nuclear and renewables and that an even-handed approach must be applied to assessing the costs and benefits of each energy source. The Inter-Departmental Analysts Group report published by the DTI shows this to be essential if the UK is to come anywhere near close to meeting the RCEP targets for CO_2 emissions.

25. The Energy Futures Task Force has persuasively argued that the goal should be a system that, as far as is practical, is neutrally designed to be capable of accepting generation close to the points of demand as well as offering opportunities for remote generation from large plants that may have been sited to take advantage of local resources. This though, has significant implications for the development of the transmission network, its protection mechanisms and metering systems to facilitate distributed and diverse generators, ranging from commercial to domestic units. It also has implications for pricing regimes and operating expenditure, particularly for distribution network operators. The regulatory issues arising from this form of generation will also need to be addressed.

26. In terms of promoting use of renewable sources, it will be important to establish a clear economic value for environmental benefits and to resolve some of the planning difficulties that currently exist. As the Trade and Industry Select Committee have pointed out, the creation of a large number of small-scale (renewable) plants will have repercussions for the electricity transmission and distribution networks. "A critical feature of most renewables is that they are energy sources and not fuels. The difference lies in availability. Fuels are always available for use when required, albeit at a price determined by the market. Energy sources are usually intermittent, but are free. The problem is most difficult with intermittent energy sources, such as wind energy"[337]. This requires either a significant over-investment in capacity, or "capacity credit", to be sure of peak load generation and/or heavy investment in storage capacity. On the other hand, the supply of renewables such as wind power does not depend on the market and other fuels are not always available for use when required since there is a finite "run up period" for all generating plant and specific generating plant is not always available.

27. There is certainly a need for increased research and development in this area, particularly on renewable sources that have not been tackled adequately by the private sector. The development of effective, safe storage systems could also help to smooth out fluctuations in the availability of some renewable sources.

28. Prospect representatives working in this field report that there is a current lack of funding for basic research into renewable energy sources and that this is exacerbated by changing remits from funding bodies, though we note from the first annual report on the Government's 10-year framework for science and innovation that increases have recently been agreed to a number of energy R&D programmes. Further, although EU funding regimes appear to offer additional opportunities, there are significant barriers to accessing funding under a regime that emphasises economies of scale and the creation of centres of excellence and operates by means of an application process that is so complex that it is very difficult for small organisations either to resource the bidding process or carry the resultant overheads. Even in larger organisations, the resource required for bidding can prove onerous.

29. Tidal streaming and waste bio-fuels are potentially fruitful areas. The current UK research programme into bio-fuels is fragmented and under-funded and suffers from the fact that no single government department takes a lead in this area. To date most R&D on biofuels for electricity generation has focused on the potential for schemes that would supply local or regional needs. Whilst such schemes can never compete with the economies of scale offered by large power stations, the technology does offer an opportunity to meet the needs of isolated communities. For example, marginal agricultural land can be used to grow willow for biomass, which is then harvested annually and chipped for use in adapted boilers. Farm waste can be spread on the same land area, providing both nutrients for the trees and a safe disposal method that protects watercourses and the wider environment. This also offers the potential for an increase in local employment in rural areas. The development of crop-based bio-fuels for transport is at a very much earlier stage, but again there are potential benefits for rural regeneration and diversification. All generation technologies that produce their own fuel are secure and should receive the appropriate credit. Systems that can additionally run without grid connection are even more secure.

30. Scotland is an interesting example, both because of the strong political commitment to renewable generation and the potential resource base to deliver it. A recent report by the Forum for Renewable Energy Development in Scotland (FREDS) concluded:

337 Resilience of the National Electricity Network, Trade and Industry Select Committee, 2004.

— Substantial upgrades will be required to Scotland's electricity transmission system depending on the level of renewable development to be accommodated.

— Transmission capacity can only be built on the basis of firm development proposals; it cannot be built in anticipation that the newer or less established technologies will come through at some future date.

— The intermittency of wind generation combined with the imbalances that arise from generation breakdowns and demand forecast errors require additional reserves to be held. In the short-term (ie the few hours up to real-time) this is mitigated to some extent by the convenient statistical characteristics of wind, which, due to wind persistence, make generation levels somewhat more predictable.

— However, as the output of an intermittent generation portfolio can be expected to be more variable than existing conventional generation, the implications for security of supply must be considered.

— In the longer-term, retirement of existing generation within Scotland may change the network priorities. Retirement of some existing Scottish generation will reduce export levels and so make available capacity for new generation. However, if a significant proportion of existing generation should retire then, even with a significant renewables portfolio, it may be necessary to reinforce the import capacity of the network so that when generation output is low balancing supplies can be obtained from the remainder of the GB market.

31. The FREDS biomass energy group (BEG)[338] estimated that up to 450 MW of electricity could be generated using Scotland's wood fuel resource. There is also some potential to increase this amount of electrical output through the use of specially grown energy crops. The Group's report noted that biomass plant could act like conventional plant to balance the system. Biomass is a proven technology and BEG believes that significant capacity could be developed within the next five years.

32. However, there are currently indications that that the renewable targets for Scotland will be cut from 40% of generating capacity to 40% of demand by 2020. In effect this means the 40% promoted over the past couple of years reduces to 25%. This is probably a realistic reflection of the differential between installed and available capacity.

33. Whilst there is discussion of various renewable options the main focus is wind power but there are well-researched problems with the ability of wind turbines to replace existing nuclear, coal or gas generation. These are the size of wind farms and their impact on visual amenity; system stability consequences of increased reliance on wind generation and wind farm availability. We comment on each of these in turn.

34. The average 80 m diameter wind turbine has a maximum 2 MW output[339]. By contrast, a PWR station such as Sizewell B has an output of 1,200 MW, an AGR (for example Hartlepool) 1,250 MW and a large coal station (Eggborough), 1,960 MW. Therefore between 600 and 1,000 80m high turbines are required to replace a large power station.

35. However it is impracticable to group such a large number of turbines together not least because the ones at the core of the farm would be shielded by those on the perimeter and hence would be unproductive: the largest wind farm in the UK has a capacity of 40MW, the only proposed offshore plant has a capacity of 60MW. So 21 60MW wind farms or 31 40MW wind farms are required to replace an AGR even if they had the same availability but they do not. On an assumption of 30% available capacity, the actual requirement could be three times greater than this.

36. Due to the Grid Code, at current levels wind farms are not a threat to system resilience. However this is achieved by a robust Grid Code that constrains system availability, for example wind farms on the East of the Country, Yorkshire and Lincolnshire run at a planned 8% availability due to the lack of wind compared to 30% availability elsewhere. However NG estimates that above 20%, then there are serious problems with system stability that can either be achieved by a yet more robust Grid Code that reduces output (and increases visual intrusion) further. However this figure has not been published. There is conflict between building wind farms in areas of high wind, for example Wales and Western Scotland, and the current configuration of the Grid. Increasing the distance between generation and consumption will increase system losses.

37. However for wind generation to be efficient, then grid and distribution reinforcement must proceed in parallel with wind farm construction if the system is to operate effectively. DPCR 4 does not allow DNOs to do this as there is no additional allowance for more construction.

38. The British Wind Energy Association estimates availability at 35% compared to 90+% for conventional plant. Also whereas nuclear and coal stations can plan their outages, wind farms cannot plan when the wind will not blow. Comparing nuclear and wind availability, three times the capacity of wind farms are needed if this is to become a viable alternative. For example Sizewell B requires over 1800 80m high wind turbines scattered across 300 sites.

338 Forum for Renewable Energy Development in Scotland—Future Generation Sub-Group (2005).

339 British Wind Energy Association.

39. In practice, E.On have estimated that effective wind availability falls between 10 and 20% requiring 80% of wind capacity to be supported with reserve plant, usually gas or coal.[340] This reserve capacity will be less efficient if it attempts to load follow and quickly respond to drops in wind generation output: also this operating regime will require more frequent maintenance. The basis of payments to generators and carbon emissions entitlements would need to be revised for this to become a practicable alternative.

40. International experience is illuminating. Denmark has invested heavily in renewable energy to reduce its reliance on fossil fuels and imported energy with the main source being wind power. Since 1985, about 3,317 MW of mega wind turbine capacity have been installed of which 420 MW are sited offshore.[341] This investment is supported through heavy subsidies and a statutory obligation on Transmission System Operators to buy the wind output. "One consequence is that Danish householders pay almost double the UK price for electricity. Another is that wind stations and district CHP plants have regularly produced surges of surplus power, severely complicating regulation of the grid".[339]

41. Therefore a commitment to wind as the main component of a growth in renewable generation comes at a price that without subsidy may be uneconomic and open to criticism from a UK public that have been accustomed to relatively cheap energy over the last decade. It also requires network solutions that have to be factored into price regimes and then constructed assuming opposition to the visual impact of wind farms is overcome. Numerous policy considerations and adjustments flow from these limitations including review of the Grid Code; network operators funding to reconfigure their networks which need to be physically reinforced and more actively managed and the electricity trading system needs to factor in higher payments for reserve plant if substantial wind generation is to become practical.

What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

42. The problem with micro systems is that to be economic they must be locally controlled, such that consumers can use what they want when they require it. However if extra energy is generated or required it must go to or come from the "grid", but we cannot have local systems controlling the grid. To reconfigure existing networks to move from passive to active systems with greater local and potentially intermittent generation is an enormous project that has extensively covered in the deliberations of the Distributed Generation Coordinating Group.

3. *What is the attitude of financial institutions to investment in different forms of generation?*

What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

43. As we stated above markets are more likely to adopt a longer-term perspective if there is a clear economic and political framework within which to operate. Where policy direction is unclear and/or subject to sudden shifts, markets will undoubtedly work with a short-term focus. The "dash for gas" reflected the preference for near guaranteed returns in a commercial climate where corporate change increased pressure to justify investment following acquisition. The attraction of relatively short construction times, output that was pre-contracted and at the time low gas prices meant that there was no incentive to consider generation mix or long term security issues when deciding investment options. Those conditions are now in the past and the challenge for any participant is to justify commitment to new generation without a sustained period of higher trading prices. Of course such conditions will draw fire from large users and the domestic market and could weaken faith in market solutions.

44. Financial institutions evaluate investments for risk against anticipated return. The greater the risk associated with the investment the larger the premia applying to the financing. Inevitably nuclear new build involves greater initial commitment of capital and returns that are in the longer term. In our opinion apparently unique nuclear risks can be addressed by a combination of a policy framework that values the carbon free generation from nuclear stations, the early adoption of a politically and technically acceptable solution to waste, a long term commitment to a new fleet of stations based on a "standard" design, and a more streamlined planning process. In other words a stable regime in which costs, timescales and returns can be clearly calculated.

45. However we must make the observation that energy shortfall and environmental improvement are strategic questions for the country as a whole and should not depend purely upon the risk perspective of the financial markets. These are issues that the Government has itself recognised through incentivising investment in renewables despite the significant costs of doing so.[342]

[340] E.On Wind Report (2004).

[341] Wind power in West Denmark- Lessons for the UK. Dr V.C. Mason (August 2005).

[342] Public Accounts Select Committee report "Department of Trade and Industry: renewable energy" (2005), includes conclusion that "The Renewables Obligation is currently at least four times more expensive than the other means of reducing carbon dioxide currently used in the United Kingdom . . . A carbon tax would be a less complex way of reducing carbon emissions".

How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

46. We agree with the assessment by the Trade and Industry Select Committee that "Even the most enthusiastic advocates of market forces admitted that liberalised competitive markets did not necessarily provide investment in areas like infrastructure, and that state intervention might be necessary".[332]

47. Nuclear plants have relatively high capital costs but low marginal operating costs. They run most economically at very high load factors, supplying the demand for "baseload" electricity. A number of recent studies have looked at the relative costs of generating electricity from a variety of different technologies, including nuclear. From these it is possible to draw the conclusion that nuclear competitiveness mainly depends on the capital cost of the plant, which includes the construction time, together with the discount rate used. The industry is confident that new reactors will be fully competitive with other alternatives if "overnight" capital costs can be achieved in the range of $1,300–1,400/kW, assuming construction times of no more than five years and financing available at less than 10% per year. If fossil fuel use is significantly penalised by carbon taxes or emissions trading regimes, the competitiveness of new nuclear plants improves further.

48. We are well aware that the Government is not looking to finance new nuclear generation and that if a decision to proceed with new build were to be made the investment would have to be provided by the private sector. That investment can be realised, provided the Government takes action to address uncertainties in the consents and other regulatory processes.

49. It is also worth noting that the greatest challenges for transmission and distribution will arise from any move to large-scale generation from renewable sources. In particular, it is evident that a major expansion of distributed generation would have a dramatic impact requiring solutions to a range of engineering issues associated with distributed generation. This includes transforming asynchronous generation into synchronous systems.

50. As noted in the supplementary submission from the National Grid to the 2001 Performance and Innovation Unit review of energy policy, there are major implications for construction. NGC drew particular attention to the lead-time involved in transmission reinforcement due to the need to gain planning consents.

51. There may also be environmental implications, especially if power lines are required from remote locations to population centres and grid connections are not local. As the Energy Futures Task Force (EFTF) have stated "The goal should be a system that, as far as is practical, is neutrally designed to be capable of accepting generation close to the points of demand as well as offering opportunities for remote generation from large plants that may have been sited to take advantage of local resources".[344] We agree with this. Point of use generation should be encouraged, not least because it avoids the energy and capital overheads required by grid expansion. However, there are also implications for pricing regimes and operating expenditure, particularly for distribution network operators.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

52. Assuming no overall increase in the level of funding available the impact of major investment in nuclear build would not take effect until funding was required, which under current projections would not be until five years after the decision to proceed was made. This time could be shortened but even if it were halved, investment in renewables would not be affected for at least three years. After that the effect would depend on the scale of investment required for new nuclear build, the financing from the private sector and other calls on the public purse. This is best judged by the Government.

53. We also consider that policy action is needed to deliver large-scale improvements in energy efficiency. The current approach, in which advice and assistance is made available via a plethora of agencies, relies on the motivation of individuals to seek out support. In addition, consumers who have already invested in domestic energy saving methods have little incentive to take further steps. Yet, by far the more significant challenge is to engage the majority of non-motivated consumers. Every effort must be made to avoid artificial barriers that discourage involvement.

343 Trade and Industry Select Committee, "Resilience of the National Electricity Network" (2004).

344 Foresight Energy and Natural Environment Panel—Fuelling the Future (2001).

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

54. Despite good early progress, UK carbon dioxide emissions are now higher than they were a decade ago. It has already been conceded[345] that the Government target for reducing emissions by 2010 is unlikely to be met. All sectors must play a role in this and it is clear, in particular, that closer scrutiny and early action is required to deal with increasing emissions both from road transport and aviation. As far as energy generation is concerned, it is also increasingly clear that other low carbon technologies, including nuclear, have a role to play alongside renewables if the UK is to keep on a realistic track towards it's longer-term targets and ultimately achieve a 60% cut in emissions by 2050.

55. Eight AP1000 reactors would generate the equivalent of the current 25% nuclear contribution, so by 2020 we could have recovered the situation of 25% of electricity generation being CO_2 emission free, reliable, with fuel from stable sources and cost effective. If this is coupled with say, 10% from renewables and 20% CCGT generation, plus contributions from micro-generation, energy efficiency measures and changes to transport fuels, we may stand a chance of meeting the Government CO_2 emission targets. Nuclear power could also be used to power hydrogen plants to power fuel cells and reduce some of the transport generated CO_2 emissions.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

56. Whilst we support measures to mitigate the effects of climate change, it is clear that diversity and flexibility of supply are key features in ensuring security. Yet, our view is that the Government is too relaxed in its assessment of the consequences of growing dependence on imported gas. On most projections of present policies, with a sharply declining nuclear contribution the world will become increasingly dependent on oil and gas supplies from a limited number of producers. By 2006, the UK is likely to be importing up to 15% of gas, and by 2006–07 the UK is also likely to be a net importer of oil. These imports will be from Russia, Iran and Algeria—hardly the most reliable of trade partners.

57. Worldwide demand for gas, in common with all fuels and many other commodities, looks set to rise sharply over the medium term. This is largely driven by the fact that major economies such as China and India are experiencing rapid economic growth, with the associated rise in energy demand. UK electricity security is projected to go from being the best in the G8 to the worst within two decades.

58. The declining nuclear contribution also makes it increasingly unlikely that climate change objectives will be met. Although Prospect supports the 10% target for electricity generated from renewables by 2010, we have yet to be convinced that this will be achieved. Both annual reports issued since publication of the Energy White Paper make clear that the share of electricity generated from renewables is rising only slowly and, on present trends, the UK will fail to meet its national target of a 20% reduction in carbon dioxide emissions by 2010. Prospect supports a continuing role both for renewables and nuclear, and urges the Government to take immediate action to ensure that both sources maximise their potential.

59. Whilst the distribution companies are aware of embedded generation connected to their network and generally know its capabilities, their plans do not generally allow for use of embedded generation to support them in an emergency for a number of reasons: it is not normally under their control, it is location specific and can only provide support for certain incidents, and with the larger sets there may be contractual and dispatch implications. As the report produced by British Power International for the DTI in the wake of the storms in autumn 2002 about the resilience of the electricity transmission and distribution systems puts it, "The expression that companies are all "fishing in the same pond" captures the essence of concern about access to additional resources during a widespread emergency . . . the industry may end up competing for the same, finite resources".

60. In summary, nuclear is more secure than renewables, but building anything contributes to closing the gap between demand and supply.

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

61. Much is made of the risk of terrorist attacks on nuclear installations. Without being complacent the security in the UK is world class and since many other countries in the world have or are embarking on new nuclear build, it is fair to ask why the UK should be viewed differently. It is important to note that existing robust security arrangements are operated by the Office for Civil Nuclear security under the Nuclear

[345] *"As of where we are now, on the trajectory we are on, we will not meet our domestic target which we set ourselves";* Margaret Beckett, Secretary of State for Environment, Food and Rural Affairs; BBC Radio 4 *"Today",* 22 April 2005.

Industries Security Regulations 2003 based on international guidance from the International Atomic Energy Agency (IAEA). Security measures required for new nuclear stations would not therefore raise new issues of principle or policy, and costs would continue to be paid by the nuclear operators.

62. The same question needs to be asked of other energy sources. With respect to oil and gas, the issue is not so much one of finite resource, at least in the short term. The real challenge is the effort, investment and underlying political conditions needed to exploit the reserves and, as the annual report recognises, to safeguard them from terrorist and other threats. These include major supply disruptions resulting from natural disasters, including hurricanes. Furthermore, the UK is only slightly ahead of a similar explosion of demand for gas in the rest of Europe and North America. The competition for gas reserves will therefore increase significantly and relying on gas imports in the long-term could be a very costly option.

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, micro generation, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

63. The nuclear option should not be considered as an alternative, but as part of a balanced energy mix. All forms of generation have drawbacks. For nuclear public and political acceptability, coupled with long construction times and problems of design changes have been historical burdens. But new technology is available; designs licensed eg in the USA and Finland; efficiency is improved and costs reduced for construction and operation. All this makes nuclear comparable with CCGT, oil and gas generation and cheaper than renewables. The options are compatible as part of a balanced energy mix. To discount any of the options at the cost of others taking a disproportionate share would be an unacceptable risk.

D. Other Issues

6. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

64. The only reasonable assumption that can be made is that the current mix/proportion of energy supply (nuclear, coal, gas, renewables) is involved in the manufacture and construction of nuclear power stations—as would be the case for other types of power station—so construction is not carbonıfree.

65. However, the seismic building volume of an AP1000 is nearly half of that of previous generations of reactors and the numbers of pipes, valves, pumps and cables are greatly reduced, so the CO_2 emissions from new nuclear construction will be less than 50% of previous build.

66. Nuclear energy generation is almost entirely free from carbon emissions.

7. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

67. Prospect has submitted separate evidence to the Department for Environment, Food and Rural Affairs (DEFRA) in response to the consultation on the management of radioactive waste. Our evidence highlights the need for:

— All potential wastes to be considered in an integrated management policy to ensure visibility from an economic and safety perspective both in the short term and over much longer time periods.

— Knowledge and expertise within the nuclear industry to be rebuilt, as much has been dissipated into contracting and sub-contracting organisations.

— Development of a long-term management solution that is accepted as legitimate in conjunction with a wide range of stakeholders extending beyond the nuclear industry and national government, and including the general public.

— The institutional structure to honour the "polluter pays" principle and also ensure that tensions between economic, short-term safety and long-term consequences for future generations are visible and given due consideration.

68. The key challenges at this stage are societal, not technical, and in Prospect's view responsibility lies with the current generation to take the steps necessary for creating the framework for safe, environmentally sound and publicly acceptable radioactive waste management. We believe that the implementation of a long-term waste management facility should start as soon as possible to minimise the burden put on future generations.

69. Prospect is concerned that however good the CoRWM process is, proposals may well falter at implementation phase due to lack of public, political or financial support. We believe there needs to be a national debate on the implementation process and criteria and that the process for identifying potential sites and the evaluation criteria for judging between sites should be developed independent from the organisation who will use them.

Additional Issues: Jobs and Skills

70. Although of underlying importance to future sustainable energy generation, the implications for jobs and skills are not explicitly addressed in the inquiry questions.

Jobs

71. Prospect believes that for all generation sources:

— Investment needs to be assessed both against the positive contribution to achievement of the climate change targets adopted by the Government and a wider range of sustainability principles.

— There should be benefits in further developing relatively new technologies and stimulating new British industries, though this is a competitive market.

— Employment impact beyond the construction phase depends on the extent of domestically produced inputs. Technology sourced locally would have a considerably higher domestic employment impact than imported technology. Employment generated would also be higher to the extent that UK-based firms were able to export their technology.

— Any rigorous analysis would, therefore, need to consider which types of energy production the UK may have a comparative advantage in producing the inputs for, including estimating the future export potential of each, and how policy can appropriately support domestic production.

— Additionally the impact of supply chain activity in supporting employment across more remote areas with fragile economies should not be under-estimated.

72. The nuclear industry plays a key role in the UK economy, employing 40,000 directly and supporting many additional jobs. Many of these are skilled jobs in areas where these are scarce, and future nuclear build would offer opportunities to maintain and grow the role played by the industry in this respect.

73. The majority of all of the UK employment regarding nuclear fuel processing is concentrated in the North West[346]. In the South East and London region (Harwell, Culham and Aldermaston) there is a significant focus on the nuclear industry cluster. The nuclear fusion research centre is based in Culham. Caithness has a large decommissioning task, with the MoD (N) operating a large nuclear shore support base in Western Scotland. Civil and military application of nuclear technologies are separate and, whilst sometimes overlooked, nuclear medicine constitutes both important part of civil use and generates significant demand for appropriate skills.

74. A new generation of nuclear stations would benefit the UK in terms of GDP and balance of payments, for instance through reducing gas imports. The benefit in GDP terms of a programme to replace the current nuclear fleet has been assessed in a recent independent study[347] at around £4 billion per year once the stations are all operational. Part of this benefit is due to the reduced need for gas (which increasingly would be imported) if the UK retains a significant nuclear capability.

75. From a new build programme consisting of five Twin AP1000 reactors built over a period of 18.5 years, the total direct jobs involved in construction, manufacturing, operation and headquarters has been forecast at over 6,000. In addition to this there would be jobs associated with the fuel cycle infrastructure and also technical support services such as research. Direct full-time jobs also create additional employment in the community, probably in the order of 2,000.

76. It is estimated that the UK supply chain could produce virtually all of the manufactured components, except for a few key items. Companies involved in nuclear technical services would also be able to export their capabilities using UK experience to support overseas activities.

77. The programme would re-invigorate the UK as a world-leading centre for nuclear technology.

Skills

78. We share the concerns of the EFTF about the shortfall that is occurring in the number of newly qualified entrants to disciplines of importance to the energy and environment sectors. We welcomed the PIU's proposal that a comprehensive survey of labour and skills requirements in the energy sector should be undertaken. We are aware of work subsequently done, and still in progress, by the Cogent and Energy and Utility Skills Sector Skills Councils, and consider that this should be published for debate and action. Sector skills agreements must be genuinely forward looking, developed in partnership and delivered by means of a joined up approach at local, regional and national level.

79. Cogent's Nuclear and Radiological Skills Survey identifies the following areas of skills shortage in the nuclear sector:

— Health sub-sector (radiologists and radiographers)

— Radiological protection—health physics

[346] Business Clusters in the UK: A first assessment, DTI (2002).

[347] "Macroeconomic Analysis of Nuclear Plant Replacement"; Oxford Economic Forecasting (March 2005).

- Radiochemistry
- Regulation
- Nuclear education in higher education
- Modern apprenticeships
- Safety case writing
- Critical assessment
- Nuclear safety research
- Control and instrumentation
- Numerate graduates
- Project management
- Corporate capabilities

80. It also notes that within the industry there is not merely a requirement for an increase in new entrants, but for better quality recruits. Aspects of globalisation have increased the need for continuous improvement and cost cutting leading to flatter structures. Thus, at all levels there is a need for high calibre recruits with the right mix of technical and key/core skills.

81. Transition to a low carbon economy will also have implications for the wider skills base, in particular to maximise the benefits and minimise the costs of change in energy intensive sectors. The approach taken must be forward looking and provide time and support for adjustment not, as in the past, based on post-hoc packages of assistance to deal with the consequences of regional dislocation. It must also focus strongly on quality of employment. Transitional skills strategies must provide support for well-qualified staff at all organisational levels as well as for lower skilled employees who may lack a portable or adaptable skills base. The Government should lead an objective, forward-looking analysis of the balance between the positive employment impacts of growth in R&D and renewables against possible negative consequences of contraction in other energy sectors. This should also take account of indirect effects, such as employment implications in the UK of the terms of trade for energy imports. It will clear make a difference whether this is for manufactured goods or for services.

82. Government must also commit to stable long-term funding and resist the temptation either to switch R&D work on and off or to fragment it to such a degree that scientists and engineers spend their time as fundraisers and managers rather than doing the R&D required. It is not uncommon for good technologies to languish for years before funding is located. Deadlines for funding calls often do not correlate well with the stages of product development. Funding of a linked modular nature would be more useful allowing for testing of a concept which, if successful, would be guaranteed funding to the next stage and so on. This would allow for building momentum on promising projects.

26 September 2005

Memorandum submitted by the Joan Pye Project

The remit of the EAC as set out in their Press Release, is extremely broad under three headings; Nuclear, Renewables and Climate Change. On the last named we are not qualified to speak and our submission will be confined to

(a) Nuclear Power
(b) Renewables

Recommendations

Our recommendation is strongly in favour of nuclear power, with as many new-build modern type nuclear power stations as practicable, to be built if possible on existing sites by agreement with the Nuclear Decommissioning Authority (NDA). We give our assessment of renewable sources of energy and their disadvantages as sources of carbon-free energy for the national energy requirement. Renewables have a place as debating platforms to arouse public awareness of the magnitude of the energy shortage confronting this country. Their limited efficiency will preclude their ever taking the place of nuclear power. (see paras under Renewables, 7(a) to (g) below)

History of the Joan Pye Project

1. This project was formed in December, 2004 under the chairmanship of Brigadier Hugh Pye, OBE, formerly Treasurer of the Merchant Venturers Society of Bristol, and responsible for the management of their charities. The project team comprises a finance expert, two former heads of projects at the Atomic Energy Research Establishment, Harwell, and a generalist with a university background who has held

positions in industry in Europe and is familiar with the European attitude to nuclear power. I act as co-ordinator. My MA degree is in Classics, my further education in science and technology was as the Director of A.E.R.E.'s PA (seven years 1954–61), and then I worked in a middle management capacity for a total of 18 years, mixing freely with the scientific community (some 2,500 physicists, chemists and engineers) and picking up a wide-ranging, if superficial scientific education.

2. Our mission statement has been printed and distributed in this area and to selective participants nationally. It is posted on our website (as above). Our objective is to turn around public perception of nuclear power into a development to be welcomed and an electoral vote-winner rather than an electoral liability. We have also established links with the British Nuclear Energy Society (BNES), with Supporters of Nuclear Energy (Secretary, Sir Bernard Ingham), with Terence Price, former Director of the Uranium Institute, and John Ritch (Director-General, World Nuclear Association). The Project now has a list of some twenty consultants and advisers, including five Professors with a wide range of academic interests, several ex-Harwell Group Leaders (personal friends) and some 200 actively interested individuals nationwide, including Sir Christopher Audland KCMG, DL (a retired diplomat whose last posting was as a European Commissioner for Energy in Brussels). We have ongoing interests in our nearest County Primary School, for which we are helping to organise some lessons next winter, with the co-operation of their Head Teacher, within their school curriculum covering outlines of the whole field of electricity generation in Britain.

3. We have financially supported the BNES and its closely allied body the Institution of Nuclear Engineers in their Education and Training programme for student reactor engineers, who will be needed to run the nuclear reactors of the future. This year our donation funded the appointment of two post-graduate students to attend the first Summer Vacation Course run at Idaho Falls by the recently set up World Nuclear University. The next World Nuclear University course will be run in Stockholm, Sweden.

Arguments in Favour of Nuclear Power

4. We support nuclear power because it is the cleanest, the greenest (no carbon emissions) the cheapest and the most secure (no long pipelines carrying natural gas from politically unstable countries in the Middle East, Russia and Asia). It is safe with an excellent safety record, having successfully overcome the teething troubles of the early development years. It produces (with modern type reactors) only 10% of the waste generated by the early Magnox reactors, thus minimising the waste disposal issue. A table (Annex 2) of the safety record on the nuclear industry proves this. In addition, it should be possible to avoid battles over the siting of new-build reactors since the NDA are discussing the building of new reactors (much smaller and more compact than their predecessors) on existing sites. We hope that, if this decision is reached, the NDA will be responsible for their final decommissioning at the end of their lives. This would surely be an obviously common-sense decision. As this option has already been mooted, we believe the Government should take steps to protect this option as it would be a tragedy if licensed sites were turned over to alternate use when they may be needed for "new-build" in the coming two or three decades. Likewise, grid connections and capacity should be reserved. If international comparisons are appropriate, it is only necessary to look at France which has embraced the nuclear industry since 1971, and now makes 80% of the electricity it needs from nuclear sources with the general support of its population. (See Terence Price's "Political Electricity" published OUP in 1990, pp 31 et seq). It should be noted that in Japan, seven BWRs (Boiling Water Reactors) provide 80% of Tokyo's electricity needs, 8.2 Gigwatts, the last two reactors having been built in under four years. (Nuclear Future—July/Aug 2005)

Disposal of Nuclear Waste

5. We are deeply interested in nuclear waste management solutions, because this aspect of nuclear power is of such concern to the general public, and we deplore the Government mismanagement of the search for best solutions to this, peculiarly British, problem. (Other nations do not see this problem as a major obstacle to nuclear power). We deplore the attitude and management status of CoRWM, the Committee for Radioactive Waste Management, now fully exposed by its former member, Prof D J Ball, who has recently resigned (June, 2005) in protest at the way CoRWM manages its remit. This Committee was set up by Her Majesty's Government in 2003, with a remit requiring (inter alia) technical expertise. The Committee had only two practising scientists of international repute among its members, a fact harshly criticised by the House of Lords Science and Technology Committee and the Royal Society. (*) The Committee acted throughout 2004 as if it wanted to minimise quality technical input. The only health expert on the Committee, Dr Keith Baverstock, objected to this, but in April 2005 the Chairman, Gordon McKerron (supported by some other Committee members) had Dr Baverstock expelled from the Committee on grounds which have not been revealed. Professor Ball, Director of the Centre for Risk Management at Middlesex University, resigned soon afterwards in protest at this dismissal and what he considered to be the incompetence of the Committee. CoRWM was instructed to take an overseeing role and appoint expert groups to assist it. Instead, it exceeded its remit by trying to do most of the work itself, for which it was ill qualified. When it did appoint specialists, it tended to call on those familiar to it rather than recognised, independent, international experts. The House of Lords expressed the view that CoRWM was not even able to distinguish quality peer-reviewed work from any other work. Professor Ball and Dr Baverstock are now

taking their cases to the Employment Tribunal on grounds of wrongful and constructive dismissal. The Joan Pye Project regards the whole story of CoRWM as a public disaster and disgrace. In contrast to the British handling of nuclear waste disposal, the Canadians took it far more seriously. Through their NWMO (Nuclear Waste Management Organisation) the matter was the subject of a national consultation (as advised by Professor Ball to CoRWM in CoRWM Report 537).

(*) House of Lords (2004) Sci & Tech Cttee Radioactive Waste Management 5th Report; House of Lords (2005a) Sci & Tech Cttee, Radioactive Waste Management, Govt Response (House of Lords Paper 89; House of Lords (2005b) Sci & Tech Cttee, Radioactive Waste Management, Hansard 12 Jan: cols 324–334.

6. We favour the proposal of Dr Fergus Gibb of Engineering Materials Department, University of Sheffield, which involves drilling a deep shaft, on land or offshore, 18″ diameter through impermeable rock geology, for four kilometres below the land surface to reach a point where the heat is sufficient to melt both the land surface and the content of the containers of high-level nuclear waste, and melt the rock at the bottom end of the shaft. This rock subsequently resolidifies, totally sealing the already sealed containers. Clearly the fission products will never be retrievable, but scientific opinion within this project asserts that this extremely long-lived high-level waste would be too dangerous to retrieve in the foreseeable future (thousands of years). The Joan Pye Project is satisfied, after discussion in details with Dr Gibb by telephone, that the required drilling technology is proven. (A non-technical account of this project of Dr Gibb is available from him or from the Joan Pye Project on request).

Renewable Sources of Energy

7. The proportions of the various components of the total energy input for the production of electricity in Britain on 2005 and in 2020 are clearly illustrated by Dr M J Hall's pie-chart attached as Annex 1. Between these years the production of fossil fuel (coal and oil) nuclear fuel and imports has drastically fallen while dependence on natural gas coming in by pipeline has increased by nearly 25%. Natural gas will have to be imported by overground pipeline over some very unstable countries; this is supposed to make up 60–70% of the UK's electricity needs, and the pipelines will be a tempting target for any terrorist or local dissident. Moreover, methane (which can leak from pipelines) is a powerful greenhouse gas, some 20 times more powerful than carbon dioxide. A leakage of just 2% of the gas produces a situation as deleterious as burning coal. The present leakage rate is about 4% and virtually no leakage can be tolerated. The CST (Council for Science and Technology) Report An Electricity Supply Strategy for the UK (May 2005) makes clear its conviction that it will not be possible for the UK to meet its obligations under the Kyoto Protocol by using emission-free renewables within the short term between now and 2012. They recommend keeping open the option for nuclear power.

The principal sources of renewable energy are set out in paras. 7 (a) to (g) below.

(a) Wind energy and "windfarms". While we believe there is a role for some renewables within the broad spectrum of electricity provision (see the CST Report mentioned above), we are convinced that the role of wind turbines has been heavily overplayed. They can never provide the vital base load power on which much of Britain's current way of life depends, and which is presently provided mainly by the nuclear industry. Since wind turbines produce only a third of their declared capacity and need to have conventional power stations "idling" for when the wind drops, they are hopelessly uneconomic. Companies rush to build them only because of a statutory subsidy worth almost three times the value of their output. (#1) A recent planning decision in Blyth, Northumberland, awarded a group of local farmers £5,000 or £8,000 per turbine per year (depending on the height of the turbine) in a proposed scheme for 117 turbines in a large stretch of unspoilt countryside. One local farming family, the Thorntons, are quitting their farm after residence for over one hundred years because they refuse to live in a forest of windmills. (#2) Even to achieve the predicted amount of energy will require the proliferation of windfarms cresting the tops of some of the finest upland scenery in Britain—a major attraction for the thousands of foreign tourists visiting the UK. We maintain that the Government has no mandate to disfigure our native countryside with structures more appropriate to an industrial landscape. The proposed windfarms will occupy an area which is orders of magnitude greater than that taken up by a single modern nuclear power station.

(#1) Article by Dr M J Hall, FRIC FInst.Biol.: in "Conserving Lakeland" Spring/Summer 2004.

(#2) Article "Couple hit by winds of change", *Motor Boats Monthly*, Dec 2003

(#3) See also *Western Morning News* 15/9/2005 "Labour's £1 billion wind turbine rip off"

(b) Fusion Power. We are familiar with the work at Culham on the JEPT project (Joint European Torus). A well-briefed member of this project estimates that a working reactor to deliver power is at least 60 years in the future. Funding for ITER (International Thermonuclear Energy Research) has only just been agreed among the European participants after three years of argument. This does not foreshadow a rapid joint research project even given the political will (Europe-wide) to push it along faster. "The ITER co-operation has no precedent in size and scope and could well become the model for other world-wide ventures in big science"—Andreas van Agt, European Commission 1993 (Source ATOM 427 March/April 1993) ("The World Takes a Further Step Towards Fusion Power".)

(c) Solar Power. Better use of solar power, both for domestic heating and heating of industrial plant, is clearly proven and worth pursuing, but it will make little difference to total energy supplies except in a country like Denmark, where solar heating built into plans for new social housing developments is widely in use. Its use for conversion of existing domestic central heating systems in the UK has practical difficulties and is likely to be small in scale.

(d) Tidal Power. A tidal power renewable energy project in north Norway (2004) will produce electrical power by extracting energy from deep-water tidal currents. Hammerfest/Storm is leading the work with Rolls Royce Marine AS, the Norwegian University of Science and Technology and other power technology groups. Their plan was to install an underwater power plant of 20 700KW turbines in 2004, sited on the seabed. A similar project is in hand off the north Devon coast at Lynmouth. Tidal power is a renewable and non-polluting source and power (depending on tides) can be accurately calculated, but the time when power is being generated may not coincide with peak demands for electricity. The Hammerfest/Storm units will generate power for about four hours out of six. The expected life of a tidal turbine is 30 years, with servicing every three years. There are many possible locations around British coasts for such a group of turbines, but they would be subject to heavy pressures from storm weather conditions, and might require a good deal of maintenance. (see also www.tidalelectric.com)

(e) Wave Power. Ocean Power Delivery Ltd. Have today (15/9/2005) announced their securing a first order for their "Pelamis" wave energy converters for a Portuguese project. Three of these machines will be located 5Km off the Portuguese coast and will have an installed capacity of 2.25Mw. If the first stage is satisfactory, an order for a further 30 Pelamis 20Mw machines is anticipated. This interesting development is, of course, not yet proven. Even the second stage will only achieve a total of 600 Mw, just over half the output of a modern nuclear power station. With likely wind/weather conditions they too will require adequate—possibly expensive—supervision and maintenance. A Scottish company is to manufacture the components on the Isle of Lewis (Source: Ocean@oceanpd.com 15/9/2005)

(f) "Cleaner" Coal: Carbon Capture and Sequestration (CCS). We are aware of the intensive work going on to explore this new technology, but the technology is in its infancy and it seems premature to attempt to comment.

(g) Greater Energy Efficiency. Improvements in energy-efficient use could also make a greater contribution to the supply of energy. The EU's "Action Plan to Improve Energy Efficiency in the European Community." found that efficiency savings amounting to more than 18% of current energy consumption could be achieved by 2020 using existing technology, if there was the political will to achieve it. This is enough to offset the closure of UK's nuclear plants and, if applied throughout Europe, would equate to saving the whole energy demand of Austria, Belgium, Denmark, Finland, Greece and the Netherlands combined.

8. Cost of Electricity. With recent heavy increases in oil prices due to a variety of causes, the economists calculate that the price of electricity per unit to the consumer is now roughly equal as between fossil fuel and nuclear power—estimated at 2.3 pence per KwH. A comparison with costs per unit from renewables (windfarms, wave and tidal, and biomass) is unfair because of the heavy Government subsidies for renewables. Hundreds of millions of pounds, perhaps over a billion of investors' cash from all over the world is being channelled into the UK to take advantage of lucrative tax breaks and other incentives that have made Britain the most attractive place to build windfarms in the world (Source: Article, *Sunday Telegraph* 24/7/2005, by Robert Watts). The graphs prepared by the Royal Academy of Engineers in their Report "The Cost of Generating Electricity" (March 2004) give a true comparison of costs since all subsidies have been subtracted, leaving a very favourable advantage for nuclear power.

Conclusions

9. For all these reasons we recommend:

   (i) Government to be invited to back a programme of new-build nuclear power stations, starting as soon as possible.

   (ii) Government to be requested to stop subsidising windfarms.

   (iii) Government to take action, not hide behind options.

Signed: Brigadier Hugh Pye, OBE, Chairman, The Joan Pye Project

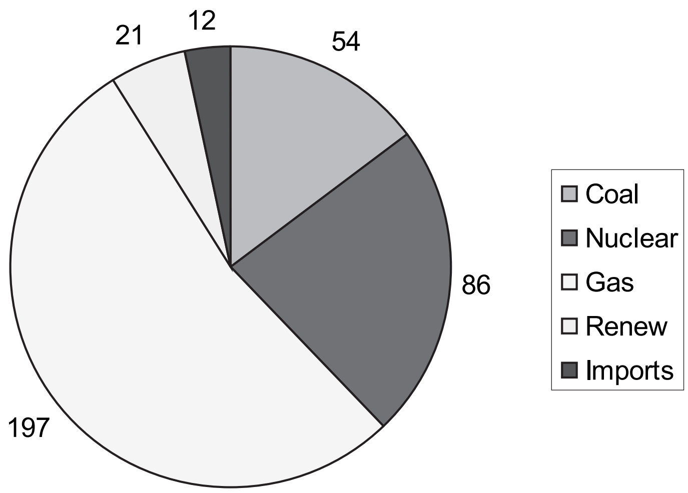
Joan Pye, MA, FINucE(Hon), Co-ordinator

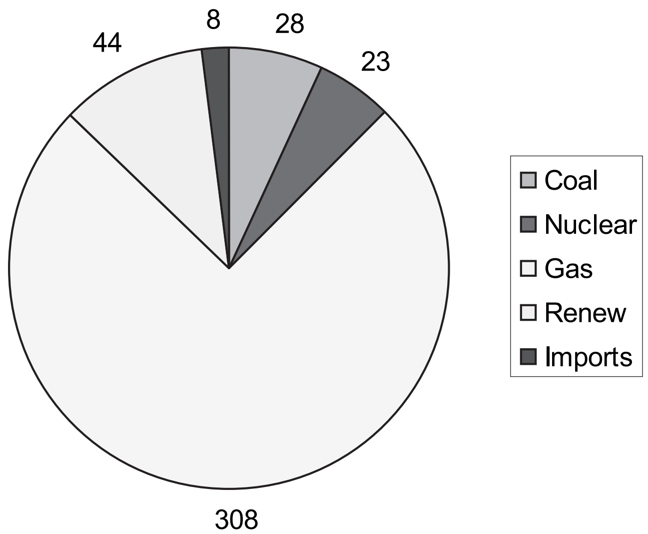
10. Acknowledgements

Grateful acknowledgements are due to those who kindly commented on earlier versions of this submission, including particularly Sir Christopher Audland, KCMG, DL, Dr M J Hall FRIC, FInst.Biol., Sir Bernard Ingham, and Terence Price who gave permission for me to use material from his book, "Political Electricity" OUP 1993.

Annex 1

Projected Electricity Generation by Fuel Type (TWh) in 2005 (from DTI website)





Annex 2

Table

NUCLEAR SAFETY IN COMPARISON WITH OTHER ENERGY INDUSTRIES

Power Source	*No of Events*	*No of Deaths*	*Deaths/Events*	*Deaths/GWE/Year*	*Deaths/TWE/Year*
Coal	187	8,272	44	0.342	342
Oil	334	15,623	47	0.418	418
Natural Gas	86	1,482	17	0.085	85
LPG	77	3,175	41	3.729	3,729
Hydro	9	5,140	571	0.884	884
Nuclear	1	31	31	0.008	8

Note: This table has been drawn up by Commander Tim Hale, RN using information from the ENSAD (Energy-related Severe Accident Database, held at the Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland)

16 September 2005

Memorandum submitted by Quo-Tec Ltd

Question	*Theme of response*
A. The Extent of the "Generation Gap"	
1. What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant?	23% of the UK's present electrical demand is satisfied by nuclear power. If closures proceed as planned only three of the current stations will be operating in 2020 and these will be capable of satisfying only 7% of the demand.
How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?	The demand for electrical energy is likely to continue to increase especially if hybrid vehicles and low carbon technologies for vehicles (eg fuel cells) are introduced. Energy efficiency improvements can operate only on the margins. Many of the savings have already been captured.
B. Financial Costs and Investment Considerations	
2. What are the main investment options for electricity generating capacity?	Nuclear fission and renewables (wind, hydro, solar, wave, tidal) if carbon emissions are to be reduced/contained. Nuclear fusion is the best long-term option and should receive increased funding.
What would be the likely costs and timescales of different generating technologies?	The RAE study showed that nuclear is cost competitive whereas wind is not. If wind is to be a serious option then adjacent storage facilities (eg flywheel systems) will be needed for the times when there is no wind.
What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)?	Others are better qualified to answer this question.
Over what timescale could they become operational?	As above.
With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience?	It should be possible to learn from the mistakes of the past and produce much more realistic and robust cost estimates. Quo-Tec is developing a proposal to capture the knowledge of retired nuclear experts. This has received encouragement from the industry and discussions have been held with the EPSRC to sponsor PhD students to work closely with these experts. The aim is to provide, in a permanent form, the tacit and formalised knowledge needed to underpin a successful next generation of nuclear power systems. A proposal for a pilot project will be presented to DTI shortly.
What are the hidden costs (eg waste, insurance, security) associated with nuclear?	There should be no hidden costs. Waste treatment is now well understood and costed. Insurance costs need to be assessed in the light of increased security needed to counter the increased threat from terrorism.
How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?	Others are better qualified to answer this.
Is there the technical and physical capacity for renewables to deliver the scale of generation required?	No, not without severe environmental impact.

Question	*Theme of response*
If there is the capacity, are any policy changes required to enable it to do so?	See Above answer.
What are the relative efficiencies of different generating technologies?	Other respondents will have this information.
In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?	No comment.
3. What is the attitude of financial institutions to investment in different forms of generation?	No comment.
What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required?	The length of time to obtain planning permission makes it very difficult for financial institutions to invest in nuclear. New nuclear stations will have to be built on the sites of the old where the local population will welcome the employment created.
How does this compare with attitudes towards investment in CCGT and renewables?	Perceived as much less risky.
How much Government financial support would be required to facilitate private sector investment in nuclear new build?	Government incentives and intervention will probably be necessary.
How would such support be provided?	Not qualified to comment quantitatively.
How compatible is such support with liberalised energy markets?	All energy markets are subject to non-market forces and governmental interventions and always have been.
What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?	Investment in renewables could be scaled back with consequently lower energy costs. Energy efficiency should be synonymous with economic efficiency and should continue unchanged.
C. Strategic Benefits	
4. If nuclear new build requires Government financial support, on what basis would such support be justified?	Combination of lowest cost and lowest environmental impact.
What public good(s) would it deliver?	Safe, secure energy which is not dependent on oil.
To what extent and over what timeframe would nuclear new build reduce carbon emissions?	Not qualified to answer.
To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?	It would ensure security of supply.
Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?	Yes.
5. In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency?	No comment.
How compatible are the various options with each other and with the strategy set out in the Energy White Paper?	No comment.

Question	*Theme of response*
D. Other Issues	
6. How carbon-free is nuclear energy?	Probably the best of any system when full life cycle is considered but others have done detailed studies on this.
What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station?	Again this work has been done.
How carbon-intensive is the mining and processing of uranium ore?	No more so than coal, gas or oil.
7. Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?	There is a misconception here. The solutions exist and are in operation daily in many countries.

17 September 2005

Memorandum submitted by the Renewable Power Association

The Environmental Audit Committee seems to be re-opening the review already undertaken in the lead up to the Energy White Paper (EWP). If as much effort had been expended in implementing the EWP recommendations, rather than reviewing them, much more progress would have been made.

In our view, the questions posed, in the most part, are too wide-ranging and the enquiry would have benefited from more focus. The line of questioning seems to centre on whether new-build nuclear is required in order to "keep the lights on". Given that renewables and energy efficiency were the two main planks of the EWP, the slow deployment of renewables is inevitably used to justify asking if new nuclear build is necessary[348]. However the renewables programme was never intended to replace existing nuclear output. If that were the case, the targets would have needed to be twice as ambitious.

We have therefore chosen to focus this evidence on the slow deployment of renewables, and what should be done about it, and to comment on the mounting criticism of the Renewables Obligation (RO) most recently from the PAC.

Slow Deployment of Renewables

Renewable electricity generating deployment is clearly not occurring as rapidly as it should. In most cases the current market value for renewable generation is greater than the generation cost; so what is the problem?

There are a number of factors—

- grid constraints[349];
- planning constraints; and
- lack of availability of long term contracts at sufficient prices (for all but onshore wind energy and the limited amount of remaining landfill gas capacity).

All three of these factors are within the Government's sphere of influence. Even if the first two constraints are removed, the final one will remain, as it is a factor inherent in the design of the RO. It is this factor that we focus on in this response.

Whilst the current market value of renewable electricity generation is high, as illustrated in the table below, the prices available to generators on a long-term basis are significantly lower. This is because suppliers discount the future values of ROCs significantly—due to the risks inherent in the RO.

348 Interestingly the lack of progress in energy efficiency seems to merit less attention. Electricity consumption has been growing consistently for many years by around 1.5% per year, with no sign of slowing.

349 Ofgem has recently issued an Open letter on the potential for offers under standard licence condition C8 of the electricity transmission licence to be issued within longer timescales than those set out in the licence http://www.ofgem.gov.uk/temp/ofgem/cache/cmsattach/12310—20005.pdf?wtfrom = /ofgem/index.jsp

Technology band	*Average auction price for six months' worth of output from NFFO contracts, beginning October 2005*
MIW	4.65p/kWh
Wind	9.05p/kWh
Hydro	9.41p/kWh
Biomass	7.43p/kWh
Landfill Gas	9.31p/kWh

Source: NFPA website, http://www.nfpa.co.uk/

Reasons for Suppliers' Discounting the Value of ROCs

Banks do not regard ROCs as a secure income stream against which to lend project finance. Therefore generators must seek fixed price contracts with suppliers. However suppliers are reluctant to give long term contracts at fixed prices, because they fear they may be left having to pay out prices which reflect historical ROC values which have since fallen significantly or at worst are worth nothing as the obligation has been fulfilled or potentially even withdrawn due to policy change.

Measures which would reduce these perceived risks are:

- Raising the RO quota from 2015–16 onwards—to keep the cliff edge further away[350]
- Implementing the "ski-slope" solution described by Ilex Energy Consulting[351] (this lessens the risk that the value of any particular ROCs will fall to zero, as if the obligation is met, the price of ROCs is smoothed evenly across all market participants thereby falling below the buy-out price, but in a predictable way).

Another approach would be to have an intermediary body that operates between electricity suppliers and renewable generators. The RPA has been advocating this approach, as described in its "pre-ROC proposal" since November 2003. It is described in significant detail on the RPA website[352], but outlined in the text below.

The RPA's Proposal for an Agency Offering Bankable PPAs

The RO is criticised for being poorly targeted, as those generators whose plants have already been commission and are no longer subject to fixed price NFFO contracts are able to access the short term (high) value for their output, whereas new-build generators, who need a larger revenue stream in order to finance the capital costs—are only able to access the heavily discounted price.

If renewable power is sold on a short-term basis its value is based on the value of the electricity and the level of shortfall anticipated in the current obligation period. If it is traded on a long-term basis, the value assigned to the ROC is reduced considerably, as described above. For the purposes of project financing, a fixed price contract with a creditworthy counterparty is required. If an agency were to act as an intermediary—purchasing output from renewable generators on a long-term fixed price contract, whilst selling it to electricity suppliers on a short-term basis, this would greatly assist generators to obtain finance (or cheaper finance) and realise more of the value of their power.

For biomass, wave and tidal projects the fixed price contracts on offer are not sufficient to make project commercially viable. This scheme could be self-financing, as the amount needed to pay some types of generators (eg wind, landfill gas or small hydro) would be lower than the amount received from selling their power on a short-term basis. The extent to which the scheme could be self-financing depends on the relative levels of cheaper and more expensive projects participating in the scheme, as well as the level of shortfall in the ROC market.

Criticism of the RO

In the RPA's view Government should put more effort into bringing down the barriers to renewable deployment and following through on its other climate change policies. The EWP, in leaving the nuclear question open, has resulted in a tendency to re-examine whether the overall energy policy is correct, to the detriment of moving forward with the drive for renewables and energy efficiency.

The investment climate for renewables has suffered, in particular from the regular questioning of the Renewables Obligation, most recently by the Public Accounts Committee report, and prior to that by the National Audit Office.

It is most disturbing that the RO is being criticised for features that were inherent in the design of the policy, and which the Government entered into knowingly.

[350] This is explained in document found on http://www.r-p-a.org.uk/content/images/articles/cliffedge2.pdf

[351] This can be obtained from the RPA website;
http://www.r-p-a.org.uk/article—default—view.fcm?section = 1&articleid = 1313

[352] http://www.r-p-a.org.uk/article—default—view.fcm?section = 1&articleid = 681

It is self-evident under a "technology blind" policy that the cheaper technologies may be remunerated to an extent over the minimum required to make projects economically viable. It is self-evident, too, that projects which have already been commissioned would be able to command a higher price than new-build projects seeking project financing.

If the Government had wanted to ensure that renewable projects received only just enough remuneration to stimulate their development and no more; if it wanted a policy that delivered a broad range of technologies and kept the cost of financing low, then it could have introduced a set of feed-in tariffs.

Feed in tariffs were not chosen, despite having been adopted widely elsewhere in Europe, as the Government wanted to limit the potential cost to consumers. The Renewables Obligation sets the target volume of renewable electricity required and sets the overall cost of the policy, and the market determines how much volume is delivered for that cost. In contrast under a feed-in tariff policy, Government would set the price, and the market would determine how much volume is delivered. The greater the volume, the higher the total cost to consumers. When the Government introduced the Renewables Obligation, the cost was deemed to be acceptable, and there was cross-party consensus on that issue. A legitimate question is the value being achieved in terms of the volume of renewable output being delivered for that cost. Instead the fundamental principles of the policy are being questioned, and the Government (DTI) is doing nothing in response.

The scrutiny of the RO from the NAO and PAC should be directed at *how the policy can be made more effective*, rather than questioning whether five years ago the right policy was chosen. We are where we are, and changing the Renewables Obligation now would be extremely problematic.

If investors begin to lose faith in the Renewables Obligation (for example as a result of the NAO and PAC criticisms and the absence of a robust rebuttal from the DTI) then a vicious circle ensues. Less money is invested in new renewables capacity, the shortfall in achievement of the obligation is widened, which increases the price of ROCs, intensifying the political pressure to change the policy. The DTI should be defending its choice of policy robustly. Instead it seems willing to cave in. An example is its proposal to reduce ROC support to landfill gas, in a misguided response to the NAO report. It has also failed to address the need to set increasing targets beyond 2015–16 as part of the 2005–06 Review of the RO. This in itself is known to lead to a tailing off of investment.

Finally to return to the question of new nuclear build; Government would have to set an extremely secure policy framework if private money is to be encouraged to invest in new nuclear build. It would be profoundly unfair if, in recognition of this, Government put in place a framework in which nuclear could be made to work, whilst it left renewables to fail because it was not prepared to provide a similarly secure framework to encourage investment in renewables.

20 September 2005

Memorandum submitted by the Research Councils UK

Introduction

1. Research Councils UK (RCUK) is a strategic partnership that champions the research supported by the eight UK Research Councils. Through RCUK the Research Councils are creating a common framework for research, training and knowledge transfer. Further details are available at www.rcuk.ac.uk

2. This memorandum is submitted by Research Councils UK on behalf of three of the Research Councils (Engineering and Physical Sciences Research Council, Economic and Social Research Council and the Natural Environment Research Council) and represents our independent views. It does not include or necessarily reflect the views of the Office of Science and Technology (OST). RCUK welcomes the opportunity to respond to this inquiry from the House of Commons Environmental Audit Committee[353].

3. This memorandum provides evidence from RCUK in response to the questions outlined in the inquiry document, in addition to supplementary views from:

Engineering and Physical Sciences Research Council (EPSRC)	Annex 1
Natural Environment Research Council (NERC)	Annex 2

4. The summary below provides an overview of cross-Council activities of relevance to the inquiry. The comments provided by EPSRC in Annex 1 give a summary of current and future energy R&D activities. The comments provided by NERC in Annex 2 address the specific issues raised by this inquiry.

[353] http://www.parliament.uk/parliamentary_committees/environmental_audit_committee/eac_21_07—05b.cfm

RCUK OVERVIEW

5. The Research Councils recognise the importance of conducting technology-based research in the context of a thorough understanding of markets, consumer demand and public acceptability. Within this context, cross-Council initiatives, in collaboration with stakeholders, play a crucial role. NERC, EPSRC and ESRC received additional funding in the 2002 Spending Review to launch the "Towards a Sustainable Energy Economy" Programme (TSEC). This Programme was designed to adopt a multidisciplinary, whole systems approach to energy research. The earmarked budget for TSEC was £20 million of core funding plus £8 million for renewables previously earmarked following the Performance and Innovation Unit Review of Energy R&D in 2001. TSEC is a broad-based programme of research which aims to enable the UK to access a secure, safe, diverse and reliable energy supply at competitive prices, while meeting the challenge of global warming. In the event, in order to support a number of high quality projects that could not otherwise have been supported, the TSEC budget was augmented to a total of £36.5 million with the additional funding drawn from Research Council baseline funding and from the additional £30 million funding for energy announced under the 2004 spending review. The TSEC budget was allocated through five funding streams: establishment of the UK Energy Research Centre (UKERC); Managing New Uncertainties; Keeping the Nuclear Option Open; Renewable Energy, and Carbon Management. Further information on these programmes can be found in paragraphs 6, 7 and 8.

6. The initial aim of TSEC was the establishment of the £14 million UK Energy Research Centre (UKERC) which is focussing on addressing system-level issues in energy generation, supply and consumption, and which will act as the hub of the new National Energy Research Network. EPSRC, together with NERC and ESRC, are funding the UKERC, with EPSRC providing £5.6 million, NERC providing £5.2 million and ESRC providing £3.2 million over an initial five year period. The main research grant started in October 2004. UKERC is already forming a focus for networking the UK energy research community and for developing international collaboration. For example, UKERC hosted a workshop on innovation and research for energy within the official programme of events marking the UK presidency of the G8. UKERC's research and networking remit covers demand reduction, future sources of energy and energy infrastructure and supply with energy systems and modelling, materials for advanced energy systems and environmental sustainability as cross-cutting themes. UKERC also features a permanent meeting place in Oxford which will host international visitors as well as providing a venue for community meetings.

7. EPSRC has taken the lead in enabling the establishment of the £6 million "Keeping the Nuclear Option Open" (KNOO) initiative due to start October 2005 which will run for four years. With a £0.5 million contribution from BNFL, KNOO will address issues such as fuel cycles and fuel management, future reactor systems including Gen IV technologies, waste management, storage and decommissioning and extending existing plant lifetime through materials science and technology. The other key Government and industrial stakeholders involved with the initiative are: AWE; BNFL; British Energy; DEFRA; the Environment Agency; the Health and Safety Executive; DTI; Mitsui Babcock; MOD; Nirex; NNC; Rolls-Royce PLC; and UKAEA.

8. An additional £8.5 million from EPSRC has enabled joint funding with NERC, ESRC and BBSRC of research consortia under the TSEC Programme's carbon management: sequestration (£2.0 million); and biofuels (£2.5 million)—which will run for 3 and $3\frac{1}{2}$ years respectively; three research groups on transition to a sustainable energy economy (University of Sussex) (£2.8 million); economic policy analysis (Cambridge) (£2.4 million); and energy consumption (Surrey) (£3.0 million)—each for five years; and a consortia on public engagement with renewable energy technologies (£0.5 million) which will run for three years.

9. In April 2005 the Research Councils established a new Energy Programme, led by EPSRC. The Energy Programme will expand the Research Councils' total investment in energy research over the SR2004 period from the present level of approximately £40 million per annum in 2005–06 to approximately £70 million per annum in 2007–08. Much of the increased expenditure is expected to be in the engineering and technology research areas supported by EPSRC, but will also encompass the range of energy research issues including social, economic, environmental and biological contributions that will be developed in conjunction with other Research Councils.

10. NERC, EPSRC and ESRC each contribute to the total budget of £10 million for the Tyndall Centre for Climate Change Research at 50%, 37.5% and 12.5% proportions respectively. The Centre has research collaborations with numerous partners such as the CCLRC, the Environment Agency, DEFRA and the Potsdam Institute for Climate Impact Research. The Tyndall Centre supports transdisciplinary research, assessment and communication of the options to mitigate, and the necessities to adapt to climate change within the context of sustainable development. The Centre's total budget for the first phase of funding is £10 million over five years. Research relevant to energy efficiency comes under the research theme "Decarbonising Modern Societies", which aims to provide technical, regulatory, social and policy options

to reduce atmospheric concentrations of greenhouse gases nationally and globally. The total expenditure in this theme amounted to £2 million over the life of the present first funding phase. To aid knowledge transfer, the DTI additionally provides £70k per year to allow the Centre to run a Business Liaison Programme.

Table 1

SUMMARY BY FINANCIAL YEAR OF EPSRC'S AND NERC'S EXPENDITURE (IN MILLION) IN ENERGY ACTIVITIES

	2000–01	*2001–02*	*2002–03*	*2003–04*	*2004–05*
EPSRC support	£9.3	£11.5	£11.6	£12.3	£13.8
NERC support	£1.1	£1.0	£1.0	£0.7	£2.4

Notes on data:

1. The data presented in the table are for expenditure on grants in the financial years shown.

2. The data shown do not include the NERC (£5M) or EPSRC (£3.75M) contributions to the £10M Tyndall Centre Programme.

3. The data shown includes expenditure on the UK Energy Research Centre but not on other TSEC activities.

Annex 1

MEMORANDUM FROM THE ENGINEERING AND PHYSICAL SCIENCES RESEARCH COUNCIL (EPSRC)

Background

1. EPSRC supports research and training in the core physical sciences (mathematics, physics and chemistry), underpinning technologies (eg materials science and information & communications technologies) and all aspects of engineering.

2. EPSRC awards research grants through two main delivery modes ı responsive and managed. Through the responsive mode EPSRC invests in the highest quality research projects, as judged by peer review, within subject areas of the researchers choosing. In managed mode, researchers submit their research ideas in response to a research remit specified by EPSRC and key stakeholders; conditions may be applied to applications, for example the requirement that proposals involve an industrial collaborator.

3. EPSRC believes that it is technically feasible to meet the likely shortfall in electricity generating capacity by approaching the "generation gap" from a truly mixed energy supply perspective, including most if not all of energy generation technologies such as renewables, cleaner fossil fuel technologies and nuclear fission and in the longer term fusion power. EPSRC also recognises the huge potential for energy efficiency improvements to lead to a reduction in both energy demand and CO_2 emissions.

4. Research, development, demonstration and technology transfer are all essential to enable the implementation of innovation in the energy supply market and funding agencies must work in effective partnerships to support innovation. EPSRC would emphasise that the shortage of trained personnel within the energy industry as a key area of concern.

5. This memorandum provides an overview of the research in energy supported by EPSRC including current and future activities.

EPSRC Support to Energy Research in the UK

6. ESPRC aims to support a full spectrum of energy research to help the UK meet the objectives and targets set out in the 2003 Energy White Paper.

7. EPSRC has a large portfolio of research relevant to energy. Research activities include technologies associated with the extraction of energy resources (principally coal, oil and gas), energy production (utilising carbon-based, nuclear, and renewable sources), and electricity transmission and distribution. The transmission and distribution of electricity encompasses research relating to power systems management, protection and control systems, energy vectors such as hydrogen, energy storage and recovery and embedded generation . Research funded includes also some areas of research underpinning the current and future activities in the power sector such as nuclear physics. EPSRC funds also a diverse range of research into the development and introduction of potential energy efficiency measures in areas extending from the built environment to industrial processes and products, from materials to power generation, and from markets and regulation to organisational and individual behaviour. Table 2 summarises EPSRC spent by technology in the financial years from 2000 to date.

Table 2

EPSRC'S EXPENDITURE BY FINANCIAL YEAR IN ENERGY ACTIVITIES

Technology	*2000–01*	*2001–02*	*2002–03*	*2003–04*	*2004–05*	*Total*
Biofuels	£21,540	£51,545	£141,990	£126,420	£86,550	£428,045
Biomass	£159,422	£301,443	£271,907	£803,033	£1,026,848	£2,562,653
CHP	£17,675	£77,637	£34,473	£39,319	£42,048	£211,152
CO_2 Sequestration	£22,544	£41,589	£66,865	£30,323	£40,177	£201,498
Conventional	£339,850	£819,493	£895,434	£618,298	£677,010	£3,350,085
Energy Efficiency	£1,693,629	£1,342,372	£1,546,543	£1,834,048	£1,076,677	£7,493,269
Fuel Cell	£707,136	£949,997	£1,126,368	£779,552	£800,046	£4,363,099
Geothermal	£40,493	£61,000	£49,078	£17,547	£14,772	£182,890
Hydrogen and Vectors	£34,097	£318,500	£510,479	£1,480,079	£1,362,229	£3,705,384
Networks	£810,258	£1,003,320	£1,173,606	£1,500,383	£2,054,832	£6,542,399
Nuclear	£117,634	£288,900	£237,622	£173,555	£85,825	£903,536
Photovoltaics	£2,729,527	£2,929,647	£2,474,110	£1,964,252	£2,348,995	£12,446,531
Storage	£774,615	£743,677	£702,320	£517,164	£408,505	£3,146,281
Waste	£39,962	£80,939	£124,826	£169,024	£119,580	£534,331
Wave and Tidal	£184,599	£452,661	£417,115	£730,707	£954,827	£2,739,909
Wind	£256,148	£300,041	£421,680	£309,070	£149,590	£1,436,529
Grand Total	£7,597,119	£10,156,071	£10,089,833	£10,430,515	£12,706,341	£50,979,879

Notes:

1. Data for TSEC is not included, refer to RCUK overview paragraph 6, 7, 8.

2. Data does not include fusion, refer to paragraph 15.

8. EPSRC provides a major investment in renewable energy and related R&D, at a level of £31.7 million in the period 2000–01 to 2004–05. Renewable sources of power include wave, wind, biomass, solar PV, and fuel cells utilising renewable hydrogen sources. The portfolio includes issues relating to the integration of renewable sources of generation into the energy grid. An indicative breakdown of EPSRC's investment classified by technology area is provided in Table 2—although the nature of research is such that it is likely that EPSRC funded research, being undertaken in other areas such as materials, chemistry and physics, may also give rise to useful results in this field. Full details of all of the projects identified by EPSRC as relevant to the inquiry can be provided if required.

9. The investment by EPSRC in these areas reflects current and past research priorities in energy research. EPSRC has supported a series of managed programmes in energy-relevant topics including fuel cells, photovoltaics, energy storage, renewable and new energy technologies, and energy supply research for the 21st century. The operation of responsive mode and managed programmes in parallel means that while strategic investment in targeted areas have a significant influence on the overall distribution of research funding, the ongoing award of research grants in responsive mode allows for a broader range of innovative research ideas.

10. EPSRC is continuing to make strategic investments in research addressing both the supply and demand side of the energy economy through a major research programme on Sustainable Power Generation and Supply (SUPERGEN). SUPERGEN, started in July 2003, is a multidisciplinary research programme that addresses simultaneously technical solutions and market and public acceptability issues. As such it is ideally placed to inform the development of effective regulatory strategies to enable the transition towards a low carbon economy. EPSRC total investment in SUPERGEN is of £25 million over five years. Research is delivered through multidisciplinary consortia of the order of £2–3 million tackling key challenges in improving the sustainability of the power supply industry. The activities of the SUPERGEN Programme have been expanded into the social, environmental and life sciences to address these challenges. This has enabled SUPERGEN to become a collaborative activity across the research councils including BBSRC, ESRC and NERC. Initial priority areas funded under the SUPERGEN Programme were biomass, wave & tidal generation, hydrogen generation & storage, and future distribution networks. The second phase of the programme, with grants awarded early in 2004, is focusing on conventional generation plant lifetime extension and photovoltaics. The third and fourth phase priorities, with grants awarded between January and August 2005, include fuel cells, energy storage & recovery, distributed technology and next generation photovoltaic materials. Priorities for the fifth phase include wind technologies, biological fuel cells and network infrastructure, these awards are expected to be announced later in 2005. The expectation is that the total value of the Programme over the five-year period, inclusive of third party contributions, will be in excess of £40 million.

11. EPSRC is also working in partnership with the Carbon Trust on "Carbon Vision", a £14 million joint R&D programme on low carbon innovation, with additional funding from ESRC and NERC. This programme is supporting research to underpin the development of tomorrow's low carbon technologies. Carbon Vision's current activities are research consortia in low carbon buildings and low carbon industrial processes. The £5.4 million Carbon Vision Buildings consortium aims to create and assess a range of options

whereby the owners and operators of the national building stock can reduce carbon emissions significantly in comparison with today's performance. The Carbon Vision Industrial Processes consortium (£1 million) aims to develop a methodology for a systematic life-cycle estimation of carbon inventories in different industries (food, chemicals, plastic, construction and biomass). EPSRC and ESRC have also invested further £0.8 million in a Carbon Vision project aiming at developing detailed understanding of the barriers that apply at times of disruptive innovation towards low carbon systems, and at identifying responses to these barriers that will promote step changes in carbon efficiency, The Carbon Vision programme includes management arrangements to encourage close co-operation between the research teams. An engagement group of key research users is being established for Carbon Vision Buildings to provide advice and guidance to ensure that the Carbon Vision portfolio delivers high quality stakeholder-focused, solutions-driven research. As a final phase of the current Carbon Vision programme, ESPRC is planning to fund two awards to develop future research leaders in low carbon technology and, in particular, in energy efficiency. Each award will be allocated £1 million to provide research support in terms of staff and other items to excellent researchers who have the potential to become international leaders. We will also be looking for commitment from the university in terms of longer term support for the research group and for exploitation. The successful candidates will also be provided with contacts and mentoring to help them develop international and high level business and policy-related contacts.

12. A Collaborative Training Account to provide masters level and continuing professional development training in nuclear energy related skills has been funded with £1 million from EPSRC and £1.6 million from various stakeholders such as Government bodies (NDA, MoD, Cogent), regulators (HSE/NII) and leading industrial employers (BNFL (including NSTS, Energy Unit, British Nuclear Group), UKAEA, AWE, Rolls-Royce Naval Marine, Serco, British Energy, Nirex, NIS, NNC, NPL, Mitsui Babcock, Atkins Nuclear, INucE and BNES).

13. The Nuclear Technology Education Consortium (NTEC) includes eleven universities and other training partners and the key public and private sector stakeholder groups in the UK. NTEC will cover decommissioning and clean-up, reactor technology and fuel cycles, environment and safety, policy and regulation, project management, fusion and medical use.

14. A Letter of Arrangement (LoA) has been agreed between EPSRC, the Ministry of Defence, the Atomic Weapons Establishment, British Nuclear Fuels PLC and British Energy PLC. The first activity under this LoA is to establish a Nuclear Engineering Doctorate (EngD) Centre. The EngD is a four year, industrially relevant doctoral training programme which offers a radical alternative to the PhD, geared to training research managers of the future. It is hoped that the first intake of students will take place in the 2006–07 academic year.

15. From April 2003, EPSRC funds the UK Fusion programme based at Culham. The UK Fusion programme includes the UK participation to the European Programme Joint European Torus (JET) and the development of the UK's own spherical tokamak—the Mega Amp Spherical Tokamak (MAST). The programme is currently supported by a single large grant of £48 million for four years from April 2004 to March 2008. A mid term review of the activity is scheduled for January 2006 which will look at the level of funding for the second half of the grant and to address the current plans for JET extension and the associated host subscription requirements. The research programme funded by EPSRC is aligned to the development of the International Thermonuclear Experimental Reactor (ITER) and will be enhanced by £8.65 million in this spending review period.

16. EPSRC continues to invest in research and training relevant to the oil and gas sector and areas such as clean coal, efficient combustion, combined cycle and gasification technology. EPSRC recognises the potential of carbon sequestration combined with fossil fuel plant as a potential zero-net carbon energy source; this option should be explored further as one of a number of priorities within a broad-based R&D programme.

17. EPSRC is working with the DTI under the auspices of the Memorandum of Understanding with the USA on collaboration in energy research, as part of this agreement, this year EPSRC will fund postgraduate research students to spend an additional year working on hydrogen-related research at Sandia National Laboratories in the USA.

18. Energy has been identified as a strategic area to be addressed by the EPSRC Science and Innovation Awards programme. Established in partnership with the Higher Education Funding Council, the Science and Innovation Awards programme aims to address academic capacity needs in areas with declining number of entrants as a result of a changing research landscape. £2.7 million have been awarded to the University of Strathclyde to focus on future trends in power technology.

19. Platform grants are one of the key mechanisms by which EPSRC strives towards maintaining and developing the strength of the UK engineering and scientific research base, by supporting, through underpinning funding, those UK groups considered to be world leaders in their fields. Platform funding is aimed at providing a baseline of support for retention of key research staff with the aim of providing stability to these groups. It is also anticipated that it will provide the stability and flexibility to permit longer-term research and international networking, and to take a strategic view on their research. An example of such a platform grant is supporting a group at Imperial College London looking at the development of clean, small scale energy generation technologies and their integration with the existing power system.

20. EPSRC supports the establishment of networks in new interdisciplinary research areas to develop and stimulate interactions between the appropriate science, technology research community and industrial groups. An example is the Radioactive Waste Immobilisation network which aims to provide a forum for all stakeholders to foster an integrated approach to nuclear waste management through improved communication and the identification of new collaborative research programmes.

21. The Faraday Partnerships have been established to strengthen the way technology is developed and exploited within the UK by stimulating closer communication and cooperation between researchers and new product developers. DTI and EPSRC sponsor the Integration of New and Renewable Energy into Buildings Faraday Partnership. This provides a national focus for research, training and technology transfer in building-integrated new and renewable energy technologies, relevant to research into energy efficiency. It includes research on options beyond the basic energy efficiency packages of measures in the domestic and non-domestic building sector, with over 225 companies, Universities and other organisations involved. The core funding consists of a grant from the DTI of £1.2 million for three years, and a grant of £1 million from the EPSRC. In addition, ESPRC provided funding for fourteen postgraduate studentships in collaboration with industry sponsors.

22. Fifty per cent of EPSRC's current energy research portfolio is conducted in collaboration with industry, involving over 200 companies, with the value of their cash contributions totalling over £7 million.

23. Working with the DTI, EPSRC is organising an Energy Research Summit Launch, to be held in November 2005. This will launch the expanded Research Councils' Energy Programme and provide the starting point to develop better strategic engagement on research and training priorities with energy-related business. Participants will be asked to identify common business-led research or postgraduate training opportunities which will then be worked up in more detail, culminating in a second Energy Research Summit in spring 2006.

24. EPSRC aim to appoint a prominent member of the energy research community as an energy senior research fellow to be an envoy and advocate for the Research Councils' energy work. In particular, their work will involve developing the international profile and level of collaboration and to provide information to EPSRC on potential international research opportunities. The appointment will be made in early 2006.

Annex 2

MEMORANDUM FROM THE NATURAL ENVIRONMENT RESEARCH COUNCIL

The Natural Environment Research Council (NERC) welcomes the opportunity to comment. NERC is one of the UK's eight Research Councils. It funds and carries out impartial scientific research in the sciences of the environment. NERC trains the next generation of independent environmental scientists. Its priority research areas are: Earth's life-support systems, climate change, and sustainable economies.

NERC's research centres are: the British Antarctic Survey (BAS), the British Geological Survey (BGS), the Centre for Ecology and Hydrology (CEH) and the Proudman Oceanographic Laboratory (POL). Details of these and of NERC's collaborative centres can be found at www.nerc.ac.uk.

NERC's comments draw on inputs from BGS, CEH and Swindon Office staff.

General Comments

1. The inquiry emphasises financial costs, and although it is concerned with carbon emissions and the public acceptability of nuclear waste, it does not address other environmental or social issues which are necessary for a holistic picture and for proper assessment of the sustainability of the UK's energy-generation choices.

2. The inquiry also focuses entirely on electricity generation—in isolation both from other forms of energy and from the uses to which different forms can be put. Obviously, electricity is easily moved around to provide both motive power and space heating, for example. But space heating (and cooling) can also be provided by other forms of energy, eg heat from the earth (geothermal energy) available at the location where it is needed. Our apparent electricity needs should therefore be assessed in the light of alternative ways of meeting them.

3. Nuclear-related questions requiring attention by the Committee concern the supply of uranium: its origin, transport, and possible limits on availability.

A. The Extent of the "Generation Gap"

What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?

4. As indicated above, the provision of energy to users is not all about electricity. Some demands can be met by other forms of energy, such as geothermal energy for space-heating and cooling, and although switching to such sources may not fully compensate for predicted electricity shortfalls, their contribution could be significant.

B. Financial Costs and Investment Considerations

What are the main investment options for electricity generating capacity? What would be the likely costs and timescales of different generating technologies?

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

5. BP's/Scottish power recently announced (July 2005) their plan to construct the Miller hydrogen-burning power plant with CO_2 capture and geological storage. It could be operational by 2009 if construction is commissioned by 2006—much sooner than a nuclear power plant. BP is still working on the detailed economics but it is likely that the cost will be similar to or below the cost of nuclear or offshore wind, and the plant will have significant flexibility to meet demand swings (unlike nuclear or wind). It will avoid about 1Mt/year of CO_2 emissions. It uses natural gas as the primary fuel. Other companies such as Progressive Energy have designs and plans for coal-based hydrogen power coupled with CO_2 capture and storage. These designs compare favourably with nuclear and offshore wind in terms of costs per KWh. and, again, have flexibility to meet supply swings. These installations will not become a commercial reality until there is an economic benefit to the operators for decarbonising fossil fuels.

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

6. There are hidden costs associated with all energy sources. Rarely is holistic accounting used. The hidden costs of nuclear new build include not only decommissioning and waste-handling costs, but also the cost of environmental and social impacts, which need to be explicitly assessed.

7. The current nuclear waste legacy is large in volume and radiation. This has been and is being dealt with to remove the risk to future generations. Much depends on whether reprocessing is to be allowed. If it is then future nuclear power will generate significant waste streams. If not then the volume of waste will be much smaller and more easily absorbed within existing and proposed management plans. Assessments of environmental capacity will have to contribute to these plans. Some people consider that components of nuclear waste will provide an exploitable resource to future generations; others consider that it will not be possible to adequately communicate warnings about storage sites to (distant) future generations.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

8. Each of the renewable sources has its own limits on capacity and the limits are not independent of one another. For example, different sources may compete for the same space and/or compromise each other's requirements for water or wind. However, they may work synergistically, for example providing complementary generating systems and transfer routes. Increasing renewables generation may conflict with other land uses (agricultural food production, forestry, landscape, etc) and these impacts need to be examined, but the use of small-scale local generation mechanisms (eg micro-wind) could avoid that. Policy may be necessary to change people's appreciation of energy.

— *What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?*

No comment.

— *What is the attitude of financial institutions to investment in different forms of generation?*

No comment.

— *What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?*

9. Financial risk is not the only risk that needs to be considered; the cost of and responsibility for failure and environmental damage has to be identified at the outset.

— *How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

No comment.

— *What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?*

No comment.

C. Strategic Benefits

If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?

10. Support could be most obviously justified by the need to reduce greenhouse-gas emissions (to meet our Kyoto commitment). Other grounds could include reduction of other atmospheric pollutants if there were an equivalent reduction in fossil-fuel use (eg nitrogen and sulphur compounds).

11. The environmental costs of all energy generation mechanisms need to be considered by means of full life-cycle analysis. New nuclear development should not be looked at in isolation from other generating systems, but should be seen as a component of a diverse rounded supply sector, with a view to replacing nuclear fission with nuclear fusion in the intermediate to longer term. The cost benefits of maintaining our centralised electricity grid rather than moving to more community-based systems should also be considered.

12. The main public good to be delivered would be mitigation of climate change (but this would only be delivered in combination with a wider energy-supply and demand package). Others could include cleaner air and a secure electricity supply.

— *To what extent and over what timeframe would nuclear new build reduce carbon emissions?*

13. Carbon emissions will not be decreased simply by the construction of nuclear power stations. A decrease is dependent on decreased demand, and on what happens to our use of electricity, and energy generally, from other sources. At present our consumption of energy is rising, and new nuclear might serve merely to meet that rising demand or replace existing nuclear capacity. Without new nuclear, it is probable that our carbon emissions will rise more dramatically.

— *To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?*

No comment.

— *Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?*

No comment.

In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?

14. The Energy White Paper (EWP) suggested putting nuclear development on hold until the waste-management issues had been addressed; these are currently being considered. The EWP goals are environmental improvement (reduction in carbon emissions), security of supply (through diversity), improving quality of life (less fuel poverty) and economic development (through innovation). Nuclear can contribute to all the goals as part of a diverse energy-generation mix.

D. Other Issues

How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?

15. The emissions (a) associated with construction are far less than renewables which require massive infrastructure per KWh delivered. Construction on the surface, using existing techniques, will, however, require cements and metals that are associated with carbon emissions. New construction techniques could utilise underground voids. This could impact on terrorism and security issues. With regard to the operation of a new nuclear power station (b), nuclear energy has very low life-cycle emissions. The carbon emissions of uranium mining are likely to be very high but not significant in the context of nuclear's overall very low life-cycle emissions.

Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?

16. The public needs to gain a good understanding of the security and risks of waste management. Solutions do exist and are being used internationally. We need to consider the effect on waste streams of reprocessing; existing wastes contain a significant component from this.

21 September 2005

Memorandum submitted by Sir Robert McAlpine Ltd

Memorandum by Sir Robert McAlpine Ltd a major civil engineering contractor with experience of building six of the existing nuclear power plants and of ongoing nuclear work at Sellafield.

Our responses to the questions published are as follows:

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

No response, because not our area of expertise.

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity?*

The investment options must be environmentally clean to be acceptable, thus they should not emit CO_2. They are:

Good options

— Wind, proven for small amounts, but susceptible to absence of wind.
— Tidal barrages use proven technology, eg at La Rance in France: the Severn Barrage, could produce 17TWh, ~6% of UK needs.
— Tidal Stream: promising technology, but not yet proven in commercial service.
— Nuclear, for base load generation.

Non-options

— PV is too expensive for base load generation.
— Micro CHP is unproven and still produces CO_2.

Bad options

— Gas powered generation emits CO_2 and is thus much less desirable than the "carbon-free" generation. More gas plants are probably inevitable to some extent, but should be minimized. Security of supply is an issue if a high proportion of generation comes from gas, as much of our gas will be imported.
— "Clean coal" is an aspiration rather than proven technology, and is thus not an option. Sequestration of carbon dioxide, as would be necessary for a new clean coal power station, is not possible in the foreseeable future. The only CO_2 so far sequestrated has already been captured and separated from other gases at the well head, and the process relies on a small number of suitable existing oil/gas fields to receive the CO_2. Separating CO_2 from flue gas emissions is more difficult, and receiving sites for sequestration have not been identified.

What would be the likely costs and timescales of different generating technologies?

What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)? Over what timescale could they become operational?

Costs were investigated by the Royal Academy of Engineering: "Costs of generating electricity" March 2004. We consider these figures to be a good indication of real costs. This showed nuclear as the cheapest carbon-free source of power, and the least susceptible to variation in fuel costs.

Nuclear plant and tidal barrages require a long timescale to implement, partly due to the long planning/public inquiry process they need. Gas is much faster to build. Thus unless strategic decisions are taken in good time, gas plant will be built as the only option that can be achieved in time then available.

Thus a strategic decision in favour of some nuclear and tidal barrage generation is needed quickly.

With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience?

A new nuclear station is not dissimilar to any other major civil engineering project or power station, so estimates are realistic and robust. Cost estimates have been proven in South Korea for new nuclear stations and are being confirmed in Finland.

An important lesson has been learned that we need to build a series of virtually identical nuclear power stations to reduce risks and costs. The previous UK experience was to change the design each time to improve it, but this increased costs enormously. A standard international design must be adopted and the Regulator (NII) should not re-examine plant design for each site, rather restrict examination to site-specific issues only, such as foundations and seismic risk.

What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?

The waste and security costs are not hidden.

— Waste costs for keeping waste safely on the power station site are known, because this is what is currently done. "Final disposal" costs can only be known if and when Government makes a decision.

— Security costs currently are known. For new build adjacent to existing nuclear sites, the additional cost of providing security at a slightly larger site will be small.

The best option for funding waste disposal is to follow the US practice where the utility pays the Government an amount for each unit of electricity generated, and the Government is then responsible for disposal of the waste after an agreed date. This means the utility's liability is not subject to potential major variation as a result of political decisions, and the public can have increased confidence that the organization most likely to endure in the very long term, ie the government, is responsible for the waste.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

No. Tidal barrages could provide perhaps 7% of power requirements; wind power, the other sizeable, proven renewable generator, needs too much back up for when the wind stops blowing (and this has happened across the entire UK at the same time). Also the cost would be too high. Few non-governmental observers believe that even the Government target of 10% renewables by 2010 will be met, never mind the higher targets for later years.

A policy change in favour of carbon-free base load generation is needed, ie nuclear and tidal barrages.

What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

No response—not our area of expertise.

3. *What is the attitude of financial institutions to investment in different forms of generation?*

What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables?

We have spoken to financial institutions. Their view is that the planning risks must be taken by Government because of the high risk of a late political decision canceling new nuclear build, as happened before in the UK.

How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?

Following from the previous response, Government will, initially, have to fund the planning stage, but these costs could be recovered from the first few new power stations when they start operating.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

There need be only minor effects. Renewables are needed alongside new build. Renewables will continue to rely on long term subsidy, and if subsidy continues then so will investment. 40% of generation by carbon-free nuclear power would still leave 60% generation available from renewables, which is in line with the 2050 aspiration and a long way from being achieved.

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

Financial support would be justified on the basis that new nuclear build requires political will over a period of year during the planning process. It would be unreasonable for the private sector to carry this risk as a change in political will might reverse support at a late stage through no fault of the promoters, as happened before. The financial support during the planning and development stage could be recovered during the operation of the new plant.

It is also justified in terms of security of supply which ultimately is a government responsibility.

It would deliver:

- economical base load generation;
- reduced CO_2 generation, and thus potentially reduced climate change;
- a good climate change example to the developing world;
- security of supply; and
- a continuing influence in the management of nuclear power worldwide as a result of current state-of-the-art experience, which would assist global security, eg in Iran.

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

This would depend entirely on how much new build is undertaken. Replacement of existing nuclear generating capacity should be the minimum, but twice that level would be a better target. New nuclear plant is expected to generate for 60 years.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

Significantly. It is the only form of generation where the fuel is brought to the UK a long time ahead of use. It is also comes from politically stable countries. Even gas supply from friendly countries can be disrupted by terrorist activity at any point over a long supply line. New build would be distributed over several independent sites, each of which is compact and subject to high level security, so supply is much more robust.

Even the most optimistic estimates only aspire to 60% renewable by 2050, so security of supply of fuel for the other 40% necessitates nuclear plant.

Is nuclear new build compatible with the Government's aims on security and terrorism both within the UK and worldwide?

Following from the previous response, new build is the most compatible. Regarding security of nuclear materials, they are available in many parts of the world. The security we provide at our power stations is quite sufficient to ensure that they are not the softest targets for any potential theft of radioactive materials, and they therefore will not add to the global security risk.

Regarding terrorist attack, new generation plants have been designed to resist aircraft impact, and they will have good security against attack, as is the case now.

5. *In respect of these issues [Q 4], how does the nuclear option compare with a major programme of investment in renewables, microgeneration, and energy efficiency? How compatible are the various options with each other and with the strategy set out in the Energy White Paper?*

Nuclear power compares favorably with other sources of generation in terms of cost and proven technology. It requires, however, a long timescale to implement.

It is compatible with the White Paper objectives in that the White Paper specifically kept the nuclear option open. Since the White Paper was published, the decisions in Finland and France to procure new build and the strong moves in that direction in the US mark the increasing appreciation in the Western world that the new generation of nuclear power is safer, produces less waste, and is economically competitive with gas and other forms of generation. The UK should also recognize the changes in public perceptions: according to a MORI poll, more people now favour new build than oppose it.

There is no incompatibility between different forms of generation. The UK needs diversity of supply to guard against circumstances changing adversely. New build is an important part of this diverse supply.

D. Other Issues

6. *How carbon-free is nuclear energy? What level of carbon emissions would be associated with (a) construction and (b) operation of a new nuclear power station? How carbon-intensive is the mining and processing of uranium ore?*

Nuclear energy is effectively carbon free in operation. The carbon produced in mining, operation and waste disposal is trivial compared with burning fossil fuel, and similar to renewables.

7. *Should nuclear new build be conditional on the development of scientifically and publicly acceptable solutions to the problems of managing nuclear waste, as recommended in 2000 by the RCEP?*

No. Nuclear waste is currently managed in a scientifically and publicly accepted way.

If new nuclear plants are built adjacent to existing nuclear sites, then there is no reason to move the existing ILW waste stores off the site. The security for the new build plant will cover the "old" waste store. This will eliminate unnecessary movement of radioactive waste around the country, and save money. Note that Scotland has forbidden the movement of LLW from Dounreay to Drigg, and a new LLW store will be built at Dounreay.

A clear plan for "final disposal" of nuclear waste should be prepared. This might consider what to do with the ILW in 60+ years time when the new fleet of nuclear plant is to be decommissioned.

23 September 2005

Memorandum submitted by Royal Dutch Shell plc

1. Shell shares the widespread concern that the emission of greenhouse gases (GHG) from human activities is leading to changes in the global climate. Our commitment to CO_2 reduction is serious and demonstrable, as illustrated by our existing voluntary GHG target, which will see GHG emissions across all the facilities we operate 5% lower in 2010 than they were in 1990, even though our business has grown in that period. However the needed future global reductions will require a new set of technologies.

2. Shell clearly recognises that a major change in energy infrastructure and the way energy is used will be needed over the coming decades if society is going to address the issue of climate change. No single solution will deliver this major change. Shell has a long history in research and development of new technologies, which are an important element of our strategic direction around the world and we have developed the broadest new energy portfolio in the industry, with the largest investment in these technologies of the oil and gas majors.

3. We welcome the Committee's Inquiry into these matters. Although Shell does not have a position on nuclear power we would like to comment on some of the Committee's other areas of interest.

4. In expanding our energy portfolio we have invested nearly US$ 1 billion over the period 2002 to 2005. We are the number 2 wind company in the USA and number 7 in the world, powering hundreds of thousands of homes with wind energy.

5. Shell believes that wind energy has real potential for the UK, as the most economic and potentially environmentally acceptable large-scale renewable resource and we are focusing on the development and operation of offshore wind farms in the UK.

6. We are one of three companies that have been granted a Round 1 option to lease an area of the Irish Sea from the Crown Estate to develop an offshore wind farm near Blackpool. It will have up to 90 turbines with a project capacity of up to 324 MW. Development is dependent on the results of a full economic feasibility study and environmental impact assessment.

7. Shell is also part of a consortium called London Array Limited that has been granted an option to lease an area from the Crown Estate to develop an offshore wind farm in the outer Thames Estuary. London Array is a flagship project that is leading the Round 2 process and was the first of these projects to submit a planning application in June 2005. This £1.5 billion project will be built in four phases, with the aim of commissioning 1,000 MW by 2010–11. If fully developed it would meet 10% of the Government's 2010 renewables target and meet the electricity needs of 25% of London's households or the entire domestic supply for Kent.

8. We see the development and application of new technologies as part of our objectives in dealing with climate change and security of supply and believe that our two large offshore wind farm projects could make a material contribution to achieving the UK's renewable energy targets. It is also clear to us that the only technology that can deliver the anticipated shortfall in renewable energy capacity required by the UK's 2010 and 2015 targets is likely to be offshore wind. However under the present operation of the Renewables Obligation (RO) the economics of offshore wind projects are not attractive and are below the threshold at which such projects are sufficiently attractive for us to invest. In our submission to the DTI's recent consultation we identified the following points:

— We consider that the aggregate financial support envisaged under the RO scheme can be sufficient to deliver the desired outcome on renewable energy targets.

— However we believe that an adjustment to the mechanism is needed so that this aggregate is redistributed, giving relatively more support to more capital intensive technologies, specifically offshore wind.

— Unless this redistribution takes place there is a significant risk that insufficient offshore wind energy capacity will be installed to meet the UK's renewable energy targets. Offshore wind would be needed to contribute half or more of these targets. This could mean up to 10 projects would be needed, delivering about 4 GW of power in aggregate by 2010 and about 6 GW by 2015.

— We do not think there are ready alternatives to this offshore wind capacity that would still enable the renewable targets to be met.

— Redistribution of the available financial support could be achieved by a relatively simply mechanism. This would involve capping the "recycle value" of the ROC and applying the resultant surplus to support specific offshore wind projects. To give an order of magnitude, very broadly, the £1 billion or so of RO support planned around 2010 would have the effect of preferentially directing about £250 million of financial support to offshore wind and leaving about £750 million to support other renewable energy sources. We believe that this £750 million would be sufficient to support less costly technologies such as onshore wind.

— To support an investment made before 2010, it is important to have confidence that ROCs will have value into the 2020s and beyond. A means of enabling this would be to extend and increase renewable targets beyond 2010 and to confirm this soon.

9. It is our view that offshore wind is the lowest cost route to target delivery and can be delivered through the RO if adjustments are made. Offshore wind technology has already proven its ability to perform on a material scale and has started to demonstrate its ability to deliver a vital contribution to the UK energy mix.

10. We recognise that the challenge to reduce emissions of carbon dioxide will require significant and material contributions from a range of technologies. Shell is committed to delivering a number of these technologies and within this has firmly identified offshore wind as a priority. We have declared objectives to incorporate offshore wind as a material business within our business portfolio over the next five years.

6 October 2005

Memorandum submitted by The Royal Society

This submission has been prepared in consultation with our Energy Policy Advisory Group (EPAG) and has been approved by Treasurer and Vice-President Sir David Wallace CBE FRS.

SUMMARY

— Renewables and energy efficiency measures are not sufficiently developed to make up for the shortfall in energy generating capacity caused by the phase out of nuclear power stations and older coal plants.

— The introduction of an appropriate economic instrument would encourage the development of cleaner technologies and a move away from carbon based fuels as well as promoting energy efficiency measures.

— Low carbon electricity generation options such as nuclear new build and the employment of carbon capture and storage technologies need to be considered as they help to ensure diversity of supply whilst minimising carbon dioxide emissions.

— The development, deployment and financing of these technologies are global issues, going far beyond the UK.

Introduction

1. One of the major challenges facing the UK is how to generate a secure supply of electricity whilst minimising our emissions of carbon dioxide to the atmosphere. At present, emission reduction measures are not sufficiently developed to make up for the loss of capacity resulting from the phasing out of nuclear power, which currently generates about a quarter of our electricity in the UK.

2. According to the Government's own estimates, unless the rate of development of both renewable and energy efficiency measures make up for the loss of capacity resulting from the phasing out of nuclear power we will be more dependent on fossil fuels to generate electricity in 2010 than we were in 1995, which is not consistent with the UK Government's aim of a 60% reduction in carbon dioxide emissions by 2050.

3. The incentive should be for all technologies and electricity generation options that reduce CO_2 emissions. Reducing reliance on fossil fuels has the additional benefit of increasing the security of supply through encouraging diversity of generation.

Economic Instruments

4. Most alternative forms of energy cannot yet compete with the cheapest fossil fuels—currently natural gas—particularly when the latter's environmental costs are not yet factored into the price of the fuel. The introduction of an appropriate economic instrument that places a penalty on the emission of carbon dioxide, such as a carbon tax or auctioned tradable emission permits, would help to achieve energy savings and allow greener generating technologies to become cost effective. In our report "Economic instruments for the reduction of CO_2 emissions" (Royal Society 2002) we consider the impact of a "small" carbon tax. An initial level of the tax would increase the cost of electricity by no more than 1 p/kWh. Analysis, supported by the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report Synthesis Report (2001), has shown that the impact of a carbon tax on the long-term growth global Gross Domestic Product (GDP) for drastic reductions in carbon dioxide emissions would be insignificant.

Energy Efficiency

5. Economic instruments, such as a carbon tax or an emissions trading scheme, can provide a significant incentive for driving energy efficiency measures. However, while the current UK Climate Change Levy goes some way towards promoting energy efficiency measures across the economy its effectiveness is limited, as it excludes major energy users such as households and transport.

6. Implementing the appropriate regulation is also important. Part L of the Building Regulations has been an effective measure for reducing building energy consumption in the last two decades, but it has only a limited impact on the existing building stock. In the domestic sector, the introduction of Home Condition Reports in 2007 will highlight and stimulate energy efficiency measures and generate information on home energy ratings. However further incentives, such as price, are required to motivate people to make efficiency investments to the fabric of their property which may only be realised after long periods of time.

Carbon Capture and Storage

7. Given the resources of fossil fuels available and the need to reduce CO_2 reaching the atmosphere, the potential for carbon sequestration should be seriously explored. Several oil and gas companies are already undertaking carbon sequestration pilot projects, pumping the gas into deep submarine saline aquifers and oil fields. We have previously highlighted the need for further research and development to establish the feasibility, cost and safety for such mechanisms of reducing atmospheric CO_2. The IPCC Special Report on Carbon Dioxide Capture and Storage (2005) considers the issues associated with geological and oceanic carbon separation, capture, and storage. We recommend that the findings from this report are incorporated into future UK greenhouse gas abatement strategies.

Renewables

8. Renewable technologies have the theoretical potential to satisfy the annual demands for electrical energy in the UK but not necessarily the instantaneous delivery requirements (ie power). With this proviso, in principle the offshore wind resource alone could supply more than the UK's entire electrical energy requirement. However, a number of factors currently restrict the growth and development of the renewables industry and hence the chances of meeting the UK's targets of 10% by 2010 and 15.4% by 2015. Some of the implementation issues examined below could be resolved if well-designed economic instruments were in place.

Capacity credit

9. The electrical energy generated from renewable sources replaces that from conventional generators and does not emit carbon dioxide, thereby contributing to the Government's emission reduction targets. However, renewable generation capacity does not completely replace conventional generation capacity, because some operate intermittently. The capacity credit is therefore defined as the amount of conventional generation plant that the new plant would, in practice, replace. This ranges from 0% in the case of tidal barrages such as the very large Severn barrage scheme, which as the tide turns generates no power and therefore depends entirely on back up generation plant, up to 100% in the case of biofuels, which can run continuously. In the cases of wind, wave and multiple tidal stream sources only marginal contributions to capacity credit are envisaged. Studies by the National Grid (House of Lords 2003), for example, show that an additional wind generation capacity of 25,000 MW of wind generation capacity across the GB electricity supply was found to displace only some 5,000 MW of conventional plant capacity. Similar results have been found in other studies (Grubb 1988 & ILEX Energy Consulting 2002). This constraint could change radically, if it ever became possible to develop and implement widespread energy storage schemes.

Costs

10. Whereas the electrical energy costs of conventional power stations remains fairly constant regardless of site, renewable energy costs are dependent on the available resource, which varies between geographical locations. Additional costs may also be incurred for connection to the grid, particularly for remote locations, and maintenance, which may be much higher for off-shore wind farms and tidal stream power. Therefore there is not a single cost that can be attributed to renewable electrical power generation.

11. For on-shore wind farms the direct cost of electricity produced will be dependent on how it is financed and the actual electrical energy output due to factors such as wind variability and sundry energy losses. The high rates of return on investment guaranteed by the Renewable Obligation Certificate (ROC) subsidy, in practice, encourage balance sheet and equity financing to offset debt so that quoted electricity generation costs are lowered. In addition, to variations in the energy output due to wind variability, intermittency in supply also leads to additional costs including the capital and operating costs of providing standby and back-up plant.

12. Tidal stream power has the potential to provide a more predictable supply of energy than wind and is now in early stages of development. Wave power, however, still faces significant engineering challenges. Estimates for the costs of both technologies vary but it is hoped that current demonstration projects will help to provide more information as to their costs and viability. Recent estimates of the costs can be found in the Royal Academy of Engineering report The cost of generating electricity (2004).

13. Photovoltaic modules are currently economically viable for applications where there is no easy access to the grid, but as a direct competitive source of electricity, photovoltaics are currently well out of range. In areas with low amounts of incoming solar energy, such as Northern Europe, the cost of electricity produced by such modules is around 40 p/kWh, whereas in Southern Europe, the USA and most developing countries it is around 15 p/kWh.

14. Biomass is organic material derived from plant and animal life and can be burned as fuel. Economics associated with electricity generation of energy crops has become more favourable where crops are located in the vicinity of an existing conventional plant and the biomass is used in conjunction with coal or gas. Further cost reductions may be found using more advanced technologies than direct combustion such as those based on gasification and or pyrolysis. Five years ago prices for energy crops were estimated at 5.5 p/kWh DTI (1997) and 4–5 p/kWh (Toft & Bridgewater 1997). More recently a study by Future Energy Solutions AEA Technology predicts that by 2025 costs could be in the range of 3–4.5 p/kWh (IAG 2002) after substantial learning effects are taken into consideration and improvements in overall system efficiencies have been achieved. Biomass in the form of landfill gas might achieve prices less than 4 p/kWh.

Providing the supporting infrastructure (such as access roads and extensions to the electricity network)

15. In the UK the geographical areas which offer the most potential for renewables are remote from suitable connection points. Many are in the North of the country where connection would add to the already significant North-South movement of power. There will also be significant implications for the Scotland/England interconnectors. Without significant development of these transmission facilities only a fraction of the large renewable resources in Scotland will be utilised. Responsibility for the connection and maintenance costs of the new supply is still a major issue that needs to be resolved. Conversely, however, some remote sites may find planning consent easier to obtain due to less opposition from local residents.

16. There is a technical limit to the development of some renewable energy supplies if their output is geared solely to direct connection to the electricity supply system. A modern power system cannot operate with more than a limited amount of randomly intermittent power. Such limits remain at present a matter of speculation for the essentially integrated island systems operated in England, Wales and Scotland and in Northern Ireland and Eire respectively. As the relative quantity of power from intermittent sources (wind, wave or solar) increases, the quality of supply may decline in terms of the stability of the frequency and the

presence of unwanted harmonics. To maintain development of renewable resources, in order to mitigate carbon dioxide emissions and to improve future security and sustainability of energy supplies, lessons must be learned from other countries with greater percentages of various renewable resources in their electricity supply systems and new technologies need to be developed and adopted.

Manufacturing and installation capacity

17. The investment in renewable build is primarily driven by the rewards offered within the renewable obligation subsidy scheme. The uncertainties attached to the scheme for investors are discussed in the House of Lords Science and Technology Committee 4th Report of Session 2003–04, "Renewable Energy: Practicalities". In our report on Economic instruments for the reduction of carbon dioxide emissions (Royal Society 2000) we noted that despite some significant engineering issues, which are still to be solved, the build rate to meet the Government's 2010 targets for renewable installations would have to be met by increasing the amount of wind generation. The scale of this build was calculated at the time at between 3,000 and 5,000 new turbines by 2010, which is in excess of one per day. An aspect of concern for all potential investors in the development of new, non-wind renewable technologies is that if this rapid growth of wind generation is sufficient at any time to approach the Government targets, then the value of the subsidy from the renewable obligation scheme will decrease substantially, possibly to zero (p 45, Vol I of the House of Lords report). This would have a severe impact on the potential introduction of any new emerging technology seeking to recover initial capital and development costs. This is a point that was recently raised by the Scottish Executive in their proposed modifications to the Renewables Obligation (Scotland) 2005–06 (Scottish Exec 2005). Consideration should be given to how subsidies can be distributed to ensure the continued development of greater variety within the spectrum of future renewable technologies within the scheme of subsidies and capital grants.

Clean Coal

18. Clean coal can be variously defined as: the more efficient use of coal; the reduction in oxides of nitrogen and sulphur (NO_x and SO_x) emissions; and more recently to include capture and storage of carbon dioxide. The efficiency of electricity generation from coal has progressively increased over the whole of this century. Coal-fired plants can achieve in excess of 40% efficiency, Combined Cycle Gas Turbine (CCGT) plants in excess of 50%. Further improvements depend on the ability to produce gas turbine materials capable of withstanding higher temperatures. Whilst dramatic improvements are not expected, there will be further modest advances. Projections suggest that over the next two or three decades coal-fired steam plants might increase their efficiency from 40% to 42% and CCGT plants from 52% to 60%. In this context it is worth noting that a 1% increase in efficiency is not only of very significant economic importance but also implies a 2% reduction in CO_2 emission for a station with 50% efficiency. Further gains can be expected by increased use of combined heat and power plants—where the waste heat from the station is used for local domestic or industrial heating requirements (Royal Society 1999).

Nuclear New Build

19. The Government Energy White Paper proposes no new nuclear build unless it is clear that the option is required to attain the Government's carbon targets. We believe that it is vital that the Government should keep the nuclear option open as, in the short to medium term, we are not confident that energy efficiency measures and renewables will be enough to meet the needs of environmental protection while providing a secure supply of electricity at an acceptable cost. The Royal Society/Royal Academy of Engineering report (1999) addresses this complex issue, and outlines the important factors to be considered for new nuclear build. If nuclear power is to play a long-term role in reducing greenhouse emissions, the decision to build new nuclear power plants must be taken in the very near future. Furthermore, given the increasing global demand for new nuclear power plant, particularly pressurised reactors, consideration should be given regarding the physical feasibility of building the required number of new reactors in the timescale required.

Management of nuclear waste

20. Modern nuclear reactors produce much less waste per kilowatt hour over their lifespan than older existing plant and therefore would only add a small percentage to the existing challenge of nuclear waste disposal. The problem of disposing of existing radioactive waste needs to be resolved regardless of whether a new generation of nuclear power stations is commissioned. Any plans to build new nuclear power stations could therefore be developed in conjunction with the resolution of a strategy for dealing with the long-term storage and disposal of existing and future radioactive waste. For this reason, the UK does not necessarily need to have a solution (for long-term storage and disposal of existing nuclear waste) before making a decision about the building of new nuclear power stations.

Research and Development of Energy Technologies

21. There is a need for sufficient levels of funding of research and development to ensure sustained growth of energy technologies, particularly those associated with renewable energy and carbon sequestration. The correct balance will depend on the technology in question. Wind turbines, for example, no longer require core research funding but do require investment in development to reduce manufacturing, production and installation costs. Much of the necessary research and development should be done in collaboration with other countries. It is not feasible for the UK to work in isolation in areas such as the development of designs of new nuclear power stations or large-scale carbon sequestration. The recent announcement by the DTI (2005) to participate in international research collaboration on nuclear energy is welcome.

Public Concern and Acceptance

22. Utilisation of technology and sometimes the conducting research itself is dependent on public acceptance. It is clearly best to debate new technologies and establish their acceptability before there is substantial investment, otherwise there will be a delay in seeking more acceptable alternative solutions. This is particularly true for the nuclear industry but also extends to other areas of the energy debate such as onshore wind turbines and large scale sequestration of carbon dioxide.

Planning and consents

23. The current position in the UK suggests that planning regulations are still a major barrier to new renewable generators and anything that can be done to ease this situation is commended. It is vital to ensure that the information available to planning committees is not out of date, in particular for wind farms where noise and visual intrusion are often cited as reasons for denying permission. Technology has progressed and can now mitigate some of these objections, and planning committee members need to be made more aware of the progress. We welcome projects that aim to raise awareness of the benefits of renewables to local communities.

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5 October 2005

Memorandum submitted by RWE npower plc

INTRODUCTION

1. As one of the UK's leading integrated energy companies, RWE npower supports the Government's vision of moving towards a sustainable energy future. RWE npower, part of the RWE Group, is one of the UK's largest energy suppliers and we have a diverse portfolio of over 8,000MW of generation capacity in the UK. We sell our expertise in power generation in key markets and are one of the UK's leading renewable energy developers and operators.

2. We welcome the opportunity to contribute to the Environmental Audit Committee's inquiry into nuclear, renewables and climate change. We have not attempted to address every issue raised by the inquiry, but have focused on those parts of the inquiry to which we believe we can most usefully contribute.

THE EXTENT OF THE "GENERATION GAP"

3. The UK has benefited from a diverse energy mix which has helped to ensure security of supply through the balance of nuclear (around 16%), gas (around 31%) and coal (around 35%) generation. In recent years there has also been an increase in renewables, which now constitute between 2.5 and 3% of the UK generation portfolio.

4. Even with energy efficiency measures reducing demand growth below historic levels, we anticipate that peak demand will grow by almost 9GW between 2005 and 2015. During the same period, 7.5GW of nuclear plant (Magnox and AGR) is expected to be decommissioned as well as up to 4GW of older Combined Cycle Gas Turbine (CCGT) stations. This requires investment in 20GW of new plant by 2015 in order to maintain a 20% capacity margin. With peak demand then forecast to grow by almost 4GW between 2015 and 2020, and the retirement of old coal and oil plant under the Large Combustion Plant Directive (LCPD) by the end of 2015, the UK would require almost the same amount of new plant again to maintain security of electricity supplies.

5. The security of the UK's energy supplies has been under increasing scrutiny in recent months. Concern will increase following recent forecasts from the Met Office predicting a colder than average winter, and the Winter Outlook Report recently updated by National Grid will not silence all doubters. Much attention is inevitably focused on fears over supply in the immediate winter, but there is a need to consider the more serious concerns to electricity from 2008.

6. These concerns are avoidable with suitable infrastructure investment if action is taken now. Whilst the National Grid's Seven Year Statement shows substantial planned new capacity, very little of this is actually under construction. A major impediment to commitment is absence of clarity on two important environmental issues: LCPD and Phase 2 of the EU Emission Trading System (EU ETS) beginning in 2008, and also whether there will be any successor to the Kyoto Protocol or even any carbon trading post-2012.

7. We are concerned that the definition of a combustion plant currently being proposed under the LCPD will curtail the life of "opted out" coal plant even further. In summary, we have strongly urged the UK Government to implement the LCPD on the basis of plant = "boiler", rather than plant = "stack" at least for plant opting out under the terms of the 20,000 hour derogation. If the LCPD is implemented in the way currently proposed, the UK would be deprived of the security that retiring coal plant can provide during the challenging transition from a high carbon generation industry to a low one.

8. There is no clear view of the availability or cost of CO_2 emission allowances from 2008, during the second phase of the EU ETS and therefore no market view of the value or cost of power. Yet the UK energy industry urgently needs to commence investment in new forms of generation to meet demand and further reduce emissions. We propose that the UK Government resolves the issue of the allocation to the electricity sector urgently, in advance of finalising the National Allocation Plan and submitting to the European Commission.

9. In light of such fundamental uncertainties, it is difficult to evaluate the outputs, costs and revenues for investment appraisal purposes with any degree of confidence. Any appraisal would need to factor in a variety of adverse regulatory scenarios or apply a marked cost of capital premium to reflect the risks. In these circumstances investment decisions tend to be postponed, the risk of supply disruptions inevitably increases and the costs of responding to shortage are ultimately higher. The principal impediment to effective markets and investment decision-making is uncertainty regarding the environmental legislative and regulatory framework.

Financial Costs and Investment Considerations

Costs and Timescales

10. The investment costs of a new power station will necessarily depend on the specific characteristics associated with each individual project, such as siting and technical characteristics. It is also difficult to provide meaningful generation costs because of future fuel price uncertainties, costs of carbon and varying load factors. Assuming fuel prices over the long-term revert to reasonable fundamental levels, electricity from a new CCGT would cost in the range £33–36/MWh, while coal generation would cost £38–44/MWh. It would take about three years for a new CCGT to become operational once consent had been obtained, while a coal plant would typically require slightly longer, four to five years post-consenting.

11. Onshore wind costs are currently in the range of £600–750 per kilowatt and it takes around two years to plan, contract and build an onshore wind farm, following planning permission. The planning process typically adds a further three years. It is anticipated that new onshore capacity will be constructed at the rate of approximately 500–600MW per year in the short to medium term. The cost per unit of electricity generated by renewable technologies depends heavily on the load factor assumed, and hence is site specific. Therefore it is not possible to quote generic figures.

12. Offshore wind costs are typically between £1,300 and £1,400 per kilowatt with projects taking three to five years to plan and build, subject to receiving necessary consents and resolution of other issues including MOD/aviation constraints, offshore grid access, transmission system operator issues and the funding gap. It is anticipated that capacity in excess of 1,000MW per year of offshore wind generation could be built if the issues identified above could be addressed. Offshore wind through-life cost estimates also vary, in part due to relatively few sites having been built in the UK, but they are likely to be significantly higher than onshore wind. Marine (wave and tidal) technologies are in their infancy with through-life costs in excess of 10p/kWh, although it is anticipated that these will fall over time as the technologies mature, as they did for onshore wind.

New-Build Nuclear

13. New-build nuclear generation could form part of a diverse UK energy mix in the future and would go some way to reducing emissions. However, given the lead time necessary for planning, consenting, procurement and construction, it is unlikely that any new nuclear units could be available before 2015 and equally unlikely that a sufficient amount could be built sufficiently quickly to compensate for the LCPD-driven closure of coal plant.

14. Public mistrust of nuclear power also remains a factor. If the technology is to have a future in the UK, the debate must be conducted in the context of a clear long-term energy policy. There are real barriers to investment in new nuclear generation. Solutions need to be found to issues like technology licensing, the consenting process, site availability, sources of fuel supplies, decommissioning and waste disposal. The biggest barrier is economics, however. With a clear, long-term energy policy and climate change strategy the market will determine whether, and when, nuclear plant should be built. It is crucial, therefore, that attempts to stimulate new nuclear development in the UK must not create market distortions. This could undermine investor confidence in the whole market, risking security of supply in the near-term, and upset the balance and flexibility of our energy mix.

Renewables

15. Renewables alone cannot fill the anticipated capacity gap, but should be seen as an essential component of the UK's electricity generation portfolio. Independent studies have shown that the current transmission and distribution system could accommodate at least 20% of generation from renewable sources and this proportion could be increased in the future as the design of the distribution evolves. Renewables have the potential to make a significant contribution to electricity generation in the UK, especially when the potential of onshore wind is combined with technologies such as offshore wind and marine (wave and tidal). However there are barriers, and these will only be overcome if the political will to address them continues.

16. Onshore wind development continues to be impacted by delays in the planning process, MoD and aviation issues, and the availability of transmission capacity. Policy in these areas should continue to be reviewed and may require amendment in the future. Grid capacity is also a major constraint. Government funded studies in 2003 for Scotland have indicated the action required and plans are now being implemented. However, Wales needs similar studies and more rapid implementation.

17. With regards to the technology itself, a sufficient number of wind turbine manufacturers are currently developing wind turbines of a size suitable for large-scale offshore wind generation. However the technology is not yet proven, and certainly the capability for build does not yet exist. For onshore development, the diversity of manufacturers and technologies is already adequate. However the build capability is not.

18. Without firm commitment to a wind farm build programme in the UK, it is difficult to see that the manufacturers will either sufficiently accelerate their offshore technology development programme, or put in place an adequate build capability. In order to accelerate the offshore technology development it may also be appropriate to incentivise owners and developers to support the process by including small demonstration projects of "first production" large scale turbines in the current build programme.

Microgeneration

19. Microgeneration is in its infancy with only limited installations of micro-CHP, photovoltaics (PV) and micro-wind. Micro-CHP has the potential to become a mass market retail offering as over 1 million boilers are replaced per annum. We believe that PV and micro-wind are likely to remain niche retail products. All these technologies have the potential to make a contribution to reducing emissions. As the price of these technologies reduce, the uptake of them will be greater.

20. There are complications with all these technologies not least the arrangements for paying and settling the accounts for exported electricity and ROCs. There are also metering issues, reliability issues and warranty issues. In time if distributed generation becomes widespread it will have an impact on centralised generation. This is not likely to have a significant impact in the next 10 years.

Attitude of Financial Institutions and Investors

21. Despite the widespread recognition of the challenging generation gap faced by the UK, investment even in CCGT new build, is not immediately forthcoming. Recent history, with a number of generators having faced financial difficulties as wholesale prices declined, as well as uncertainties over long-term energy policy and regulatory framework, have made potential investors reluctant to commit the significant levels of capital necessary. The Government must provide clarity on issues such as the EU Emissions Trading Scheme and the implementation of the LCPD as soon as possible.

22. For renewables, there has been increasing confidence amongst banks and investors about the risks as the forms of government support are becoming better formulated, proven and understood. Renewable technology manufacturers are consolidating and there have been a number of successful renewable project finance investments recently.

23. An example of the confidence of banks and investors in the renewables industry was RWE npower's innovative Zephyr Investments Limited transaction in 2004. Zephyr Investments Limited is a £400 million joint venture between RWE npower and two private equity investors (Englefield Capital and Arcapita). The company will own a UK portfolio of over 400MW of onshore and offshore wind farms developed and constructed by npower renewables by the end of 2006. The business is supported by a loan from a syndicate of 13 banks. A number of investors are actively seeking to make similar investments at present.

24. When considering changes to the Renewables Obligation, it is important not to undermine the current investor confidence. Nevertheless, it would be possible to encourage investment in offshore wind through targeted revenue support or supplementary contractual arrangements.

25. Government should aim to ensure that the construction of new nuclear power stations is an option that can be considered alongside the construction of other types of new power plant (such as CCGT). We believe that whilst it is right to seek to remove any barriers which may stop new nuclear from competing on level terms with other technologies, it would be wrong to force it into the energy mix. Markets are most successful when the participants are free to make investment decisions within a high-level framework set by Government, which reflects the overall objectives and limits but does not dictate the means of achieving them.

26. The UK is fortunate to have such diverse sources of energy as wind, gas, coal, hydro, co-firing biomass and nuclear and can continue to maintain the high standard of security that comes with this diversity of supply, through further investment, with clarity on urgent pieces of environmental regulation and the right policy framework. Such a framework would ensure that private capital would continue to meet the nation's energy needs in a secure, sustainable and cost-effective way.

18 October 2005

Memorandum submitted by the Scottish Green Party

The Scottish Green Party believes that there should be no nuclear new-build. Nuclear power is not economically viable, safe or likely to have a significant impact of CO_2 emissions

The nuclear industry has been trying to make nuclear power economic for 50 years, yet in April 2005 the Nuclear Decommissioning Authority took on the liabilities of BNFL & UKAEA—some £56 billion. Why pay this premium to incur nuclear power's inherent problems of:

- accumulating radioactive waste, active for up to 250,000 years;

- diverting resources away from energy efficiency, cogeneration[354] and renewables;
- risk of nuclear accident (as at Chernobyl);
- inability to restart generation for days after an unexpected shutdown;
- radioactive pollution from reprocessing nuclear waste at Sellafield (such as the leak of some 20 tonnes of uranium and plutonium fuel at the Thorp reprocessing plant at Sellafield, including, reportedly, enough plutonium to make 20 nuclear weapons);
- risk of theft of weapons-useable plutonium;
- risk terrorist attack on nuclear reactors and waste storage facilities; and
- risk of nuclear waste transport accident or sabotage (rail, sea).

When the Government published its Energy White Paper in February 2003, the then Energy Minister, Brian Wilson, said, "If renewables and energy efficiency can prove themselves over the next five years there will be no need for new nuclear power stations.[355]" The Scottish Executive's own figures (2001) show that Scotland's renewable capacity is around 6 times Scotland's annual electricity requirement, leaving enough spare capacity to power most of England as well[356]. We could be well on target to pass this test by 2008, were it not for such a lack of serious government support. But here we are, in 2005, assuming renewables will fail and still asking if nuclear power is an option.

How "renewables and energy efficiency can prove themselves over the next five years" unless there is a strategic plan for energy efficiency and renewables development as a matter of priority is not clear. And it must be stressed that this inquiry is just considering electricity, which accounts for only one fifth of our energy use. Nuclear power cannot address non-electrical energy use, such as transport and non-electrical heating. So even if nuclear power were truly CO_2-free, it would do little to tackle climate change when some 80% of CO_2 emissions come from transport.

But nuclear power isn't CO_2-free, as is so often claimed by its supporters. Even with the best uranium ores, when the whole cycle is considered, nuclear power generates approximately one-third as much CO_2-emission as gas-fired electricity production. The rich uranium ores required to achieve this are, however, so limited that if the entire present world electricity demand were to be provided by nuclear power, these ores would be exhausted within three years[357], even less if we think nuclear power can be used to make hydrogen for fuel cell use in transport. Use of the remaining poorer ores in nuclear reactors would produce more CO_2 emission than burning fossil fuels directly.

In March we learned that the most comprehensive survey ever into the state of the planet found that human activities threaten the Earth's ability to sustain future generations[358]. The Millennium Ecosystem Assessment was drawn up by 1,300 researchers from 95 nations over a period of four years and concluded that the way society obtains its resources has caused irreversible changes that are degrading the natural processes that support life on Earth. Just last week[359], we learn that a record loss of sea ice in the Arctic this summer has convinced scientists that the northern hemisphere may have crossed a critical threshold beyond which the climate may never recover. Scientists fear that the Arctic has now entered an irreversible phase of warming which will accelerate the loss of the polar sea ice that has helped to keep the climate stable for thousands of years.

Yet the Government is still considering prolonging an uneconomic nuclear industry which will have negligible impact on CO_2 emissions, rather than divert that money into a serious programme of energy efficiency, cogeneration and renewables, including micro-renewables. Micro-renewables not only address some of the base-load problems of supplying large conurbations, but they also make people more aware of their electricity consumption. Coupled with 2-way metering, micro-renewables could transform the public's perception of renewable energy[360].

We in the so-called developed countries only live such lifestyles because we've had 150 years of cheap energy, in the form of oil. Since 1981, we have been using more oil than we have discovered—yet our global demand for energy is spiralling upwards. No mix of renewables can supply our current demands for energy—they are unsustainable and the biggest problem is transport, not electricity generation. Producing all our (UK) electricity from renewables resources is technically possible and more economically viable than nuclear power. We have to change the way we think about work, life and transport and that has to begin with decentralising our electricity supply systems and making a firm decision against new nuclear power stations.

In response to some of your specific questions:

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354 Cogeneration is the simultaneous production of heat and power in a single thermodynamic process.

355 *Guardian* 25 February 2003, "Green Power—Five years to prove its worth"' by David Gow. http://www.guardian.co.uk/guardianpolitics/story/0,3605,902411,00.html

356 http://www.scotland.gov.uk/pages/news/2001/12/SE5008.aspx

357 http://beheer.oprit.rug.nl/deenen/

358 http://news.bbc.co.uk/1/hi/sci/tech/4391835.stm

359 Global warming "past the point of no return", Steve Connor, Science Ed, *The Independent*. Published: 16 September 2005.

360 Taken from the Scottish Green Party's response to the DTI's consultation on Microgeneration Strategy and Low Carbon Buildings Programme.

A. The Extent of the "Generation Gap"

1. *What are the latest estimates of the likely shortfall in electricity generating capacity caused by the phase-out of existing nuclear power stations and some older coal plant? How do these relate to electricity demand forecasts and to the effectiveness of energy efficiency policies?*

According to http://www.dti.gov.uk/energy/inform/energy_stats/electricity/index.shtml, in 2004 major power producers used the following (Million tonnes of oil equivalent).

Coal	30.375
Gas	26.182
Nuclear	18.164
Net imports	0.644
Oil	0.572
Other renewables	0.540
Hydro	0.366
Total major power producers	76.842

So removing nuclear and coal capacity would reduce output by almost 50 Mtoe or over 60%. It is clear that to end coal and nuclear electricity generation without serious investment into the alternatives is impossible without severe cuts in power. The Scottish Green Party has been calling for investment into energy efficiency and renewable electricity generation for decades. This gap can only be filled if demand is reduced and the electricity we do require is generated from renewable sources wherever possible. Scotland at least has hydro power, but there is little scope for new hydro stations. Therefore, it is vital to implement a mix of energy efficiency and renewable electricity generation.

B. Financial Costs and Investment Considerations

2. *With regard to nuclear new build, how realistic and robust are cost estimates in the light of past experience? What are the hidden costs (eg waste, insurance, security) associated with nuclear? How do the waste and decommissioning costs of nuclear new build relate to the costs of dealing with the current nuclear waste legacy, and how confident can we be that the nuclear industry would invest adequately in funds ring-fenced for future waste disposal?*

In April 2005 the Nuclear Decommissioning Authority took on the liabilities of BNFL & UKAEA. According to Nuclear Engineering International (11 August 2005)[361] the total estimated lifecycle undiscounted cost of operations, decommissioning and clean up is now estimated at £56 billion, up from the 2002 estimate of £48 billion. Should the UK's plutonium stock be reclassified as waste then the costs would increase by several billion pounds. For reasons of waste alone, nuclear power can never be profitable.

The Scottish Green Party finds it hard to believe that the commercial non-viability of nuclear energy has still not been recognised by the Government. Numerous studies have been carried out into the commercial viability of nuclear power, including the recent Rocky Mountain Institute paper entitled *Nuclear power: economics and climate-protection potential*[362],which concludes that "on the criteria of both cost and speed, nuclear power seems about the least effective climate-stabilising option on offer".

Costings for nuclear power are unrealistic if cost trends aren't taken into account. How will price of uranium ore increase with time? How will increased oil prices impact on the economics of nuclear power? These are questions which cannot be answered and the precautionary principle should prevail.

The Scottish Green Party is not confident that the nuclear industry can ensure the safety and disposal of the existing legacy of waste, let alone adding to it with the waste from "at least eight AP1000 reactors or equivalent". We also have reservations over AP1000 design itself, the selling points of which include that it is cheaper and quicker to build. Installing the cheapest design does not inspire confidence and adds further to the claim that nuclear power is uneconomical.

Is there the technical and physical capacity for renewables to deliver the scale of generation required? If there is the capacity, are any policy changes required to enable it to do so?

Renewables have to be made to work and they can with demand reduction. As referred to above[3], the Scottish Executive's 2001 study indicates that nearly 60GW of new renewable energy generating capacity could be available in and offshore Scotland at under 7p per unit in 2010 (including connection costs but not grid strengthening costs), as shown in the table below.

[361] http://www.neimagazine.com/story.asp?sectionCode = 132&storyCode = 2030326

[362] http://www.rmi.org/images/other/Energy/E05-08—NukePwrEcon.pdf (11 Sept. 2005)

Technology	*Generation (GW)*	*Energy (TWh)*
Offshore Wind	25	80
Onshore Wind	11.5	45
Wave Energy	14	50
Tidal stream	7.5	33.5
Agricultural wastes	0.4	3.5
Small hydro	0.3	1
Energy Crops	0.14	1.1
Forestry Residues	0.09	0.7
Total	**59.1**	**216**

For comparison, the total UK installed generation capacity is around 80GW, while the total amount of electricity supplied in a year is around 390TWh.

A 2004 study by Gross[363] says the UK has a practicable potential to meet 230TWh per year using renewable energy. This is a more recent UK-wide study and obviously England & Wales have more renewable electricity potential than 14TWh. However, the levels given in the Gross study assume a constrained build rate and no network reinforcement for onshore wind, and biomass (energy crops) figures are based on conservative assumptions for land availability. So they may be more realistic than the Scottish Executive's 2001 figures.

According to Gross, UK electricity demand is 320TWh per year and the UK has a practicable potential to meet to 230TWh. Based on these figures, the UK should be aiming to reduce its electricity demand by around 30%, as shown below:

320 (current UK electricity demand) − 230 (UK renewable potential) = 90/320 = 0.28 or
a 28% reduction in current demand to make a realistic renewable supply mix work.

Renewable alternatives to electricity are more developed and currently more feasible than similar moves to tackle the even bigger transport problem. Therefore, the Scottish Green Party believes that electricity demand cuts of 50% can, with sufficient investment, be achieved by 2020 with a 2015 target of a 30% reduction.

As for baseload, the economically recoverable marine resource for the UK has been estimated by Ocean Power Delivery at 87TWh per year[364], or approx. 25% of current UK demand. This potential could be realised by 2020 with sufficient investment, although we still need to assess the environmental impacts on marine ecosystems. Again, the more localised generation the less demand for baseload.

Residential appliances and equipment use 30% of all electricity generated in OECD countries[365]. Assuming that the electricity generation and industry sectors make up a large part of the remaining 70%, while promoting marine renewables for baseload, we also stress the urgency to localise the grid, encourage 2-way metering systems and microgeneration, install district heating, and significantly increase CHP, especially for industrial processes. The looming energy gap can be filled without nuclear power, but it does require Government will.

What are the relative efficiencies of different generating technologies? In particular, what contribution can micro-generation (micro-CHP, micro-wind, PV) make, and how would it affect investment in large-scale generating capacity?

The Scottish Green Party believes that localisation of electricity supply is a vital component of decentralising our electricity supply to enable a switch away from centralised systems which are no longer effective for supplying electricity in a modern context. Micro-generation is an important component of this decentralisation process. Large-scale generating capacity should be reserved for situations where local production cannot meet demand, eg large industries and concentrations of residents in an area which required more than micro-generation can provide. There has to be Government encouragement for people to start to generate as much of their own electricity as possible, including 2-way metering to deal with surplus capacity.

363 Gross, R, "Technologies and innovation for system change in the UK: status, prospects and system requirements of some leading renewable energy options", Energy Policy vol 32, no 17, Nov 2004.

364 http://www.oceanpd.com/Resource/default.html

365 http://carroll.org.uk/archives/2005/05/25/leaked-g8-draft-climate-decisions/2

3. *What is the attitude of financial institutions to investment in different forms of generation? What is the attitude of financial institutions to the risks involved in nuclear new build and the scale of the investment required? How does this compare with attitudes towards investment in CCGT and renewables? How much Government financial support would be required to facilitate private sector investment in nuclear new build? How would such support be provided? How compatible is such support with liberalised energy markets?*

The Scottish Green Party believes we have to move away from the purely profit-driven motives of big business and actually start changing for the benefit of all—this generation and those to follow.

What impact would a major programme of investment in nuclear have on investment in renewables and energy efficiency?

For the reasons stated above, the Scottish Green Party fears that any money invested into nuclear is money diverted away from renewables and energy efficiency.

C. Strategic Benefits

4. *If nuclear new build requires Government financial support, on what basis would such support be justified? What public good(s) would it deliver?*

If nuclear power is competitive, as its proponents claim, there should be no Government support for building new nuclear power stations. If it is an economically viable industry, then the industry should invest in the capital accordingly. Under no circumstances, should public money be put towards nuclear power and diverted away from renewables and energy efficiency.

To what extent and over what timeframe would nuclear new build reduce carbon emissions?

That nuclear power can alleviate climate change is a fallacy. As stated above, even with the best uranium ores, when the whole cycle is considered, nuclear power generates approximately one-third as much CO_2-emission as gas-fired electricity production. The rich uranium ores required to achieve this are, however, so limited that if the entire present world electricity demand were to be provided by nuclear power, these ores would be exhausted within three years[4]. 80% of CO_2 emissions come from transport, which nuclear power cannot begin to tackle.

To what extent would nuclear new build contribute to security of supply (ie keeping the lights on)?

If we have to resort to nuclear power to "keep the lights on" then the Government has failed in its duty to ensure a diverse mix of energy supply, especially worrying given we are approaching a peak in oil production. Nuclear power has failed the test and a new round should not be an option.

19 September 2005

Memorandum submitted by ScottishPower

1. Introduction

Background on ScottishPower

ScottishPower welcomes the opportunity to contribute to the Environmental Audit Committee's inquiry. As one of the UK's largest energy companies, we are pleased to offer our views on the issues identified by the Committee.

These views are based on our practical commercial experience across the energy supply chain, including generation, transmission and distribution, and supply. In the UK, ScottishPower:

- operates some 6,200 MW of generating capacity, from a diverse portfolio of thermal electric, hydroelectric, renewables and CHP sources;
- is the 3rd-largest distribution company, operating and maintaining large power transmission and distribution networks;
- supplies energy and energy services to more than five million domestic customers; and
- is one of the leading developers of windpower, with 300 MW of onshore wind currently operational or under construction. Upon completion of our windfarm at Black Law later this year, it will become the largest in the UK. We are also in the final stages of seeking consent for our Whitelee windfarm, which will be the largest in Western Europe.

Meeting the Government's 2010 and 2015 renewables generation targets of 10% and 15% respectively will require significant investment in plant and infrastructure. In meeting this challenge ScottishPower plans to invest £1 billion over the next five years in delivering a further 1,000 MW of renewable energy. In addition as part of the RETS programme of network reinforcement in Scotland, we plan to invest £190 million in the first phase of upgrading and reshaping Scotland's high voltage transmission lines.

In partnership with AMEC and Ocean Power Delivery, we are also pioneering the development of marine energy in the UK. Current feasibility studies of the Pelamis wave energy technology could, with appropriate financial support, lead to the development of a revolutionary 22.5 MW wave farm.

With substantial coal- and gas-fired generation assets, we believe there may be opportunities to develop and apply carbon capture and storage technologies in the UK, and we support the aims of the Government's carbon abatement strategy, announced in June 2005.

Our industry and commercial experience gives us a valuable perspective on the impact of Government policy on the energy sector, and we hope this perspective and our projections for the future development of the energy market are of interest to the Committee.

Policy Context

In the 2003 Energy White Paper, the Government set out four key objectives for future UK energy policy: moving to a low carbon economy; maintaining the reliability of energy supplies; promoting competitive markets in the UK and beyond; and ensuring that every home is adequately and affordably heated.

ScottishPower has supported these policy goals and in particular believes that the Government's ambition to reduce carbon dioxide emissions by 60% by 2050 is achievable, but only if the correct market framework is implemented. Achieving a low carbon economy requires Government, regulators and business to work hand in hand to design the correct regulatory framework and market mechanisms for delivery. The existing mechanisms of the Renewable Obligation Certificate scheme, the Energy Efficiency Commitment and the EU Emissions Trading Scheme have already started to deliver the low carbon economy. However we encourage Government to continue to develop mechanisms with transparent and long-term outlooks, which serve to remove regulatory uncertainty. We believe that such mechanisms will stimulate investor confidence and that market based, tradable mechanisms, which are not technology specific, will be more effective at securing buy-in from companies and delivering security of supply.

ScottishPower would support a move to bring industry and Government together to determine future mechanisms and would seek to be fully engaged in any such initiative.

In its 2nd Annual Report on the Energy White Paper[366], the Government committed itself to:

> "giving the market as much advance notice and clarity as possible on the way new measures—particularly environmental regulation—will be implemented to inform decision-making and maximise the scope for efficient market response. There could be implications for security of electricity supply arising from the impending introduction of a series of European initiatives and Directives aimed at reducing pollution."

We acknowledge the importance of environmental legislation in driving energy policy. This includes climate policies, such as the EU Emissions Trading Scheme, the Large Combustion Plant Directive and the Renewable Obligation, as well as measures to tackle pollution and environmental impact. In the UK the combined effect of environmental policy drivers has already had a profound effect on the generation mix in recent years, accelerating the growth of gas, hastening the retirement of coal plant, and delivering support for renewables. Whilst ScottishPower supports the environmental objectives that are driving this change in the generation mix, we believe that it is essential that advanced notice of environmental legislation is needed to ensure early market signals to aid investment decisions. Equally timely decisions around the future legislative environment are required to give investor confidence and secure adequate rates or return.

In practical generation terms, the effect of the EU ETS and LCPD will be to increase commercial pressure on fossil fuel-based generation. Despite this pressure, in addition there has been a prolonged lack of clarity in respect of the LCPD methodology and confirmation of running hours. Equally for the second phase of the EU ETS, discussion is taking place as to the appropriate allocation mechanism. It is clear that such discussion and the subsequent decisions taken will benefit certain technologies at the expense of others. This presents a massive risk for investors and heightens the likelihood of incorrect investment decisions. Such an environment does not promote an optimal outcome and has the potential to affect security of supply and investor confidence. Therefore without early clarity on these issues there are clear implications for generators and the investment decisions that they need to make, at a time when significant changes in generation patterns are already taking place. For example moves from baseload operation to more flexible operating regimes are already under way.

[366] "Creating A Low Carbon Economy: second annual report on the implementation of the Energy White Paper", page 18, Department of Trade & Industry, July 2005.

For policy-makers, the key challenge continues to be balancing the environmental policy priorities, and the mechanisms designed to achieve them against the commercial operation of the electricity market and the expectations of industry and investors. Again, we believe that an open debate between Government and industry is required, during which priorities and mechanisms to achieve them can be discussed. In any event such mechanisms should be long term and stable.

In the longer term, there will need to be significant changes to the make up of generation in the UK in order to achieve Government targets on renewable generation and climate change. Given current environmental and economic pressures, it is difficult to see a long-term future for existing coal-fired generation, although clean coal technology and carbon sequestration may encourage new investment in coal. The other key determinant on the future of generation will be Government policy on nuclear new build or clean coal development.

In determining the UK's future generation mix there are many options open. As the experiences of other countries suggests, there is no single technological route to follow. Under different scenarios, a variety of generation mixes can deliver a low carbon economy in the UK. ScottishPower believes that renewable technology has an important part to play in meeting the Government's targets and as such are currently developing a range of technologies and rewiring the electricity networks to accommodate more remote and diverse sources of generation. It is our belief that renewable, nuclear energy and clean coal are not mutually exclusive. No matter which large generation plant the UK deems to be most effective for meeting all requirements, including security of supply, renewable generation should and can play a significant part.

The low carbon economy will come at a price—however it is constituted, the future generation mix that delivers the Energy White Paper's aims will require significant further investment. ScottishPower has stated consistently that delivery of the White Paper is likely to lead to a rise in unit prices of at least 15% in real terms by the end of the decade. Clearly, this excludes the recent effects of gas and coal prices on the wholesale markets. The costs associated with implementation of the environmental measures have yet to be fully factored into end-consumer tariffs and therefore there is potential for environmental legislation to impact upon the White Paper's other objectives around fuel poverty and UK competitiveness.

Whatever the options pursued, each will have its costs; and all of the possible options will cost more than UK consumers currently pay. Investor confidence in the future development and direction of policy is therefore critical. Under any future scenario for the UK's energy needs, long-term signals will be required from Government in order to create the conditions for investors to discriminate between market risks and regulatory and environmental risk, and to ensure that these investments do not run the risk of becoming stranded assets by sudden or unexpected shifts in policy.

2. Future Generation Capacity

In the UK, estimates of the likely shortfall in electricity generating capacity caused by the phase-out of nuclear plants and some existing coal plant prompts important questions about the security, diversity, and—importantly—the flexibility of future energy supply.

The majority of independent studies point to a tightening supply margin in generation in the next five years or so, with the possibility of a generation shortfall occurring in the medium term.

ScottishPower has its own views on the likely shortfall in generation in the future, but our views of the generation gap correspond broadly with independent analysis of the issue. In our view there will be a need for new investment in the medium term.

The gap in future generation can be filled in a number of different ways, depending upon the energy market scenario, which develops. The measures taken by Government to address the UK's predicted shortfall, and industry's response, will determine future generation mix.

Under all possible future scenarios, there is a strong role for further renewables development and action to deliver greater energy efficiency:

— on renewables development, the 2020 20% renewables target is challenging yet achievable with certain targeted measures (including an upward revision for the RO target beyond 2015). Delivery will mainly come from onshore sources such as wind and biomass (which we foresee will meet the majority of the 2010 targets) with the remainder met by offshore, marine and tidal. We broadly agree with the resource estimates identified by Government within the recent renewable obligation review, but at the same time highlight that additional measures are necessary to stimulate the offshore wind sector, and that it is imperative that market stability is maintained if onshore wind's contribution is to be fully realised.

— on energy efficiency, the Government's challenging targets will require a significant step change in activity. There is much progress to be made in reducing energy consumption as a means of curbing carbon emissions, as the White Paper envisaged, and Government must lead the battle for "hearts and minds". With this in mind, ScottishPower is engaged in the work of the UKBCSE in their consideration of tackling fuel poverty and maximising benefits in energy efficiency.

ScottishPower is firmly committed to tackling energy efficiency and we were successful in exceeding our obligations under the first round of the Energy Efficiency Commitment. Although EEC has been a successful programme, relative to the performance of other programmes across Europe, the 1% reduction achieved through EEC is not sustainable and a doubling of energy savings under EEC2 will be challenging to deliver without a market mechanism to create more tradability and provide greater incentive for innovation.

To achieve greater energy efficiency gains, the UK needs to go beyond EEC. We agree with assertions that there is the potential for 40% energy efficiency gains—but again the real challenge in respect of energy efficiency is convincing consumers of its value. Reductions in electricity use must be customer driven, as the market alone is not going to deliver a step change. Unless the Government can address, for example through fiscal measures, the slow rate of progress in this area, it is unlikely that the 40% reduction will be achieved.

The Energy White Paper rightly identifies security of supply as key to the UK's future energy interests. The national importance of security of supply suggests the need for a mix of generating types.

The strategic importance of flexibility in supply—as well as security and diversity—is often overlooked. It is a prime consideration. As the UK moves to a position of increased capacity from renewable generation and reliance on gas fired plant, it is imperative that the overall generation mix takes account of the issues with availability, flexibility and fuel sources in securing energy supply.

3. Financial Costs and Investment Considerations

Financial Costs

In recent years, costs studies from a range of sources have produced an equally diverse spread of estimates for the cost of different generation technologies. Across the board, however, taking into account differing cost assumptions (carbon, waste, support mechanisms), our view is that the aggregated costs of different technologies can work out broadly in line.

The costs of generation and benefits of the associated carbon abatement are widely reported in a variety of previous independent studies. Our considered view reflects a range of costs for new generation plant, which for electricity, will occur within the following ranges (costs shown below prior to inclusion of environmental externalities):

Coal (Pulverised)	− 3.0 ppu–4.5 ppu
Coal IGCC	− 3.5 ppu–5.0 ppu
Gas	− 1.75 ppu–3.0 ppu
Nuclear	− 3.0 ppu–5 ppu
Onshore Wind	− 3.0 ppu–5.5 ppu
Offshore Wind	− 4.5 ppu–7.5 ppu
PV	− 8.0ppu–12.0 ppu*
Marine	− 6.0 ppu–10.0 ppu*
Biomass	− 1.5 ppu–4.5 ppu

* costs may reduce considerably as the technology is optimised.

There is no lack of technological options. Adoption of technologies will be determined by timescales, and by the support mechanisms introduced/continued by Government. In defining its approach to differing generation solutions, Government should avoid confusing energy supply objectives with economic development objectives: the market should be concerned with the deployment of working technologies, rather than the pursuit of uneconomic or immature ones. Government should recognise the sensitivity of the market to any support for particular generation types. There should be a clear demarcation between the market structure and the support mechanisms for different technologies. As an example, ScottishPower believes that the Renewable Obligation Certificate Scheme has been a successful and effective mechanism, in that it delivers a market response to a Government policy objective.

Investment Considerations

As outlined above, delivering the low carbon economy requires a climate of stability, clarity and long-term commitment from Government if industry and investors are to be able to make investment decisions.

Investors need the security of long-term revenues. The risk of political interference or policy revision can undermine severely market and investor confidence. Wherever possible, market-based mechanisms to deliver policy—such as the Renewable Obligation and the EU ETS—should be enshrined in legislation and operated on a long-term horizon (perhaps 20–25 years). Continuous reviews of policy mechanisms can have the effect of damaging confidence in the long-term market, and thus threaten the very targets they are intended to support.

Developers will enter the market depending on risk appetite, cash rates and the expected rate of return. Existing mechanisms, such as the Renewable Obligation, should not be disrupted. In that sense, parallel mechanisms in support of other technologies, such as clean coal or nuclear, should not be regarded as competing with renewables.

Given the age of the UK's generation plant and the impact of environmental legislation, the long-term legislative stability is particularly important at the current time. Decisions about whether the UK will be a leader or follower in respect of technology are becoming increasingly pressing. Government has the ability to introduce additional mechanisms and support methods to determine this position. However the policy context will drive the adoption of a single or multi-technology solution based on the decision that Government makes in relation to the generation mix required.

Opportunities exist in the commercialisation of a number of different technologies. Depending on the attitude of Government and industry the UK could play a role in their development. It should be noted that if the UK is not a technology leader, then there will be an impact on the timing and cost of new technologies entering the UK market.

4. Conclusion

ScottishPower believes that BETTA market functions effectively in creating an openly traded market. Current issues and uncertainty in the market place, including security of supply, are often as a result of political and regulatory uncertainty. We believe that Government should set a broad market framework with clear and consistent market mechanisms and regulatory environment. Where possible such measures should be enshrined in legislation and be long term in nature. The market should then be left to deliver within the framework, with industry and investors managing market risk and Government managing political and regulatory risk.

It is our view that such arrangements and stability will allow the market to deliver security of supply. It is clear, when looking at the Renewable Obligation, that it has been successful due to the long-term commitment of the mechanism and the extended lifespan keeping investment interest and support.

However, we would suggest that there has to be a focus on joined-up Government working, both at regional and local level, if policy objectives are to be delivered. As an example, the Renewable Obligation has suffered due to local Government slowing down the planning process and regulation, for example transmission charging, making investment decisions uncertain.

30 September 2005

Memorandum submitted by the Scottish Renewables Forum

Please find enclosed our views relating to your forthcoming inquiry into "Keeping the Lights on: Nuclear, Renewables, and Climate Change".

Scottish Renewables is Scotland's leading renewables trade body, representing over 150 organisations and individuals involved in the development of renewable energy projects in Scotland. Our membership ranges from community groups and sole traders, up to major Scottish utilities and international plcs. Between them they are active in the development of biomass, hydro, solar, wave, wind and tidal energy projects. Further information about our work and our membership can be found on our website.

The Environmental Audit Committee's inquiry comes at a crucial time in reviewing the UK's capacity for electricity generation, transmission and the impact on reducing carbon dioxide emissions. Our submission provides evidence and opinion in support of the role of renewables within this debate and aims to highlight the implications of government policy at both UK and Scottish levels. This submission is complementary to the evidence submitted to the Scottish Affairs Committee inquiry into Meeting Scotland's Future Energy Needs (HC 259-I, 23 March 2005).

The key points which Scottish Renewables will make are:

1. Renewable energy is delivering and proving its worth to UK energy supplies. The UK's plans to encourage further development of renewable schemes has led to a rapid upscaling of project development. This trend is particularly strong in Scotland where significant resource is located. However, if this initial work is to be realised and result in achievement of renewable targets, then government and parliament must ensure continued confidence in the ability of government to support delivery, by not altering the fundamentals of the market.
2. The key issue facing UK is how to consider the replacement of current conventional generation that will complement the planned renewable target (20% of the UK market, and 40% of the Scottish market by 2020); ie the issue is how to achieve the non-renewable mix. The debate is not, therefore, about renewables vs. conventional as both will be needed.
3. If renewable energy in the UK is to be successful there must be co-ordination across Government departments and with government agencies. Too often our industry must deal with conflicting policies and regulations.

4. The costs of generating electricity in Scotland is being disadvantaged under the creation of the UK electricity market due to high transmissions costs, thus unfairly increasing the costs of renewable-sourced electricity within the UK.
5. In considering a future appropriate energy mix, the issue of non-electrical sources is often forgotten. Renewables also has a role in helping to meet the UK's future heating and transport energy needs.
6. Renewable energy, of all generating technologies, contributes the least to carbon dioxide emissions and will assist the UK in meeting its targets in emissions reduction with minimum concern over waste disposal.
7. Renewable energy sources provide a strategic fit with the UK Govt's aims on security of supply.
8. Increased investment in renewables development can assist the UK's exporting potential for both electricity supply and the manufacture of renewables technology, eg the Pelamis project in leading the marine energy sector. In this regard, prioritisation of renewable development will maximise future economic export opportunities.

The following information provides detail on each of these key points.

Renewable Energy Working Alongside Conventional Generation

The UK Government has set a target that 10% of its electricity comes from renewable sources by 2010. Beyond this is a 15% target for 2015 and an aspiration that the 2010 target is doubled by 2020.

Within Scotland we have higher targets. For 2010 there is an 18% target and a 40% target for 2020. These targets reflect Scotland's substantial renewable resource and aspirations for associated economic development, and also recognise that Scotland will make a sizeable contribution to UK targets.

Currently approximately 14% of Scotland's electricity comes from renewable sources. The bulk of this is hydro, but wind and landfill gas also make contributions. There are also sufficient wind energy projects now under construction or with a resolution to consent from determining authorities to ensure that Scotland meets its 18% target. Achievement of this Scottish target will be important to ensure that Scotland can make a strong contribution to the GB's electricity target.

Looking at Scotland's 2020 target it should be noted that all renewable technologies will need to play their part here. We would envisage that this target will be met as follows:

— $\frac{1}{4}$ hydro (ie 10%)[367]

— $\frac{1}{2}$ wind (ie 20%)

— $\frac{1}{4}$ emerging technologies (ie 10%) = biomass, tidal and wave energy

These targets are not to be interpreted as ceilings on each energy source. It is worth noting that there is currently a substantial amount of wind energy in the Scottish planning system now. We would not expect all of these projects to come to fruition either because of planning or grid constraints. There have been calls on the Scottish Executive to develop a National Strategic Plan for wind or even to impose a moratorium on project proposals. We would caution against this.

The Scottish Executive's Forum for Renewable Energy Development in Scotland (FREDS) has recently provided guidance for communities, planners and developers in Scotland[368]. However, the Scottish Executive still needs to provide better guidance on "cumulative impact"[369] to assist planning authorities with multiple applications for development in a particular locality. Hopefully, the Environmental Advisory Forum on Renewable Energy set up the Deputy Scottish Minister for Enterprise, will meet this need.

To ensure that other renewable technologies can play their part in meeting future energy needs the UK Government—in partnership with the devolved administrations—needs to ensure the following:

(a) Marine energy is given a positive financial and planning framework to develop in. This will provide incentive to technology and project developers to move forwards in developing first generation projects.

(b) Appropriate support mechanisms for biomass energy are developed, including development of a heating target (see later). It should be noted here that previous UK Government support on biomass has not been usable in Scotland because it has focused on energy crop support instead of support for forestry diversification. This discrepancy has now been resolved.

(c) Encouragement of micro-generation—including ensuring support in planning and building regulations and providing incentives to electricity supply companies to facilitate cost effective connection and allow the sale of electricity from household or small business sources. The current

[367] While hydro currently provides approx 11% of Scottish electricity needs, we would expect this contribution to fall as rising electricity demand will not be offset by new generation. Thus while the level of hydro generation will increase over time, its percentage contribution may fall. We have estimated this at 10% for simplicity.

[368] FREDS Future Generation Sub Group (June 2005) Scotland's Renewable Energy Potential: Realising the 2020 Target.

[369] Cumulative impact primarily affects wind energy proposals but can be applied to a mix of technologies or development types in a particular locality.

> system frustrates connection of micro-generation through being costly and bureaucratic. We are hopeful that the Department of Trade and Industry's recent consultation on microgeneration will assist in resolving some of these matters.

It is also worth noting that there is much discussion about the need for grid upgrades and new infrastructure as a result of new renewable energy proposals. New generation of any kind does need new infrastructure. However, much of the upgrade plans for new infrastructure is to modernise old infrastructure up to 50 years old and the costs shared with those wishing to utilise it for generation. Infrastructure upgrades are essential for both security of supply to growing cities (such as Inverness) and to enable new generating sources to supply the National Grid.

Another issue also needing to be considered is the issue of intermittency and the effect that a high penetration of renewables will have on the whole electricity system. Wind and wave energy generate variable levels of power dependent on weather conditions. Tidal energy is a predictable but not constant source and varies across the day and seasonally.

However, at the levels of penetration of these technologies expected by industry experts express confidence that "intermittency" can easily be managed. Indeed, such a problem is an insignificant one when compared to the daily challenge of managing the constant rise and fall of electricity demand. The GB System Operator National Grid Transco has stated that:

> based on recent analysis of the incidence and variation of wind speed we have found that the expected intermittency of wind does not pose such a major problem for stability and we are confident that this can be adequately managed . . .[370]

Furthermore, the Carbon Trust in its "Renewable Network Impacts Study" of 2004 stated that:

> At the current target levels, intermittency is not a significant issue affecting the development of renewable generation[371].

Replacing Ageing Conventional Generation

A key question facing the UK Government is how it plans to replace existing conventional generation with new generation. With renewables set a target of increasing its contribution from 10% to 20% some of this will be replaced. However, there will still need to be some new conventional plant.

There has been much play in the media about the choice between renewables and nuclear and how they can help to meet UK climate change obligations. However, it is the Scottish Renewables' view that there is no policy choice here, and choosing renewables does not necessarily mean rejecting nuclear. We would reject this argument because renewable energy is worthwhile on its own terms as a viable energy source. Similarly the case against nuclear does not stand or fall because of the strength or weakness of the renewables argument.

The wider challenge for the UK is therefore how to replace existing conventional generation. Put simply there needs to be a debate on what a future 80% of conventional generation will look like and what further contributions renewables can make.

Scottish Renewables would therefore urge the Inquiry to help move the debate forward: it should not be about the 20% vs 80% but how best to provide for a future 80% of UK's electricity needs. New build and replacement will be needed here. As with renewables, we see that conventional generation works best when there is a mix, because this means that the strengths and weaknesses of each technology can be balanced.

As for the interplay between conventional and renewable and generation and demand we would note the importance of a mixture to ensure that stability of supply is maintained. Key here is having future thermal plant that can be turned up or down to reflect (a) changes in demand, and (b) changes in contribution from more intermittent sources. Clean coal and gas are best placed to provide such thermal plant, but both pump storage of hydro and biomass can also play a role.

Nuclear energy provides baseload power but cannot be turned up or down easily. However, this fact can be balanced by the continued use of pump storage and demand side management tools such as use of white-goods metering.

Co-ordinating Policy and Regulation

It is noteworthy that a continued frustration of ours is how regulation of the electricity market can often work against achievement of policy objectives in electricity. While there are different roles for policy and regulation, there would seem to be scope for a degree of rationalisation.

Our key concern is the implementation of the British Electricity Trading & Transmission Arrangements that has seen the Scottish electricity market and the English-Welsh market merge. While this provides a larger market for generation, the current system will retain a number of regulatory differences. For example,

370 National Grid UK, 2004. Seven Year Statement. www.nationalgrid.com/uk/

371 Carbon Trust, 2004, The Carbon Trust and DTI Renewables Network Study.

transmission is classified differently in Scotland, so more renewable generators will be exposed to transmission charges than in England and Wales. Also the level of charges in Scotland is substantially higher.

We estimate that of the total £290 million charging bill payable by generators, £140 million will be met by Scottish generation, despite making up only 13% of total GB generation. This means that the average Scottish charge is six times higher than the average English-Welsh charge. Such a result penalises all forms of generation and ignores the fact that the development opportunity is often greater (primarily due to better resources or more site locations).

Considering Energy—Not just Electricity

Electricity use makes up approximately 20% of our total energy use. Heating makes up approximately 40% and transport fuel approximately 40%. Given concerns about future costs of gas as we become more dependent on imports, alongside concerns about oil price rises, it would therefore make sense to consider likely impacts of these changes on the cost of future heating and transport needs, and whether there will be an economic impact to the UK because of this.

Renewable energy can provide energy for heating and transport. For example biomass and solar energy can help provide heating energy (biomass works best in combined heat and power applications where heat and electricity are generated). Biofuels and wastes can be used to make bio-ethanol and bio-diesel to mix with or replace petrol or diesel. Longer term renewable electricity projects could be used to aid hydrogen production for use in fuel cells.

Thus while most of the policy debate is focussed on electricity needs, we are fast approaching the time when long-term changes will be required in how we meet heating needs. Consideration of meeting energy for future transport needs is not too far behind this. We would therefore urge your Inquiry to consider in more detail how these issues should be be considered and resolved by the UK Government.

I hope that the above information is of assistance to you in your inquiry. If you would like further information, or would wish us to present our views to the Inquiry itself, we would welcome the chance to assist you further.

21 September 2005

Memorandum submitted by Shanks Group plc

Introduction

Shanks welcomes the Committee's inquiry and is grateful for the opportunity to submit evidence.

Shanks is one of Europe's largest independent waste and resource management companies and offers a wide and often innovative range of waste management solutions within its various collection, transport, recycling, treatment and disposal services. The company is involved with a number of integrated waste management contracts to supply waste management services to local authorities.

Shanks has developed a solution which, through investment in new recycling and recovery infrastructure, can achieve a significant contribution to renewable energy targets and CO_2 reduction, while still meeting the primary imperatives for local waste management authorities ie the protection of public health and protection of the environment.

This solution is based on the use of a Mechanical Biological Treatment process (MBT) which along with kerbside collection, civic amenity site management, and composting forms part of the wider Shanks offering.

MBT is the generic term applied to a number of different technologies that involve the mechanical-biological treatment of municipal solid waste (MSW). Shanks uses a form of MBT that uses the biodegradable fraction of MSW—essentially anything that rots through natural bacterial action, as a source of heat. Elevated temperatures within the mass of waste and sustained airflow across and through it stabilises and sanitises the waste over a period of 10–14 days as well as reducing the overall mass by around 25%. The resultant, dried, "stabilate" material can then be further processed to recover stones, glass and metals etc to produce Solid Recovered Fuel (SRF) which has an intrinsic economic value [1] thereby converting waste into an energy resource.

SRF is easy to store and transport and with a calorific value approximately two-thirds that of coal, can be used to replace fossil fuels in power generation It has been calculated that power generation from SRF has the capability to provide as much as 17% of the UK's electricity requirements.[372]

SHANKS' RESPONSE TO THE INQUIRY QUESTIONS

B. Financial Costs and Investment Considerations

2. *What are the main investment options for electricity generating capacity?*

A recent Oakdene Hollins study[372] for the Institute of Civil Engineers and the Renewable Power Association concluded that municipal and commercial and industrial waste streams in the UK have the potential to produce up to 17% of the Country's electricity by 2020. The creation of an SRF from the residual fraction of this waste could be burned as a replacement for fossil fuels to create electricity and/or a source of heat in the case of a CHP facility.

What would be the likely costs and timescales of different generating technologies?

— What are the likely construction and on-going operating costs of different large-scale technologies (eg nuclear new build, CCGT, clean coal, on-shore wind, off-shore wind, wave and tidal) in terms of the total investment required and in terms of the likely costs of generation (p/kWh)?

Cost/benefit comparisons between large scale generation technologies on a "like for like" basis is inherently difficult for a number of reasons, not least the complexity of the energy markets and the effect of market mechanisms and subsidies such as carbon emissions targets under the EUETS and ROCs respectively.

In recognising these difficulties in making meaningful conclusions and recommendations over the most beneficial mix of energy generation capacity for the UK, the Royal Academy of Engineering (RAE) commissioned a detailed study[373] that was published in 2004 and which provides much useful and relevant information in comparing the true "costs" of various technologies, including renewables such as nuclear fission, on and offshore wind, generation from biomass, and wave and marine technologies. The findings take into consideration the actual costs of building, maintaining and running facilities, using a common financing model.

Whilst this report shows that non-renewable generation including coal fired PF, coal fired CFB, gas fired CCGT and the like provide the most cost effective option currently, when the effects of carbon dioxide emission costs (at estimated £30/t) are taken into account the differential between conventional combustion techniques and the range of renewable options is significantly reduced.

Unfortunately, the report does not provide detail relating to advanced thermal treatment technologies such as gasification/pyrolysis nor dedicated facilities for the combustion of SRF as a fuel feedstock, nor interestingly, does it extend its scope to the consideration of the relative merits of various fuel types which provide a positive value for the generator rather than contribute to the operating costs of the operation.

Shanks recommend that as an outcome of this consultation further work is commissioned to extend the work on generation from renewable sources, to a detailed appraisal of generation from SRF and other waste derived fuels which may contribute a positive revenue stream in terms of gate fee for the generator.

From its own work with developers of dedicated facilities for the utilisation of SRF, Shanks estimate that the indicative cost of electricity generation through such a plant may be in the region of 4–6 ppkWh. This excludes benefit from gate fees for supply of the fuel feedstock; this may effectively reduce the cost of generation by 1–2 ppkWh.

These figures compare favourably to the costs of the majority of other "renewable" technologies including on and offshore wind generation and generation from biomass.

For reference, typical costs identified in the RAE report for various types of renewable and conventional generation are as shown below.

	Without standby generation	*With standby generation*
Poultry litter BFB steam plant	6.8	6.8
Onshore wind farm	3.7	5.4
Offshore wind farm	5.5	7.2
Wave and marine technologies	6.6	6.6
Gas fired CCGT		2.2
Coal fired CFB steam plant		2.6
Nuclear fission		2.3

Source: "*The Cost of Generating Electricity*", The Royal Academy of Engineering—March 2004.

372 Quantification of the Potential Energy from Residuals in the UK: http://www.r-p-a.org.uk/content/images/articles/RPA&ICEEfRW.pdf

373 The Cost of Electricity Generation, The Royal Academy of Engineering, March 2004. http://www.raeng.org.uk/news/publications/list/reports/Cost_of_Generating_Electricity.pdf

Over what timescale could they become operational?

In Shanks' experience planning and permitting of MBT plants should be achievable within approximately 18 months, with construction requiring a further 24–36 months.

In terms of dedicated generation capacity to realise the energy potential from the SRF from MBT facilities, such timescales have yet to be defined as the first MBT facilities are only now under construction in the UK. However, the difficulties in overcoming the legacy of the UK's historic negative approach to "Energy from Waste" plants in the planning arena are well documented. The effect on timescales for development remains to be seen but should not be too far removed from the timeline for the establishment of the MBT facilities themselves.

Although SRF is essentially a renewable fuel, associations with the material as a "waste" rather than a resource continue to be made. Delineations between the use of a manufactured fuel to create renewable energy and waste incineration need to be made.

Is there the technical and physical capacity for renewables to deliver the scale of generation required?

MBT technology is relatively new to the UK, but has been used successfully in Europe (particularly in Italy and Germany), for over a decade. Utilisation of the resultant fuel is also well established on the continent to the extent that that there are restrictions in place upon the disposal by landfilling of material with such significant potential for energy recovery.

The physical capacity for this type of renewable energy, in the context of self-sufficiency for the UK, will be capped by the amount of suitable waste produced (currently in the order of 27 million tonnes). As previously stated, the UK's waste production should be sufficient to generate 17% of the UK's electricity requirements in 2020.

If there is the capacity, are any policy changes required to enable it to do so?

Shanks believe that there are two fundamental policy barriers to developing the necessary capacity.

— Fuel Classification

Whilst the biomass fraction within SRF is classified as a "renewable" source of energy there is a perception that SRF itself is a "second class citizen" in terms of its continued treatment as a "waste" product for the purposes of Waste Incineration Directive. Further, only where energy is recovered from SRF in an advanced thermal treatment process does the resultant electricity attract economic support under the Renewables Obligation.

We acknowledge that the current RO review process is supportive of a move towards a "waste neutral" position for generation facilities using pure biomass, whereby any waste inputs do not invalidate the accreditation of the whole facility in terms of ROC eligibility. However this does not address the issue of necessary compliance with WID which presents itself once SRF type material is accepted as a feedstock.

— Financial

Shanks firmly believe that SRF provides cost advantage to power producers in the medium to long term although this is currently insufficient incentive for power generators to invest in this technology for a number of reasons, not least the comparative surety of subsidies of other, albeit more costly forms of renewable energy.

A mechanism to facilitate incentive for change needs to be found if the potential for waste derived fuels is to be realised, whether this be through a system allied to the RO or another such similar mechanism.

3. *What is the attitude of financial institutions to investment in different forms of generation?*

From Shanks' exposure to the markets, it would appear that there is willingness to invest in renewable technology, however there is uncertainty due to lack of clarity and consistency in the Government's renewables policies.

21 September 2005

Memorandum submitted by Stop Hinkley

Introduction

Stop Hinkley is a local group campaigning against the operations and potential expansion at Hinkley Point in Somerset. We support energy conservation and renewable energy as means to produce energy and reduce the need for up to one third of energy production in the first place. We are concerned about the risks associated with the industry, both immediate and to future generations, and over safety—to potentially tens of thousands of people and also the health of individuals exposed to the routine daily radioactive discharges from nuclear plants.

Opposition to Wind-farms

In the Government Energy Review last year, the nuclear option was left open, apparently at the behest of Tony Blair and in the face of Cabinet opposition, as most of the nation was against the idea, tested by various opinion polls. This option is to be reviewed in 2006 and will hinge on the success of renewable energy. Should wind-power fail, in other words, then nuclear is back on the agenda. This unfortunate dynamic sets renewables as an obstacle to more nuclear power and therefore a target for pro-nuclear lobbyists.

This may be one motive for some vociferous local and national protest groups. Related to a proposed wind-farm at Hinkley Point in West Somerset, key anti-wind campaigners have worked at the Hinkley complex, according to a regional newspaper.

Nuclear New-generation Safety

However advocates of the nuclear technology should recognise that the next generation of nuclear reactors will not be "safer, cleaner and greener" than the current 30 and 40 year old reactors. The Westinghouse AP1000 design vaunted by BNFL, and suggested in the inquiry brief, has had its safety valves, pipes and cables stripped out by 70% to reduce building costs. It may never receive a UK operating licence due to having no secondary containment to protect the public in the event of an accident. Safety systems considered essential to Sizewell "B" have been replaced by a "passive safety" feature that would simply spill a huge tank of water onto the overheating reactor, while operators try to get it under control. Concreting has been reduced by 65% on the Sizewell "B" plant also a Westinghouse, to save costs, rather than increased as a vital defence against terrorism. The Finnish Government seemingly excluded this design due to their concerns about its vulnerability. One nuclear consultant has said a large airliner could slice through the reactor like cutting the top off an egg.

Carbon

The supposed carbon-free quality of nuclear power is not entirely a convincing argument as it actually produces four times as much CO_2 as wind-power per kilowatt generated. The German EKO Institute found a typical 1,250 megawatt nuclear power station produces up to 1,300 million tonnes of the greenhouse gas in its lifetime, considering all its processes from uranium mining, plant building, generation, decommissioning to the long-term, unresolved problem of dealing with nuclear waste.

Costs

For those concerned about the public costs of wind-power, which although inevitable in a fledgling industry will be relatively minor, the financial track record of the nuclear industry is truly appalling. British Energy's bankruptcy was only avoided by much help from the national Treasury, thousands of hours work at the DTI and costs for fuel and (useless and polluting) reprocessing externalised onto publicly owned, loss-making BNFL. Last year rows were a daily feature between disenfranchised share-holders and BE bosses. Over the decades nuclear has hoovered up much-needed research money for renewables, especially locally popular tidal-power. It would do so again given a chance, thus ruining the future for cleaner technologies. Nuclear decommissioning of plant is currently priced at £55 billion and will probably rise further given the industry's track-record. Dealing with nuclear waste still has no final cost as, even after 50 years, there is no decided route for dealing with this toxic legacy which has half-lives with five-figure numbers.

Current Safety in the Nuclear Industry

In July last year the Environment Agency lambasted the industry's safety and pollution standards with over forty indictments against British Energy. Hinkley "B", our local surviving nuclear power station, suffered countless emergency shut-downs in 2003 forcing its bosses to admit needing to invest millions into improving its reliability and reducing human errors. Hinkley "B" owners, British Energy have acknowledged the existence of cracks in the reactor core graphite which contains and allows the cooling of nuclear fuel rods. A consultant has suggested continuing to run reactors with damaged reactor cores could lead to fuel fires which could escalate, burning for two or three days and contaminating thousands of people.

Nontheless BE are planning to extend the lives of their ageing reactors as shown in the Chairman's report last week. But last December their report to shareholders suggested they may need to shut reactors early due to internal damage. The industry's concern for profit may be eroding their judgement over safety margins.

Health Effects of Radiation

Perhaps the most worrying aspect is the continued wall of secrecy surrounding the industry. A committee examining cancer risks from radiation was gagged by Government lawyers (*Sunday Times* 1 August 2004). So the committee's report, warning of greatly increased risks to those living near nuclear power stations, was watered down. Even so, the Committee Examining Radiological Risks from Internal Emmitters (CERRIE) still said there was an error in current health risk calculations "of at least one order of magnitude". Professor Dudley Goodhead, leading the committee said chillingly that all decision-makers should take note, particularly where children in affected local populations could be concerned.

A more recent COMARE report (Committee on Medical Aspects of Radiation in the Environment) suggested that living within 25 kilometres of nuclear power stations proved no threat to public health. But the report used a crude method circling the plants to a bigger distance than one would expect to find health effects from air and sea-borne radioactive particles, which also encompassed large populations. The net effect was to swamp out any significant figures in blighted towns downwind and downstream from the plants, rendering its conclusions meaningless.

Our own sponsored research has shown an increased rate of breast cancer, both mortality and incidence, in the nearest large town to Hinkley Point, Burnham-on-Sea. Mortality was double according to Office of National Statistics figures examined by Dr Chris Busby of Green Audit over a five year period. South West Cancer Intelligence Service figures showed breast cancer registrations were 21% higher than expected over a 13 year period to 2002. See www.llrc.org for details.

Conclusion

I recommend we aim for safer, cleaner and greener technology with wind-farms, energy conservation and other renewables and consign the nuclear industry to history.

21 September 2005

Memorandum submitted by John Thring

I note that your enquiry is also required to consider relevant aspects of climate change.

As a result of my wide reading on this issue I have, of course, come to some tentative conclusions and I must share these with you by way of preamble.

To be as brief as possible, my conclusions so far are that:

1. It seems inescapable that climate change is occurring, and that it will cause global warming with far-reaching consequences.
2. It may be true that the pace of such climate change is being accelerated by the actions of humankind, but it may also not be true. In the former case, there is a considerable number of encouraging initiatives under way and we must hope that they come to full fruition in time. In the latter case, all our efforts will be in vain.
3. There seem to be only four possible outcomes:
   (a) Our efforts will halt climate change for the foreseeable future. (This seems most unlikely, if not impossible. Geology indicates that the climate has always been changing, long before humankind had any influence.)
   (b) Our efforts will slow down the rate of change. However, all this does is delay the process by a number of years. (This may be the best that we can hope for).
   (c) Our global efforts at slowing the rate of change will be too small, and/or implemented too late, to make any significant difference. (My money would go on this one).
   (d) If climate change is not being accelerated by the actions of humankind, then our efforts will have no effect upon the rate of such change. (However, we do not know this and therefore need to make the attempt).

My readings elsewhere inform me that there have been some analyses of the effects of rising seawater levels, disappearance or reversal of the Gulf Stream, annual rainfall etc in the UK as a result of climate change. However, I have not been able to find any consequent proposals about how we might mitigate these effects. New Orleans has recently brought to the forefront questions about allowing low-lying areas to return to the sea, for example.

My major concern is that I can find no description of a UK strategy or policy concerning the "adaptation strategy" for dealing with the effects of climate change. I feel that it would be wise for such a strategy to consider, for example, the removal of our oil refineries to high ground (I believe all of them lie next to ports on low-lying marshland).

Similarly, I suspect that many, if not all, of our existing nuclear and carbon-fuelled power stations might be a great risk if we saw a rise in mean sea level of, say, one metre. I feel that constraints as to the siting of any new-build nuclear stations should be a consideration of your Committee, and should consider a probable, and possibly large, rise in sea levels as well as the more usual considerations of accessibility and safety.

22 September 2005

Memorandum submitted by Tidal Electric Limited

As Chairman of Tidal Electric Limited, I welcome the opportunity to submit evidence to the Committee inquiry. The inquiry comes at an important time for the country: oil and gas prices are significantly increasing, there is no clear policy on new nuclear and the Government's target of 10% market share for renewables by 2010 appears unlikely to be reached.

A. Tidal Electric

1. Tidal Electric is a British-based development company that was established in 2000 with the sole intention of building a tidal lagoon electricity generation scheme in UK waters.

B. Tidal Lagoon Generation

1. Offshore tidal lagoon power generation utilizes the vast potential of the ocean's tides. Using an offshore impoundment structure built of rubble mound construction materials (loose rock, sand, and gravel) sited in a shallow tidal flat with a large tidal range, predictable and sustainable electricity can be generated by the rise and fall of the tides. It is not directly comparable to a tidal barrage scheme (such as the Severn Barrage) as the power is generated offshore via the impoundment structure. The tidal lagoon scheme enables tidal energy to become a mainstream technology choice.

2. Offshore tidal power generators use familiar and reliable low-head hydroelectric generating equipment, conventional marine construction techniques, and standard power transmission methods.

3. The optimal site for offshore tidal power generation is the shallow water of near-shore areas, away from major shipping lanes that require deeper water. The offshore siting is the distinctive characteristic of the design and one of the fundamental claims of its patents. Turbines are situated in a powerhouse that is contained in the impoundment structure and is always underwater. Power is transmitted to shore via underground/underwater cables and connected to the grid. The structure need not be more than a few yards beyond the low tide level and the optimal site is one that is as shallow as possible, thereby minimising the cost of building the impoundment wall.

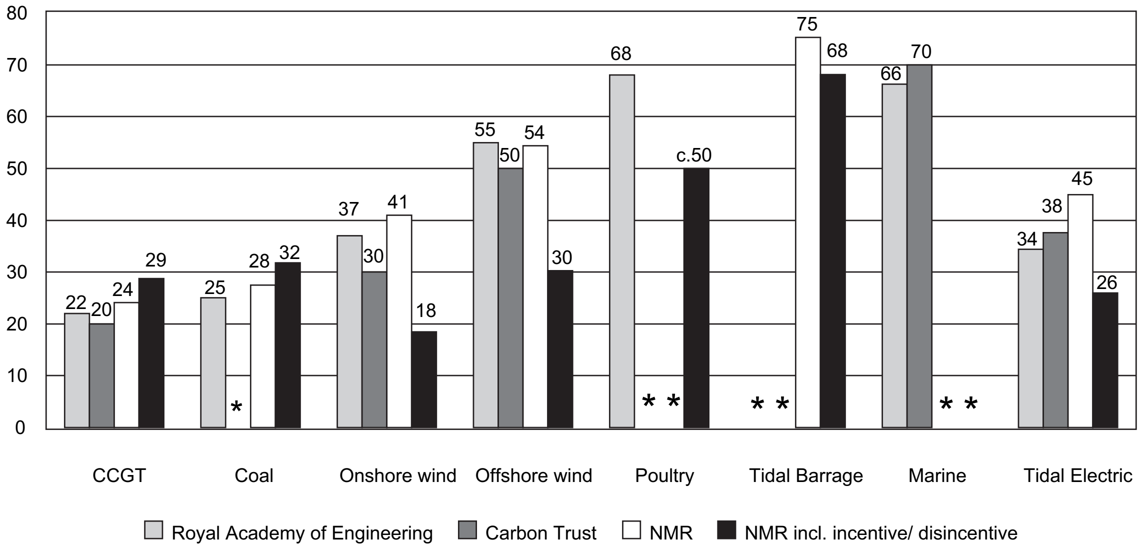
4. The impoundment wall structure is a conventional rubble mound breakwater, with ordinary performance specifications and is built from the most economical materials. In the event of a failure of the structure, the consequences do not include safety issues or major property damage. The most likely cause of a failure would be a strong nearby earthquake (unlikely in UK waters) and the most likely type of damage would be a breach of the impoundment structure. Thus, the principle consequence of failure would be economic (temporary interruption of service) and, therefore, economics are the primary driver in choosing the materials and the construction method.

5. Two sites in UK waters have been identified as suitable for the construction of the world's first tidal lagoon generation scheme: Swansea Bay and the North Wales coastline, off Rhyl. Both areas have high tidal ranges and relatively shallow waters. Feasibility work started in 2000 and preliminary consultation with local planning authorities has been undertaken. There has generally been a favourable response to our proposed schemes as they provide a sizeable renewable and predictable generation resource. Swansea Bay has a capacity of 60MW and North Wales has a capacity of 420MW.

6. We have also identified a number of other potential sites around the UK coast which meet the requirements of high tidal range and shallow tidal flats. We believe that it would be possible to generate from numerous sites, approximately 21 TWh, representing 8% of current UK electricity consumption.

C. Costs—Construction and Generation

1. Tidal Electric's financial advisers, NM Rothschild, have undertaken a detailed analysis of the construction and generation costs of tidal lagoons. They conclude that our generation, excluding subsidisation and economies of scale, is competitive with offshore wind, and arguably with more conventional methods of generation. The graph below highlights Tidal Electric's costs compared to all other forms of generation, except nuclear.



2. The cost per unit output of the offshore tidal power generator is less than that of the tidal barrage for the following reasons:

Depth

Hydrostatic and hydrodynamic forces increase markedly with depth. The impoundment structure is built on near-shore tidal flats proximal to the low tide level and avoids deeper areas. In contrast, the barrage must span an estuary and must cope with whatever depths exist on the site. In the case of the Severn Barrage, the depths are up to 40 meters below low water.

Load Factor

Barrages must generate primarily in one direction (on the ebb tide) in order to minimise progressive disruption of the intertidal zone that would eventually lead to the silting up of the head pond. The offshore tidal power generator is free to utilise both the ebb and the flood tides for generation, thereby roughly doubling the load factor of the barrage. Double the load factor is equivalent to halving the capital cost per unit output.

Efficiency

Both the impoundment structure and the barrage are intended to hold back water. The power of the tides lies only in the tidal range, the difference in water levels between high tide and low tide. The impoundment structure is built so as to perform only that function, whereas the barrage also holds back all the water below low water level and all the water in the intertidal zone. None of this water produces any power, yet it is very costly to contain.

Generation Equipment

The offshore tidal generator uses conventional low-head hydroelectric generation equipment and control systems. The equipment consists of a mixed-flow reversible bulb turbine, a generator, and the control system. Low-head hydroelectric generation equipment has been in existence for more than 120 years and state-of-the-art equipment is mature, mechanically efficient (96%+), familiar (over 100,000 units in use world-wide), reliable, and durable (the equipment comes with performance guarantees and a design life of over 50 years.) Manufacturers/suppliers include Alstom, GE, Kvaerner, Siemens, Voith, Sulzer, and others.

5. The estimated capital expenditure cost of constructing the Swansea Bay 60MW lagoon is £79 million, and the capex cost for the North Wales scheme is £375 million.

D. Development Timetable

1. To date, the proposed schemes have been welcomed by Swansea Council, xxx Council, Friends of the Earth and the RSPB as well as a number of Members of Parliament and Peers, and members of the Welsh Assembly. In order to develop each scheme, we will require the consent of the DTI and other government departments and agencies. Discussions with the DTI, the Crown Estate, the Environment Agency and the Welsh Assembly are on-going.

2. To assist us in taking our projects forward Tidal Electric has assembled an experienced, advisory team consisting of: NM Rothschild (finance), WS Atkins (civil engineering consultants), APBmer (marine engineering consultants) and RW Beck (hydrology consultants).

3. Subject to receiving the necessary planning consents and environmental permissions, the timescale from first construction to operation is two years.

4. During the construction phase, construction jobs will be created. Once each scheme starts operating, we expect that there will be permanent jobs for maintenance and operation. Secondary business activities and tourism will also add to the local economies.

E. Financial Investment

1. The project economics will allow the effective use of project finance for the development of Swansea Bay and/or the North Wales coast scheme, subject to receiving the necessary consents from government. Importantly, this means that we will not be reliant on financial support from the taxpayer.

2. We have strong indicative interest from a number of UK and overseas financial institutions, for both debt and equity financing. In addition, we are also in discussions with several major energy companies with respect to potential equity financing of one or more facilities.

F. Relative Merits of Alternative Technologies

1. While understanding the need to prioritise the development of additional and alternative sources of energy, we believe that the overall needs in the UK (and in the world as a whole) will eclipse the capacity of any one technology and necessitate the ongoing development of a range of technologies, including nuclear. As tidal lagoon generation does not compete for resources (eg land, tidal flow etc), we believe that the technology is complementary and additive to other technologies.

G. Conclusion

1. We consider that tidal lagoon generation could be applied in many sites around the UK coastline and so could reasonably generate 8% of the UK's generation needs by 2020.

2. Tidal lagoon generation offers the UK clean, renewable and predictable generation at a comparable cost to offshore wind and arguably others forms of generation. It also has potential social, economic and environmental benefits, including the protection of the North Wales coastline from further erosion and flooding.

3. Importantly, this new form of generation will help to meet the UK government's renewable and climate change targets. It would also be a significant step in the commercial development of the marine renewables sector. We are determined that this project will succeed and so enable Wales (and ultimately the rest of the UK) to showcase the technology to the rest of the world.

20 September 2005

Memorandum submitted by Dr N K Tovey, (HSBC Director of Low Carbon Innovation at the University of East Anglia)

This submission has been prepared while the author has been in China and is thus less complete than it might have been. It begins with a consideration of likely capacity requirements and demand for electricity in the UK by 2025. It then considers three separate scenarios in which all future non-renewable generation comes from (a) gas, (b), nuclear, and (c) coal. There is also an option with a variable mix of 40% gas, 40% coal and 20% nuclear for all new generation plant.

The submission has been written while the author is overseas and represents some aspects of ongoing research at the University of East Anglia.

The aim of this submission is to investigate whether it is possible to foresee a non-nuclear future and if this is so what strategies are needed to ensure that this takes place. The conclusion of this submission is that it will now be very difficult, although not impossible to avoid new nuclear power stations. To achieve a non-nuclear future will require substantive urgent action. On the other hand, in the longer term, the time frame is such that alternatives strategies will be possible. The critical period is between now and 2025 not the longer term time frame.

An Appendix discusses the issues relating to the future demand for electricity and these may be summarised as follows:

Future Capacity Demand

The future requirement for generating capacity is shown in Table 1. The business as usual growth following historic trends and will be referred to as the High Growth Case. The Low Growth Case, follows the discussion on the overall demand in the Appendix and will see further increases in capacity requirements saturate over next 5–10 years in line with the Low Growth Demand Case.

Both Cases assume that there is a high deployment of renewables achieving the Government Targets. Current trends in renewables are well below these targets and might be seen to be optimistic unless there are changes in policy.

Table 1

PROJECTED REMAINING CAPACITY OF CURRENT STATIONS AND FUTURE REQUIREMENTS IN BUSINESS AS USUAL AND LOW GROWTH TRENDS. MUCH OF THE NEW CAPACITY IS FOR REPLACEMENT PURPOSES IN THE LOW GROWTH SCENARIO

Type of Power Station	*2003 (MW)*	*Probable remaining capacity in 2025*	
Existing Coal	25,851	2,596	
Oil	3,775	140	
Gas (AGT + CCGT + Others)	24,135	21,672	
Magnox	2,486	0	
AGR	8,380	0	
PWR	1,188	1,188	
Imports	2,000	2,000 +	
Wind	835	20,000	
Hydro	1,764	3,000	
Tidal/Wave		8,000	
Other Renewables/Waste	969	5,000	
Pumped Storage	2,787	2,787	
CHP	4,231	8,000	
		High Growth 2025 (MW)	*Low Growth 2025 (MW)*
New Capacity Required		45,697	28,277

Future Demand

The reasons behind the choices of the figures in this section are covered in the Appendix and summarised here.

There has been a steady growth in the demand for electricity since 1982 at a compound rate of 1.82%. This would imply a demand of around 550–560 TWh in 2025. This represents the high growth rate. For the low growth rate the minimum indicated in the Appendix for GDP effects alone is 432 TWH, and on top of this there are populations effects as discussed above. For a low growth scenario it has been assumed that the historic growth rate will slow rapidly over the next five years and stabilise at around 420 TWH after 2011. After this time it would be necessary to have a compound annual reduction of 0.3% per household to hold things stable. This low growth scenario would be a challenge to implement.

The analysis of future demand looks at both the high growth and the low growth. The critical scenario is the low growth scenario with a high renewables component. If this scenario makes it impossible to achieve without some nuclear build, then all other scenarios will inevitably mean that a nuclear component will be needed. On the other hand it is possible that new nuclear build can be avoided in the low growth scenario.

THE FUEL MIX FOR ELECTRICITY GENERATION

Historically the majority of electricity was generated from coal fired stations with nuclear seeing an increasing role from the mid 1960s and peaking at 26% of the total output in the late 1990s. Already there has been a reduction in generation capacity and the rate of this reduction is scheduled to accelerate in the next few years with only Sizewell B available in 2025 under current plans. Most of the coal fired stations are also due for renewal in the next 10–15 years. Oil fired stations were built in the 1970s and apart from the miners' strike in 1985 have been little used and are unlikely to see any resurgence above the current 1–2% generation. Gas fired generation using CCGT generation rose rapidly from nothing in 1991 to the present level around 35%. Since the mid 1990s, and with the exception of a few small plant with other fuels, the only stations constructed have been on the CCGT type.

The Scenarios

Several scenarios have been investigated for both the high and low growth situations with a further consideration that each of the scenarios includes a moderate growth in renewable generation and a high growth. The moderate growth in renewables represents 7.5% deployment in 2010 and 15% in 2020. Currently the deployment in renewables is well below these levels and even further below the Government target to reach the planned 10.4% by 2010 and the aspiration for 20% in 2020. The high growth renewables assumes that the Government targets are indeed met, but this would need a significant change in attitude both on the part of the Government, Local Planners, and most of all the general public if these higher targets are to be met.

Before 2010 no new non renewable generation can be built unless the station is already in pipe line. The increase in demand each year significantly exceeds the increase in renewable provision, and that is without the significant nuclear closures now scheduled.

Three fundamental scenarios have been considered ie the "gas scenario" where all future new and replacement generation is by gas, a similar scenario with coal, and the third with nuclear. These are extreme scenarios but allow the range of issues such as carbon emissions to be addressed. A final scenario with a more rational combination is then considered under the heading of "variable Mix". This was set as 40% coal, 40% gas, and 20% nuclear, but other options are, of course possible, but could not be completed in the time frame involved.

The results of the scenarios are summarised in Tables 2 and 3 and Figures 1 and 2.

To simplify the discussion it is assumed that the government Targets for renewable generation are met. There is very little probability that the 2010 target will be met and so this discussion is an optimistic view of the outcome.

Table 2

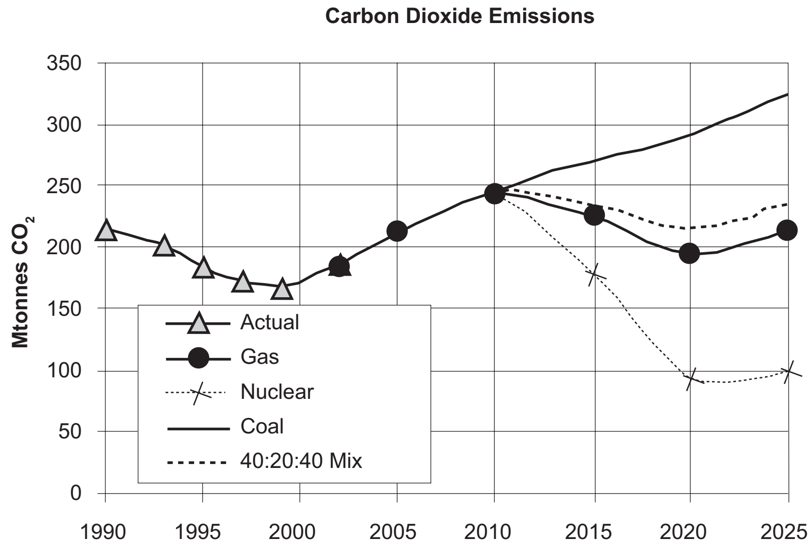
HIGH GROWTH SCENARIO: 560 TWH by 2025: HIGH RENEWABLES (MEETING GOVERNMENT TARGETS)

Scenario	*Gas Requirement (bcm)*		*Coal Requirement (Mtonnes)*		*New Nuclear Stations by 2025*	*% Nuclear in 2025*	*CO_2 Emissions Mtonnes*		
	2005	*2025*	*2005*	*2025*			*2005*	*2025*	*% change cf 1990*
Gas	34	88	51	6	0	3.9%	211	210	−2%
Coal	34	28	51	105	0	3.9%	211	319	49%
Nuclear	34	28	51	6	45	50%	211	96	−55%
Variable [40:40:200]	34	52	51	46	9	13%	211	230	7%

Table 3

LOW GROWTH SCENARIO: 420 TWH BY 2025: HIGH RENEWABLES (MEETING GOVERNMENT TARGETS)

Scenario	*Gas Requirement (bcm)*		*Coal Requirement (Mtonnes)*		*New Nuclear Stations by 2025*	*% Nuclear in 2025*	*CO_2 Emissions Mtonnes*		
	2005	*2025*	*2005*	*2025*			*2005*	*2025*	*% change cf 1990*
Gas	34	58	51	3	0	4.7%	211	144	−33%
Coal	34	25	51	57	0	4.7%	211	204	−5%
Nuclear	34	25	51	3	28	38%	211	81	−62%
Variable [40:40:200]	34	38	51	24	6	11.5%	211	155	−28%



— In the nuclear and coal scenarios, gas will still have a significant requirement. At best the requirement will be reduced by 18% (34 to 28 bcm) on projected 2005 requirements in the high growth scenario and 27% (34 to 25 bcm) in the low growth scenario. Currently gas imports are rising and an increase, and even with these lower demands, there will be a significant requirement for imported gas in the future.

— With a gas only scenario, the requirement will rise substantially at time when increasing amount must be imported. In the high growth scenario the increase in demand will be 250% above 2005 levels while for the variable mix scenario there will be a modest increase from 34 bcm to 38 bcm (approximately 12% increase.

— There is a serious security issue with respect to the gas scenario. Even with the low growth the demand for gas still rises substantially.

— 50% of coal is now imported, and substantial increases in coal imports will be required in the coal scenario unless more UK production is brought back into operation. The need for imports once again raises a question on security. However, the supply base for coal is much more diverse and security issues are much reduced.

— The nuclear only option would require as many as 45 new nuclear stations by 2025 in the high growth scenario and 28 in the low growth, even then it would be at a much lower level than France. However, such a rate of building is likely to be difficult to justify to the general public, and would require an almost immediate decision to go this route. On the other hand such an option would retain overall fuel source diversity.

— A variable mix of new generation is probably the most sensible, and this could involve a mixture of two or all three of the primary fuel sources.

— Renewable generation is not keeping pace with the increase in demand, and with the demise of the current generation of nuclear, there will be an increased fossil fuel component in 2025 compared to the present unless there is a new nuclear component.

The projections for carbon emissions given in the tables assume that there are emissions associated with the production of nuclear electricity (most studies omit these effects). In the high growth scenario only the nuclear option provides a substantial reduction. In the low growth scenario, all except the coal scenario will achieve significant cuts in emissions, but the gas scenario will only do so with a significant increase in gas consumption raising security issues. In none of these scenarios was carbon capture included for either gas and coal. While possible on a localised scale, the infrastructure needed for transmitting captured carbon from a widely scattered group of power station to the place of disposal in redundant oil wells is a major technical and financial challenge and unlikely to be substantially in place much before 2020. For this reason it has been largely discounted in the analysis.

In 1994, Dorling and Tovey completed a study indicating that the embedded carbon emissions for nuclear were around 15 gms per kWh and of the same general range as for other fossil fuel stations and this figure was reputed as being comparable with Wind generation. The actual value quoted does depend on methodology used, but all technologies seem to have embedded emissions which are around 10% of those from gas generation and are also comparable to each other. In this case the question of embedded carbon by the different technologies is to a large extent irrelevant in the overall discussion of operating life carbon emissions.

Conclusions

In the long term, there is no doubt that a sustainable future could be achieved with the use of renewables, backed up by some conventional generation. However, the time scale when this can be achieved is much greater than the critical time scale of the next 20 years.

The UK Government policy is to reduce carbon dioxide emissions and this can only be achieved without a nuclear component if either:

(a) there is a far greater increase in all renewables way above the present unattainable targets which seems unlikely in the short term, or

(b) there is a variable mix involving the building of some new nuclear stations coupled with a substantial programme to reduce demand, noting that because of population changes we need to reduce by 18% merely to stand still and that also allows no economic growth, or

(c) there is a substantial increase in the reliance of gas for generation which will lead to serious security issues.

The decisions for the way forward are difficult but must not be delayed. There must be a guarantee, not merely targets for the delivery of renewables. The Government should also allow energy prices to rise to allow the exploitation in a cost effect way of those renewables and energy conservation options which are currently priced out the market. To do this, the Government should remove the Fuel Poverty objective from Energy Policy and tackle Fuel Policy by other means.

Finally, in a recent document, British Energy have raised the possibility of an extended life for the Advanced Gas Cooled Reactors. Currently these are planned for closure after a life span which is, in some cases significantly less than the older Magnox reactors. The possibility of an extended life span of 5–10 years for such reactors should be considered in any discussion for a future nuclear build. If this indeed were possible it would reduce the urgency of any decision and also provide a longer time scale in which to exploit renewables. However, it is unlikely that such a policy will remove the need completely for new nuclear build unless there is a guarantee on delivery of renewables and the strategies outlined above in this section are met.

Annex

FUTURE DEMAND FOR ELECTRICITY

Future demand for electricity will be affected by a number of factors including:

(i) population changes,

(ii) decreasing household size,

(iii) the move towards digital television,

(iv) the increased use of appliances and decorative lighting,

(v) increased use of standby and quasi-standby on appliances,

(vi) technical energy conservation measures,

(vii) energy conservation by awareness raising,

(viii) fuel switching strategies in end use applications,

(ix) changes in electricity use in Public Administration, Health, and Education,

(x) changes in electricity use the commercial sector,

(xi) changes in electricity use in the industrial sector,

etc.

All of these affect overall future total demand of electricity but some of the more critical are discussed below. A detailed analysis could be developed by investigating each separate aspect. A discussion of how most of these s affect consumption is included in the appendix.

Population Changes

The population of the UK has risen from 55.9 million in 1971 to 59.987 million in 2003. The rate of increase from 1971 to 1995 was 0.15% per annum, but since that time the rate has increased to 0.3% over half of which arise from a net inward migration. If the current rate continues then by 2025 the population will reach 66 M. If changes affecting migration take place, then a saturation of around 63.2 million might be achieved as a lower estimate. A realistic estimate will place the figure somewhere between at around 64.6 million or 8.5% higher than in 2003. For a comparable energy use per capita this will result in an increase of 8.5%.

Household Size

In 1971 the household size was 2.91 persons per household while by 2003 this had fallen to 2.3 or 0.61 persons per household over 35 years. Though the decrease is levelling off it is unlikely the household size is unlikely to be above 2.10–2.15 persons by 2025.

Overall Effect of Population Changes on Demand

The demand for electricity in the domestic sector has a better correlation with the number of households than with the population. There will only tend to be one of each of the white goods appliances per household for instance and use of the black entertainment goods (although partly affected by number of individuals) will still be affected by number of households. Commercial and Public Administration, Health and Education will perhaps be more affected by number of individuals, but industrial use will once again be more a function of households than population (white good and car production). Using the mean population estimate for 2025 and the projected household size gives the number of households as 30.4 million—an increase of 17.4%.

This would imply that if per household use remained constant we would require 17.4% electricity by 2025. If we recognise that part of the correlation is with population rather than household then the increase will be less—perhaps around 13–15%.

Areas of Demand Increase

The current policy to move towards digital television broadcasts will see more set top boxes which on average are consuming between 10 and 15 watts. If each household had just one such box this would represent 1% of total electricity demand by 2025. If there are more than one box the figure would be proportionally higher. Digital televisions even with flat screens are consuming more energy than most no digital devices so there is a further increase here.

There has been a noticeable reduction in electricity demand per cooling appliance. However, there is now as trend towards larger such devices (eg the American Style). The present rating system is now confusing and inconsistent and it is unlikely that much further improvement will occur unless the Government persuades the EU to change the scheme. Areas or particular contention are:

(i) Frost free appliances use more energy than non-frost free, but retailers usually confuse customers that these are more energy efficient. Consumers are confused because a frost free appliance can consume 20% more energy for a given rating.

(ii) The rating system is more related total size rather than total consumption. Thus an "A" rated American machine has often a higher consumption than an inferior rated European one at "C".

There is scope of technical improvement still (eg the use of vacuum insulation panels), but these are unlikely to be commercially available in the quantities needed and almost certainly not unless the above legislation is addressed. With life spans of around 15 years, it is unlikely that much further improvements will be achieved. The thicker insulation now typical (ie and increase from around 37 to around 75 mm reduced heat gain by over 50%, but a further increase of the same thickness will have much less effect. Further more the issue of actual use (opening the door) then comes a major barrier to further reduction.

In the case of lighting, there has been a substantial increase in the use of spot lights as decorative lighting and this is more than counteracting the increase in the use of low energy light bulbs. There is also evidence of resistance by some because "they do not look like a normal light bulb" etc.

While there is scope for reduction, there are some legislative barriers which must be address if reductions are to be seen. As it is the likely savings arising from improvements in cooling and LED lighting will be offset by increased desire for larger appliances or decorative spot lights. Unless there is a major change in attitudes, it will be difficult to see anything better than a stabilising of electricity consumption per household.

The Standby Issue

The standby on appliances can be a significant proportion of total use. In the case of televisions more can be consumed when a person is asleep and not watching than when actually watching. The IEA "1 Watt" initiative for low standby consumption is welcomed, but even if implemented immediately would take 10–15 years to become fully effective, and in the meantime many more appliance will have such standby, thereby reducing potential savings.

Recent studies at the University of East Anglia have shown that computers often use more energy when idle than when active—overnight use on computers in the 24 hour suite show the highest demand overnight when fewer people are using them. Further more the software "Turn Off" on all generations of operating system post Windows 98 in actual practice does not turn of the computer—in fact a residual consumption of 12–15 watts is not uncommon representing up to 150 kWh a year per device. This is because the switch is on the low voltage side of the transformer.

Technical Measures and Fuel Switching

Technical conservation measures such as insulation etc will have limited impact as the majority of heating is not through the use of electricity. Furthermore where direct acting electric fires are used, these are often in non-central heated homes which are poorly insulated. Much of the benefit of insulation in such premises comes from improved thermal comfort and a reduction of hypothermia rather than a saving in electricity. Some preliminary studies done suggest that only 25% of theoretical saving is actually achieved because of this improved thermal comfort issue.

Improved awareness can have significant benefits. A concerted effort on a single day saw a reduction of 25%+ in electricity demand in a building at UEA. However, this saving could not be maintained and this presents a particularly difficulty challenge to educate the general public. This is also seen in other areas of energy consumption, the most evident of which is the substantial rise in the use of 4 × 4 vehicles.

Switching from electric central heating to other forms will reduce electricity demand. However, in conserving energy resources as a whole and also reducing carbon emissions there is no better way than by using heat pumps. However, these use electricity. As a result we will see the paradox of a reduction in energy demand and carbon emissions but coupled with an increase in demand for electricity.

Electric cars are significantly more efficient in the use of fuel than the internal combustion or diesel engine even allowing for the inefficiencies in the power station. An increase in these vehicles will mean an increase in demand for electricity.

Overall in the domestic sector, with the increasing number of households and the likely increase in the use of heat pumps and electric vehicles, it will be very difficult to even stabilise the total demand for electricity yet alone reduce it. This is despite several technical potentials, but these are often counteracted by social desires.

Business Activity

The GDP of the UK rose from £476 billion in 1970 to £1,009 billion in 2003 at a rate of 2.3% compound per annum. These figures are normalised to 2000 prices. If this rate of increase continue the GDP will reach £1,664 billion in 2025. If the average rate were to fall to 1.5%, the GDP would be £1,422 billion or £1,543 billion for a mean increase of 1.9%.

Though business activity has been increasing at this rate, the demand for electricity has been growing at almost half this rate indicating the wealth is being generated more effectively as time progresses. In 1970 the electricity associated with £1 of GDP was 0.478 kWh. By 2003 this figure had fallen to 0.374 kWh on a trend line with a high correlation which would suggest a value of close to 0.300 kWh by 2025. On this basis, the present trend would forecast about 495 TWH as the demand in 2025 if GDP continues to grow at the present rate. If the growth falls as low as 1.5% growth then the projected demand would be 433 TWH, while at 1.9% growth it would be 463 TWH. These projected levels are lower than that projected from a simple extension of present growth rates which also allow for population changes.

Overall Range of Demand Used in the Analysis Considered in this Submission

An alternative way to examine future demand is to examine past trends. There has been a steady growth in the demand for electricity since 1982 at a compound rate of 1.82%. This would imply a demand of around 550–560 TWh in 2025 and represents the high growth rate.

For the low growth rate the minimum indicated above for GDP effects alone is 432 TWH, and on top of this there are populations effects as discussed above. For a low growth scenario it has been assumed that the historic growth rate will slow rapidly over the next five years and stabilise at around 420 TWH after 2011. After this time it would be necessary to have a compound annual reduction of 0.3% per household to hold things stable. This low growth scenario would be a challenge to implement and would require innovation in business. The analysis of future demand in the main body of the submission looks at both the high growth and the low growth.

18 September 2005

Memorandum submitted by the UK Business Council for Sustainable Energy

Executive Summary

The UK's Energy White Paper set out a new vision for the Government's energy strategy—one that sought to put climate change at the heart of policy.

We now believe a real step change is needed both in the policy process and in the actual implementation, in order to enable the practical delivery of a low carbon economy.

The direction set by the Energy White Paper towards 2050 remains sound. The market structure, supported by an appropriate policy framework can "keep the lights on" while tackling climate change at competitive costs to the consumer. What is needed is a reinvigorated policy approach on all levels: energy efficiency, renewables, CHP and market-based instruments such as emissions trading.

1. The UK Business Council for Sustainable Energy (UKBCSE) welcomes the Committee's inquiry, and the opportunity to comment on the important issues examined.

2. The Council brings together major energy businesses focused on the delivery of sustainable energy technologies and services, including renewable energy, energy efficiency and energy efficient technologies such as combined heat and power (CHP).[374] We are working to build a progressive consensus on many of the issues shaping the development of sustainable energy in the UK.

3. The focus of this inquiry is particularly welcome given the increasing realisation that climate change is one of the most challenging and serious long-term problems we face. Prior to the G8 summit, the international scientific community gave the strong message that "the scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action."[375] The Council fully supports the necessity to reduce CO_2 emissions by at least 60% by 2050 if we are to genuinely tackle climate change.

4. Virtually all of the existing electricity generation plant and much of the transmission and distribution network that exists today will not exist in 2050. Existing power plants will be replaced, and transmission and distribution infrastructure for electricity and gas will be renewed and rebuilt. Within this lies the opportunity to set the UK on the path to a low-carbon future. The policy framework that Government sets, and the signals this sends, will inform the investment decisions made by Industry.

5. We believe that the priorities identified in the Government's Energy White Paper (2003) including energy efficiency, renewables, combined heat and power, and emissions trading can deliver the low-carbon economy anticipated. However, what is needed is consolidation and renewed vigour across all of theses policy areas if they are to deliver.

Energy Efficiency

6. As the Energy White Paper stated, "energy efficiency is likely to be the cheapest and safest way of addressing all four objectives [of the White Paper]."[376] Now, with the increasing attention on fuel prices, security of energy supply, and economic productivity, the time is right to move this agenda forward. As the numbers of household appliances increases, irrespective of their efficiency, focus also needs to also turn towards reducing energy demand. As the White Paper also stated "the cheapest, cleanest and safest way of addressing our energy policy objectives is to use less energy . . . reducing demand puts less pressure on energy supplies."[377]

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[374] UKBCSE members are: Centrica, EDF Energy, E.ON UK, National Grid plc, RWE npower, Scottish Power, Scottish and Southern Energy, and United Utilities.

[375] "Joint Science Academies Statement: global response to climate change", Royal Society, June 2005.

[376] "Energy White Paper: Our Energy Future—creating a low carbon economy", DTI, 2003.

[377] "Energy White Paper: Our Energy Future—creating a low carbon economy", DTI, 2003.

7. The Council believes that reducing energy demand, and improving energy efficiency must remain central to the Government's energy policy. Energy is not simply a commodity to be consumed but a service that provides warmth and light. We believe there remains considerable scope for the development of commercial propositions for energy services that could provide significant opportunities for demand reduction. Similarly, new technologies such as microgeneration and smart metering could play a stronger role in reducing household energy consumption, while there remains significant potential for energy efficiency measures such as loft and cavity wall insulation.

8. The Council believes that the right incentive structure and regulatory framework could create extensive opportunities for energy efficiency and demand reduction that would address large elements of the climate change and security of supply agenda. To this end the Council has convened a working group specifically to address this and develop new thinking on taking forward the energy efficiency agenda from the point of view of the energy suppliers. However, this and other initiatives will only succeed if they are supported by a reinvigorated approach from Government.

Renewable Energy

9. Even in the most ambitious energy efficiency and energy reduction scenarios, electricity and heat will still need to be produced. As this memorandum highlights, much of the infrastructure for generation and transmission in 2050 has yet to be built, so there remains an important opportunity today to set the UK on a less carbon intensive trajectory to the future.

10. The Council is confident that in the future, renewable energy will play a very significant role in electricity generation. The Renewables Obligation (RO) is successfully enabling a progressive increase in investment in new renewable generation. Industry is already investing on average £700 million in renewable energy per year, which is expected to rise to £1 billion per annum by 2010.[378] Although this investment is most apparent with onshore wind, we can clearly see much greater generation from offshore wind in the medium-term. Similarly, investments in tidal and wave are being made that would not be getting the same support were it not for the RO.

11. We believe that the target of supplying 15% of UK electricity from renewables by 2015 is achievable. However, the broad integrity of the RO needs to be maintained, such that any changes are well focussed and used to reinforce other important Government targets such as those for energy efficiency and CHP. The Council also believes that, provided the market conditions are are right, it is quite probable that the proportion of renewables in the energy mix beyond 2015 could significantly exceed 15%, particularly as newer technologies become more cost-effective.

12. In order to ensure that renewable technologies can develop to their full potential, the Government must be focussed on removing some of the barriers that are preventing greater uptake. With offshore wind there are a number of regulatory issues with respect to transmission that need more policy focus, especially if the anticipated 4 GW of generation from offshore wind is to be achieved from 2008 onwards. Similarly, microgeneration and decentralised generation face a number of planning, regulatory and policy barriers that must be addressed if they are to fully contribute to the renewable energy mix.

Combined Heat and Power (CHP)

13. Combined Heat and Power (CHP) remains the Government's unrealised low carbon technology. UK CHP use has remained at approximately 6% of total electricity supplied for the past 10 years. This is well below the EU average and compares particularly poorly with other Members States who have achieved levels as high as 40%. The scope for CHP in the UK is large: current CHP capacity is around 6 GW however Government has recognised a potential for up to five times this amount across industrial, commercial and residential applications.

14. CHP provides one of the most cost-effective carbon savings solution across all sectors of the UK economy. For many energy-users CHP is the single measure that offers the most significant opportunity to reduce energy costs and improve environmental performance. CHP, operating on over 1,500 schemes across the country, already contributes significantly to the reduction of UK carbon emissions delivering savings of over 4–5 million tonnes of carbon annually.

15. However, despite all the benefits of CHP, the changes Government has introduced to the energy market (in particular, the introduction of NETA in 2001) has caused the virtual collapse of the CHP industry over the past five years. The most important component in achieving the Government's 2010 10GWe CHP target, industrial CHP projects, is at a standstill.

16. The Council believes that the Government must radically rethink current policies towards CHP and reinvigorate its support for this proven, cost-effective and clean technology in order to not only help industry to reduce energy costs, but also to meet its security of supply and climate change ambitions.

[378] "Renewable Energy", National Audit Office, 2005.

Market-based Mechanisms

17. An ambitious energy efficiency and energy reduction strategy, continued support to renewables, and reinvigorated policies for CHP would dramatically reduce carbon emissions, bolster security of supply, and potentially offer reduced energy costs. In the context of progress in these policy areas, the need for new generation capacity will become more apparent. In this case, Council believes that the competitive market is best placed to deliver that new generating capacity.

18. The market is can be an efficient means of delivering of secure, sustainable and affordable energy to consumers. Government then needs to reinforce this with appropriate policy interventions. The Council would endorse the comments made by the Energy Minister Malcolm Wicks MP on 25 May 2005, that:

> "*we do not believe Government is best equipped to decide the composition of the fuel mix. We prefer to create a market framework, reinforced by long-term policy measures (such as the Renewables Obligation) which will give investors, business and consumers the right incentives to find the balance that will most effectively meet our overall goals.*"[379]

19. A number of significant uncertainties still surround nuclear generation that go some way towards explaining why the market has not decided to invest in new nuclear generation capacity. These include public acceptability; AGR life-extension; nuclear licensing; access to existing nuclear sites; planning, decommissioning and longer term waste management. An energy review may choose to address some of these, along with considering new measures to revitalise delivery of the Governments CHP target, strengthened action on energy efficiency, and, as appropriate addressing barriers to new investment in microgeneration and offshore wind. All of this will enable players in the market to make a wider range of investment choices.

20. In order to achieve agreed policy objectives, such as the reduction of carbon emissions, enhanced security of supply and so on, we welcome the role of policy instruments that are compatible with the competitive market. There are a range of policies being used to send signals to the energy industry in order to influence investment decisions such as the Renewables Obligation. Also, most notably, the EU Emissions Trading Scheme (EU ETS) set up this year has now put a price on carbon. The likely future cost of carbon is now a key factor in investment decisions in new power generation, and the Council welcomes and supports the EU ETS for sending a significant signal to Industry that has the potential to influence future investment decisions.

21. However, beyond 2012 there is a policy vacuum regarding the EU ETS. A decision to invest in new generating capacity is based on an investment lifetime of 20–30 years. Therefore, before investment decisions are made, investors need to be reasonably confident in the long-term stability of the policy framework in which they operate. In order to be fully effective, and to truly internalise the cost of carbon, the Government needs to provide some certainty as to the long-term future of the EU ETS. We also believe there is merit, in a long-term, science-based, EU-wide cap, which would ensure that overall emissions from regulated sectors are reduced on an agreed and appropriate trajectory.

The Institutional Framework

22. The Council believes that the Government's approach set out in the Energy White Paper, ensuring customers receive secure, affordable and sustainable energy through a competitive market can deliver the necessary carbon reductions to 2050. We fully support these objectives and the direction set out in the Energy White Paper. What are needed, however, are bolder and more ambitious policies to reinvigorate that approach. We believe one impediment to delivery lies in the current institutional arrangements.

23. The split of energy responsibilities between DTI and DEFRA, the additional roles of ODPM, HM Treasury, and within the broader climate change agenda, the Department for Transport, gives the impression of fragmentation at a political and consequently policy level. We welcome the recently created Cabinet Committee on Energy and the Environment as a step towards delivering this leadership and trust that the new focus will bring with it a unity of purpose across Government departments and their delivery agencies.

24. However, we believe there still remains scope for new thinking on the institutional framework. We note that the Government's Performance and Innovation Unit Energy Review (2002) proposed that for the long-term the Government should look to bring together responsibilities for energy, transport and climate change policy in one department.[380]

25. In Australia, the institutional structure for policy making is broadly similar to the UK, and energy policy is largely a matter for the States. Both New South Wales and Victoria have evolved some innovative arrangements for policy creation and delivery. In the early 1990's the New South Wales Government created the statutory Sustainable Energy Development Authority. In 2004 this was merged into a new Government Department to create the Department of Energy, Utilities and Sustainability with its own Cabinet level Minister. In Victoria, the statutory Sustainable Energy Authority Victoria (SEAV) was created from two predecessor bodies in the mid-1990's. With its own Board, it reports to the Deputy Premier and Minister

[379] http://www.dti.gov.uk/ministers/speeches/wicks250505.html

[380] "The Energy Review", PIU, 2002.

for Sustainability and Environment as well as the Energy Minster. It has an explicit policy role and delivers a range of programme activity concerning energy efficiency, renewable and CHP as well as fuel poverty. With both SEDA (as was) and SEAV, traditional departments have found their policy role occasionally tense, but Ministers have welcomed the focused policy interventions it gives them.

CONCLUSION

26. The market structure, supported by an appropriate policy framework can "keep the lights on" while tackling climate change at competitive costs to the consumer. What is needed is a reinvigorated policy approach on all levels: energy efficiency, renewables, CHP and market-based instruments such as emissions trading. The UK's Energy White Paper set out the Government's vision, putting climate change at the heart of the energy debate. We now believe a step change is needed in actual policy drive and implementation, to enable the practical delivery of a low carbon economy.

September 2005

Memorandum submitted by the UK Carbon Capture and Storage Consortium

Submitted by UKCCSC Management Committee:
Jon Gibbins, Imperial College London
Stuart Haszeldine, University of Edinburgh
Sam Holloway, Jonathan Pearce, British Geological Survey
John Oakey, Cranfield University
Simon Shackley, University of Manchester
Carol Turley, Plymouth Marine Laboratory

BACKGROUND

The UK Carbon Capture and Storage Consortium, with members from 15 UK universities and research institutions, is part of the Research Councils' "Towards a Sustainable Energy Economy (TSEC) programme". The mission of the consortium is "to promote an understanding of how options for decoupling fossil fuel use from carbon emissions through the use of carbon capture and storage could be used to assist the UK in achieving an energy system which is environmentally sustainable, socially acceptable and meets energy needs securely and affordably".

To place the proposal results within a UK "whole systems" perspective, the Consortium mission will be carried out through close collaboration with UKERC and the National Energy Network. The project runs for three years from June 2005, to provide research inputs to the rapidly moving UK energy debate.

Further details of the Consortium and background information on CCS can be found on the web site: http://www.ukccsc.co.uk.

COMMENTS

CCS in the UK electricity generation sector

It appears possible that carbon capture and storage will have a significant role to play in the UK generation sector, and this potential should be recognised in the Committee's deliberations.

DTI UEP electricity generation mix figures for 2000–20 and some illustrative alternative scenarios for 2020 are shown in Table 1 overleaf.

The UK power generation sector contains opportunities for the commercial deployment of a wide range of CCS technologies. However, the "commercially viability" of some or all of these measures for deployment in 2020 depends entirely on final UK carbon emission targets and the ability of alternative options to deliver at a lower price. Additional costs for the "decarbonised electricity" options using CCS are probably in the range of 1–3 p/kWh. The scenarios shown in Table 1 include an option in which significant coal generation capability is retained. This would probably involve some existing power plants being upgraded from sub-critical to supercritical steam conditions and having post-combustion CO_2 "scrubbers" added. It is also likely, however, that some new Integrated Gas Combined Cycle (IGCC) plants with CO_2 shift to hydrogen would also be built—several such schemes are already being planned. In the longer term, further existing coal power plants may be upgraded to oxyfuel operation or be repowered with gasifiers.

Natural gas combined cycle (NGCC) plant may also have CO_2 capture fitted. This could be pre-combustion capture with intermediate production of hydrogen, as at the proposed Peterhead/Miller scheme, or use post-combustion capture technology. Natural gas plants are likely to offer relatively low-cost CO_2 capture so long as gas prices are also low, particularly for new NGCC plant that is designed for capture from the outset. The last column in Table 1 shows this option—the amount of NGCC plant capacity with capture corresponds approximately to new plant that would need to be built between now and 2020 to meet demand in a high-gas scenario. In any case it is important that all new UK power plant is built to be "capture ready", even if capture equipment is not installed when it is built. Depending on future natural gas supply conditions, some existing NGCC plant may be modified to operate on gas from new coal gasifiers—these would also be suitable for CO_2 capture either when built or subsequently.

Table 1

UEP ELECTRICITY GENERATION MIX [1] AND ILLUSTRATIVE ALTERNATIVE SCENARIOS FOR 2020

	Original UEP Values					*2020 Scenarios*		
	Electricity Generation, TWh/yr					*No coal, 20% renew-ables*	*9 GW CCS 2GW new nuclear*	*Less coal, 13GW gas CCS*
Fuel	*2000*	*2005*	*2010*	*2015*	*2020*	*2020*	*2020*	*2020*
Coal	111.9	113	106	89	57	0	7	20
Coal + CCs						0	50	0
Oil	2.1	2	2	2	2	2	2	2
Gas	127	116	132	159	225	264	174	144
Gas + CCS						0	17	100
Nuclear	78.3	84	61	41	27	27	43	27
Renewables	10.1	15	39	58	58	76	76	76
Imports	14.3	9	10	10	10	10	10	10
Pumped storage	2.6	3	3	3	3	3	3	3
TOTAL	346.3	344	353	362	382	382	382	382
MtC/yr	41.9	40.1	37.9	36.6	34.6	24.0	19.4	19.7
kgCO_2/kWh generated	0.444	0.427	0.394	0.370	0.332	0.231	0.187	0.189
MT CO_2 to storage						0	54	31
Low emission power	30%	32%	32%	31%	26%	30%	52%	57%
% gas	37%	34%	37%	44%	59%	69%	50%	64%

A*ssumptions*	*Coal*	*Oil*	*Gas*
2020 plant kg CO_2/kWh generated	0.903*	0.660	0.329
. . . with CCS	0.108		0.054
Fraction of CO_2 captured	90%	—	85%
Additional fuel for CCS plant	20%	—	10%

* UEP value—pessimistic for new or upgraded coal plant with CCS

The UK has significant CO_2 storage opportunities offshore, with probably the greatest absolute capacity of any European country after Norway and the best combination of CO_2 sources relatively close to potential CO_2 sinks. Storage capacity for UK oil fields as a result of enhanced oil recovery has been estimated at approximately 700 Mt CO_2. Storage capacity in saline aquifers may be significantly larger (possibly orders of magnitude larger) than this but estimates are more difficult due to the uncertainties surrounding poorly characterised aquifers. To develop this potential, however, needs a value to be given to CO_2 by emissions trading, or by UK government fiscal policy—as well as public and legal acceptance. Deployment of such a strategy is viewed as best value bridging technology towards much more drastic CO_2 reductions between about 2020 and 2050.

The abundance of CCS options in the UK also brings challenges. A range of stakeholders need to participate in developing effective strategies and there is a risk of excessive diversification and dissipation of effort. As a result, new integrated research projects have been proposed to study the issues involved in getting the best value for the UK out of CCS applications and to make sure that maximum benefits are achieved through international collaboration on technology development. The DTI CAT (Carbon Abatement Strategy) and the Research Councils' TSEC (Towards a Sustainable Energy Economy) initiative are both planned to address CCS issues in depth, and to place them in an integrated UK energy system context and to consider the social, environmental, economic, technological and other aspects. Environmental and health and safety issues surrounding CCS on a range of temporal and spatial scales require a focused and coordinated research activity. In the longer term, it is hoped that a UK Carbon

Dioxide Capture and Storage Authority will be established by the UK Government to take overall responsibility for the regulation of this new industry, and eventually to provide long term stewardship for the CO_2 stored underground.

Global applications for carbon capture and storage technologies

The UK energy economy has the potential to develop and demonstrate CCS technologies that could find applications in many other countries. The UK has the opportunity to make a leading contribution in this field, because of:

- its industrial expertise in a number of key areas;
- the need for new UK power plant capacity over the next two decades;
- a window of opportunity in the next decade for enhanced oil recovery in the North Sea;
- national CO_2 emission targets that could justify the deep reductions that CCS technologies can give; and
- a fortuitous combination of geological endowment, with subsurface engineering.

CCS is likely also to see early use in other countries over the next two decades and, even where immediate deployment is not justified, it is important to ensure that new power plants are designed and built to be "capture ready". This can generally be done at minimal cost, for conventional pulverised coal and NGCC plants as well as new IGCC stations. It would then be possible to add CO_2 capture rapidly and at relatively low cost whenever political and economic conditions develop to justify it. The capability to achieve rapid and cost-effective deployment of CCS technology, as part of a portfolio of demand and supply side options to manage carbon emissions, is also likely to encourage a positive approach to atmospheric CO_2 concentration stabilisation.

21 September 2005

Memorandum submitted by the Welsh Anti Nuclear Alliance

Introduction

The Welsh Anti Nuclear Alliance was formed 25 years ago as an "umbrella" organisation for individuals and groups of people opposed to the expansion of nuclear power and the dumping of radioactive waste, and in favour of the conservation and rational use of energy.

It has presented evidence to three major public inquiries, and submitted evidence to a House of Commons committee, and to the Government's Energy Review.

Keeping the Lights On

A number of myths have recently been put about by the proponents of nuclear power in order to "soften up" the public, and make Government support more likely.

Nuclear power produces no carbon dioxide, and can therefore help reduce global warming.

It can be built in time to make a difference to global warming.

It is economic compared with renewables such as wind.

Advanced reactors are safer than current reactors.

Nuclear reactors are tough enough to withstand terrorist attacks.

There are acceptable ways of getting rid of radioactive waste.

The development of nuclear energy can take place alongside other measures.

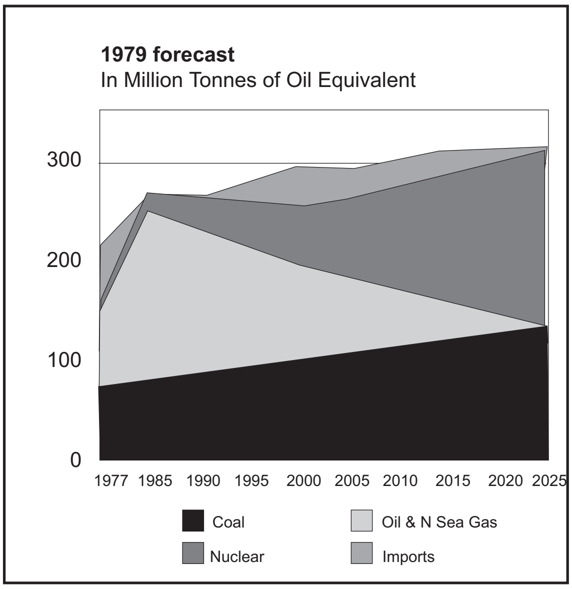
More large power stations are needed to "keep the lights on".

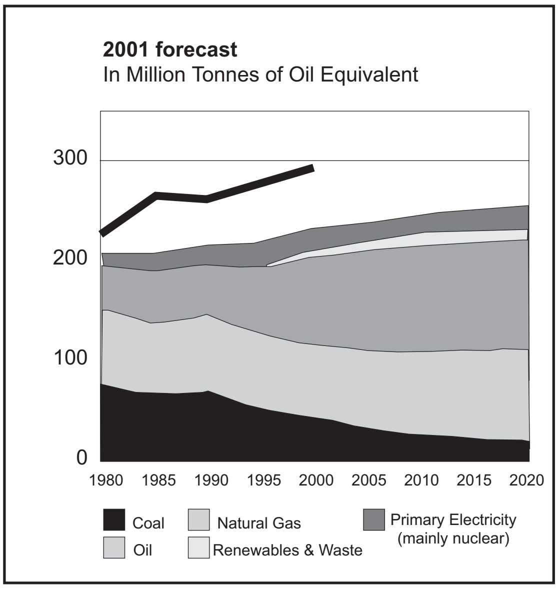
In responding to the questions posed by the Environmental Audit committee it is our intention to establish the truth regarding these claims, particularly as one of them is included in the title of the inquiry.

In order to assist the committee we have adopted the format as set out in July.

The Extent of the "Generation Gap" Due to the Phase-out of Existing Nuclear Power Stations

There is a long and inglorious history of the proponents of nuclear power pointing to a projected gap in generating capacity that could or should be met by building more nuclear power stations with the taxpayer's support.





In February 1979 the primary energy use forecast on the left was put forward by civil servants at the Department of Energy. A rapid decline in oil and gas supplies from the North Sea was forecast, requiring imports, despite a gradual increase in the use of coal. The forecasts were used to convince Margaret Thatcher's incoming Government that a huge increase in nuclear power generation was necessary.

The forecast accompanying the launch of the Government's 2001 energy review is on the right.[381] The 1979 forecast is overlaid for comparison. It indicates that the forecast primary energy use for 1980 was only exceeded at the turn of the century. The gap between the 1979 projected primary energy use for 2000 and the actual primary energy use for that year is striking. That energy gap approximates to the primary energy that was forecast to come from new nuclear power stations.

Consider what met that energy gap in reality. The answer, apart from industrial restructuring away from heavy metal-bashing, is energy conservation. We used far less in the year 2000 to run an economy that had grown considerably. The vertical shading on the right indicates the size of the nuclear "wedge" implied by replacing old reactors with new. It is well within our capabilities to achieve a further reduction in fixed energy consumption on this scale.

However, all of our combined efforts to combat global warming through energy reduction in buildings and industrial processes could easily be set at nought by an "out of control" transport sector.

As far as electricity is concerned, any "gap" is between supply and demand. It is wrong to characterise it as a generation gap. If they are to survive the scrutiny of committees such as your own, all Governments have to demonstrate that they are supporting the most cost effective, as well as sustainable ways of achieving their policy objectives. Investment in reducing demand for electricity is not only more immediate in its effect, it is far more cost effective. Furthermore, money saved through demand reduction is available for reinvestment in the economy rather than contributing to greenhouse gas emissions or becoming "locked up" in radioactive materials that will burden future generations.

What are the Main Investment Options for Electricity Generating Capacity?

It very much depends on the scale. As the Microgeneration strategy and low carbon buildings programme: consultation document (June 2005) states in its foreword "In the 1980s power stations were built on a scale to supply entire cities."

The continuation of a 1980s type strategy, implied by the adoption of a new nuclear programme, would be a recipe for disaster:

(a) Resume shutting down the smaller power stations that are sited in the cities, close to the demand.

(b) Aim at relatively few, but very large, power stations.

(c) Connect these units with heavy dependence on a few critical links.

(d) Choose an inherently dangerous technology with complex safety requirements for power generation so that power plants have to be sited remotely, and the links to the demand centres are long, and have well known vulnerabilities, which offer opportunities to malevolent individuals or groups.

(e) Use a technology that requires large capital investments and has long lead times, so that there is little or no scope to adapt to changing circumstances.

[381] Project Scoping Note—Energy Policy, Cabinet Office PIUnit, Annex 1, Table 1.

(f) Connect up all the units into a synchronous system so that each unit's operation depends significantly on the operation of all the other units, and failures can affect the whole system.

Since the 1980s greater security of supply, with a smaller planning margin, and hence greater economy, has been achieved partly through the introduction of many, small generating units, with shorter lead times, than one large one.

Innovation is continuing to lead to smaller and smaller scales of electricity generation becoming more viable, and it is these—micro-CHP, micro-wind, micro-hydro, solar thermal and photovoltaics, ground and air source heat pumps, fuel cells supplying individual customers and buildings that are likely to become the most relevant and resilient options over the next twenty years.

The solution for fixed energy use in Britain is to exploit the huge gap between primary energy demand and energy consumed by final user. This gap consists of the huge waste heat dumped by large centralised electricity generators, and the approximately 20 TWhrs of electricity lost in transmission. Micro CHP addresses both of these waste streams at the same time, but will require institutional and some technical barriers to be removed. The removal of these barriers should be addressed by the Committee.

Because individual consumers of micro-generated electricity are going to be have their own generator operating at peak times of day and during the heating season the cumulative effect on the electricity supply network is to reduce peak demand from centrally located power stations. Similarly the first 3 GW of additional electricity load from wind cooling of cities is most appropriately met by wind turbines.

It is the robustness, resilience and elegance of renewables and microgeneration that is at stake if the decision is taken to continue dependence on large nuclear power stations.

What Would be the Likely Costs and Timescales of Different Generating Technologies?

Electricity generation, by any means, will not touch the central problem faced by the UK over the next 30 years. The 10 year plan for transport has not yet begun to make any impact. A reduction in final energy consumption by the industrial sector since 1980 has been more than offset by the increase in transport use.

The PIU scoping papers for the Energy Review indicated that energy use by the transport sector is set to grow by 20% over the next 10 years, (over three times the total 20 year projected domestic energy growth) and a further 10% from 2010 to 2020.

Maintaining a nuclear sector up to and after the year 2020 will not only miss the point, but will sequester the resources that are needed to address the true problems. Some new electricity generating capacity will be needed. But intelligent criteria should be adopted to determine which capacity should be selected for development, as well as the appropriate scale.

Nuclear power stations require huge capital investments over long construction periods.

Electricity generating capacity should be promoted where it confers advantages in meeting other Government objectives. Two examples illustrate this:

> The Forestry Commission was established for national strategic reasons, not simply to provide pit props for our mining industry in times of war, but to act as a land purchaser and land user "of last resort" for an agricultural sector in crisis. There are parallels with the present except that our current strategic needs are for modernised biomass (short rotation willow rather than conifers) that can be a "lifeline" crop for farmers to grow and harvest. Biomass electricity works best in relatively small 1 to 20 MW units in associated forest areas.
>
> Offshore wave power generators can be built as modules in our under employed shipyards, towed to where they are best located and bolted together to build into massive arrays. Offshore wind power could then tap into the same grid. Britain is well placed to develop this energy source as an export industry. Again as the units of generation are small, and modular, their use confers flexibility in terms of matching supply and demand.

At the domestic scale micro-CHP as replacement central heating boilers could follow the same trajectory in terms of their introduction to the mass market as other pieces of household equipment. The average replacement cycle for central heating boilers is 15 years. Thus a long term strategy for electricity generation in say 2050 would have three full cycles of domestic central heating boiler replacement to achieve that strategy.

Although institutional barriers are coming down, there is still technical work to be done. It is no use expecting that the Building Regulations alone can produce the necessary changes. A typical sized house built to the latest Building Regulations standards requires a boiler of only about 6kW output for peak winter demand (2kW for heat loss, 2kW for ventilation loss, and 2kW for water heating) but the smallest boilers currently available start at 12kW while the smallest micro CHP boilers currently available start at over 40kW.

These things in particular are required:

> Small, efficient, micro CHP units. Much smaller units are needed to meet the reduced energy needs of well insulated homes. If they are based on Sterling Engines they can readily use bio-fuels instead of fossil fuels such as oil and gas.
>
> "import-export" meters will have to become commonplace and readily available, and
>
> a price paid to the householder for their excess electricity which is sufficient to act as an incentive to invest in micro-CHP.

The Energy Review comments (para 43) on projected cost reductions over time for new nuclear stations:

> "The pace and extent of learning may however be slower for nuclear than for renewables Because: relatively long lead times for nuclear power mean that feedback from operating experience is slower; relicensing of nuclear designs further delays the introduction of design changes; and the scope for economies of large-scale manufacturing of components is less for nuclear because production runs are much shorter than for renewables, where hundreds and even thousands of units may be installed."

It was in 1987 that the Brundtland Commission stated that renewable energy: "should form the foundation of the global energy structure during the 21 century".[382]

What is the Attitude of Financial Institutions to the Risks Involved in Nuclear New Build and the Scale of the Investment Required?

They are reluctant to invest. As the World Bank puts it: "world experiences with high investment costs, time-consuming and costly approval processes, lack of sustainable waste disposal options, risks of major accidents—together with the Chernobyl disaster—have raised grave doubts about the future viability of nuclear power. Private investors shy away from such risky high-cost investments[383]". These arguments, together with concerns about proliferation, explain its own decision not to invest in nuclear power, even as part of the fight against global warming.

It is the possibility that a huge investment can be transformed into a huge liability in minutes that lies at the heart of reluctance of prudent investors to invest in new nuclear stations. The added problem for investors is that another severe reactor accident anywhere in the world could lead to a moratorium on reactor construction in the UK.

Since the May 1995 White Paper (Cm 2860), private sector operators in the UK have been encouraged to investigate new nuclear build on a purely commercial basis. In July 2001 British Energy told the Government that they "cannot make the business case" for new reactors. In other words they were not commercially viable. The fact that no applications have been forthcoming confirms that without large taxpayers subsidy the risks and uncertainties are sufficient to deter any investment.

What Impact Would a Major Programme of Investment in Nuclear have on Investment in Renewables and Energy Efficiency?

Disastrous. The decision to "go nuclear" might appeal to political minds that require a "quick fix" in order that their attention can move on to other things, but in reality it would sequester available capital funding over a very long period, and throttle investment in renewables and energy efficiency. The government will not spend this money twice: it will either invest massively in nuclear generation or invest massively in energy-saving and alternative power. Such a decision would also send a strong but misleading message to individuals and businesses that the energy problem has been "sorted" by central government, and that they can go on consuming energy the way they have in the past.

Finland is often cited by the proponents of nuclear power as the path they wish us to follow. In Finland, once the decision to build a fifth reactor had been taken, plans to phase-out coal production and electric heating were forgotten and targets for wind and biomass energy are being missed, resulting in an increase in carbon dioxide emissions.

To what Extent and Over what Timeframe Would Nuclear New Build Reduce Carbon Emissions?

Mining uranium, and building and decommissioning power stations all use oil. When the whole nuclear cycle is taken into account a nuclear station is responsible for about a third of the CO_2 emissions of a gas fired plant, but this can only be maintained while there are rich uranium ores. The earliest realistic date for delivery of power from a new UK reactor is around 2020.[384]

382 World Commission on Environment and Development, Our Common Future, Oxford University Press, Oxford 1987.

383 World Bank web site http://www.worldbank.org/html/extdr/faq/faqf98-128.htm

384 MacKerron, G (September 2004) "Nuclear Power and the Characteristics of Ordinariness—the Case of UK Energy Policy" NERA Economic Consulting.

By far the largest part of uranium reserves are found in very poor ores, and the energy costs of mining, milling and refining reach the point at which one would get more energy out of burning the fossil fuels directly. This will happen within the lifetime of the cited reactors. The energy costs of conditioning and managing radioactive wastes from uranium tailings to spent fuel will be imposed on future generations. A programme of new nuclear plants would not contribute to carbon reductions for at least twenty years, and would take many years to balance the "carbon debt" that had been built up during construction.

The investment in new nuclear reactors will be thus be self defeating on every timescale:

During the 20 year construction period

Paying off the carbon debt during the early years of operation, and subsequently in 25 years time, as poorer and poorer ores increase the carbon emissions of mining, milling and refining.

Into the indefinite future where carbon emissions will be incurred by generations decommissioning nuclear reactors and conditioning, storing, monitoring and repackaging radioactive waste.

Is Nuclear New Build Compatible with the Government's Aims on Security and Terrorism Both within the UK and Worldwide?

No. The mastermind of the September 11th attacks, Khalid Sheikh Mohammed, reportedly told his US captors that the original plan called for 10 airliners to be hijacked. They were to be crashed into targets including nuclear power stations.

The extremely remote risk of an accidental aircraft strike has been replaced by the very much greater risk of an aircraft being deliberately crashed into a reactor. Nuclear power represents a concentration of power—making it a target for terrorists The Westinghouse AP1000 design is particularly vulnerable because of the relatively thin containment structures and the water tank on the roof. To protect them it would require vastly strengthened containments, and possibly that they be built underground, making them even less economically viable. Finland rejected the Westinghouse AP1000 as the design for its fifth reactor, because it would be vulnerable to being struck by an aircraft.

But the strength or otherwise of a reactor building misses the point. There are more vulnerable parts of a nuclear site. For economic reasons, the spent fuel from new reactors would be stored on site rather than reprocessed at Sellafield so the sites would in effect become huge radioactive waste dumps. On site spent-fuel stores would require to be terrorist proof, as well as the reactors.

In this context, the political will necessary to maintain a publicly financed investment programme in a new nuclear construction programme lasting for over 25 years is incompatible with a parliamentary democracy. Even an unsuccessful attack on any of the 480 nuclear sites worldwide is likely to adversely affect the confidence of investors and lead to the abandonment of reactors under construction.

Quite apart from circumventing non-proliferation agreements, the export of MOX fuel containing plutonium is regarded as compromising the country's security and giving opportunities for the diversion of such material to terrorists.

In Respect of These Issues, How Does the Nuclear Option Compare with a Major Programme of Investment in Renewables, Microgeneration, and Energy Efficiency?

It doesn't compare. Energy conservation, microgeneration and renewable forms of energy make poor targets for terrorists and are a more immediate and robust response to global warming than nuclear power stations. They are also compatible with a liberalised generation market, whereas nuclear investment violates that market through subsidies.

How Carbon-Free is Nuclear Energy?

Nuclear power isn't carbon-free. See above

Should Nuclear New Build be Conditional on the Development of Scientifically and Publicly Acceptable Solutions to the Problems of Managing Nuclear Waste?

The conditionality lies in a different direction.

Solutions that might be regarded as acceptable to some people at a point in time are unlikely to be so regarded by others either now or in the future. After at least three unsuccessful attempts to establish radioactive waste dumps through the usual "decide, announce, defend" route the Government has instigated two consultation processes to tackle higher level radioactive wastes (CoRWM) and lower level radioactive wastes (lead by DEFRA).

If there is to be an overarching public "contract" with the Government about the systematic and progressive reduction of hazards from nuclear sites, it will be conditional on there being no more radioactive waste created.

We cannot relinquish control of radioactive waste because it may enter the biosphere in the future. Public acceptance of radioactive waste facilities is more likely if the problem is seen as finite because no more radioactive waste is being created.

13 September 2005

Memorandum submitted by the World Coal Institute

SUMMARY

1. The need of the UK, for safe, affordable, environmentally friendly and reliable energy will require a mix of fuels and a revolution in the development and deployment of new technologies.

2. The current UK over reliance on gas and oil should serve as a lesson against future over reliance on any one fuel source or the geographic/political region that produces it. Nuclear and renewables can certainly be part a responsible energy mix, but they are not alone the solution.

3. The Government should ensure that investment in Britain's energy future is broadly based, and does not hold UK energy security hostage to either short term popular sympathies or the myths and illusions pushed by any segment of industry or society. While much needs to be done to ensure adequate investment in both safe nuclear and cheap and reliable renewables, investment in these areas cannot detract from investment in the development and deployment of clean fossil fuel technologies. These technologies have the potential to maintain the value of strategic hydrocarbon assets while ensuring near zero emissions to the environment from their use.

WORLD COAL INSTITUTE

4. The World Coal Institute (WCI) is a non-profit, non-governmental association and the only international body working on a worldwide basis on behalf of the coal industry. Membership of the WCI is open to coal enterprises and stakeholders from anywhere in the world, with members represented at Chief Executive level. More details on the WCI and its membership and can be found at www.worldcoal.org. Members include: Anglo Coal, the Confederation of UK Coal Producers (COALPRO), BHP Billiton, Consol, Rio Tinto, Total, and Xstrata.

5. WCI's key objective is to provide a voice for coal in international energy and environment policy and research discussions. Members of the WCI are undeniably and transparently pro-coal, but have explicitly committed to:

- co-operate in supporting sustainable development, including economic growth, social development and improved environmental outcomes;
- promote cleaner coal technologies and the responsible use of coal;
- encourage improving mine health and safety; and
- practice corporate social responsibility.

6. Many of the members of the WCI are multi-commodity miners; some of these are involved in both the coal and nuclear industries.

7. In large part, this memorandum builds upon recent work of the Confederation of UK Coal Producers (COALPRO)[385].

ISSUES

EXTENT OF THE "GENERATION GAP"

8. The UK has a large demand for energy (equivalent to almost 235 million tonnes of oil) of which coal supplies 17%[386]. Contrary to popular opinion, in the case of electricity coal accounts for 37% of total generation and more than half of this comes from domestic coal. This brings a high degree of security and price stability to an energy market increasingly reliant on imported natural gas.

385 See in particular, *Coal in a balanced energy policy,* Confederation of UK Coal Producers, 2005.

386 Statistical data on UK energy supply and demand comes from the *Digest of United Kingdom Energy Statistics 2005,* Department of Trade and Industry, London, and from monthly DTI website updates.

Chart

UK ENERGY PRODUCTION AND CONSUMPTION, 1970–2004

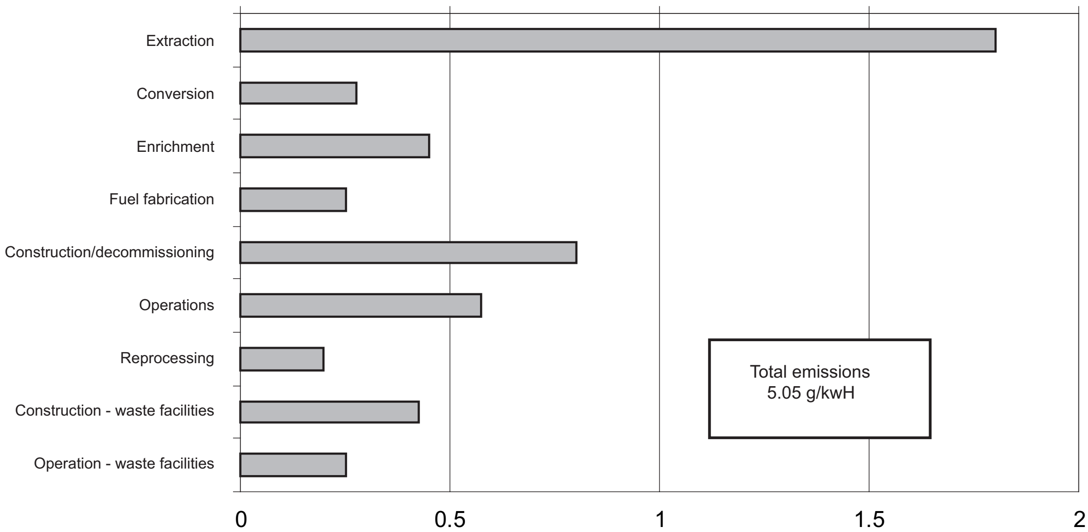


Figure 7 - Life-cycle CO2 emissions for Torness nuclear power station
Source- EPD for Torness Nuclear Power Station, AEA Technology (for British Energy Group plc)

9. In 2004, the UK ceased to be an exporter and became a net importer of energy, clearly undermining its energy security profile. The extent of the generation gap facing the UK can be indicated by the fact that over the next 25 years, EU demand for electricity is expected to rise by almost 60%[387]. Bridging this gap will require investment in new nuclear and renewables. However, given the infrastructure lead times and technical uncertainties involved in those sources, the UK would be unwise to place all its eggs in one basket and ignore both its substantial domestic reserves of coal (220 million tonnes[388]) and the international trade in affordable coal from many politically stable and friendly nations[389]. The UK has the opportunity and expertise to use its existing coal reserves in an environmentally sound manner, through the clean coal technologies[390] being developed and deployed under the just-announced UK Carbon Abatement Technologies Strategy and by programmes in other nations. This vital strategic reserve could underpin UK energy security for many years to come. This would help limit import dependency on foreign sources of uranium and other fuels, and delay the growing British dependency on Russian gas in particular.

10. Commonsense and national interest dictates that investment decisions on new energy sources (eg nuclear and renewables) should not ignore the long-term strategic demands of British energy security. For electricity generation, this means the development of the most efficient, cost-effective and environmentally responsible mix of energy sources; this means—

- safe and cheap nuclear; and
- cheap and reliable renewables; and
- clean coal.

11. None of these is cheap or easy; all require substantial investment and government leadership. None alone will bridge the generation gap facing the UK and none alone will produce the energy security that the UK needs. However, a sensible investment programme in all three will meet the UK's strategic energy and environmental objectives.

[387] *European Energy and Transport Trends to 2030,* Directorate-General for Energy and transport, European Commission, 2003.
[388] UK proved reserves at end 2004 as reported in *BP Statistical Review of World Energy,* June 2005.
[389] In contrast to oil and gas and uranium, coal is produced in about 50 countries around the world and remains the most affordable and reliable of base load fuels, supported by an existing international trading architecture and technical expertise.
[390] Including carbon capture and storage.

FINANCIAL COSTS AND INVESTMENT CONSIDERATIONS

No fuel is without cost or challenge

12. All types of generating plant face increasingly stringent regulatory and environmental controls and it is clear that no fuel source is without challenges:

— "New" renewables such as wind and solar are politically fashionable but need to overcome cost and technological barriers. At this point such technologies only supply electricity when the wind blows at a particular speed or if the sun shines. Given this limitation wind turbines, for example, may only generate 25% of their capacity, indicating it would require 2,000 wind towers, each with a generating capacity of 2 megawatts of electricity to produce as much as one conventional 1,000 megawatt power station. They could not alone provide the capacity, reliability or predictability needed to supply base load electricity to the UK. The sheer number of wind turbines that need to be erected to replace traditional power stations may prove too high for local communities opposed to them on ascetic grounds, or with concerns for ambient low frequency noise, or the safety of wildlife.

— Gas needs to overcome problems with supply and accommodate prices rising faster and higher than governments and consumers had previously anticipated. While it seems that gas will grow in importance, it also needs to address energy security issues associated with its concentration in limited areas of the world. With the loss of British North Sea oil and gas this decade, it needs to address the question, If energy security is undermined by national dependence on a limited number of foreign oil suppliers in politically unstable regions, what is the point of the continuation of that dependency that would arise from simply switching to gas?

— Oil needs to overcome similar problems to gas but with a much greater concern for energy insecurity associated with foreign oil dependency, and a much greater concern with environmental impacts, including global warming. Questions related to the limits to oil supply are as much a product of political stability as geologic concern.

— Nuclear seems to be economic in some countries, though not in others and needs to overcome major problems of public acceptance to do with issues of safety, decommissioning and the waste cycle.

— Coal must address environmental concerns related to its use, including its contribution to global warming.

— Large scale hydro (more applicable to other countries) needs to overcome problems associated with environmental degradation and displacement of people. A decline in available sites for new hydro projects presents a particular challenge.

13. The bottom line is that it is irresponsible to base national energy and environmental policies on the misguided assumption that any one fuel source is without cost or challenge. Decisions on national electricity generation are too important to be held hostage to myths and ideologies.

Fuel comparisons

14. The task of comparing fuel types is daunting. The most recent IEA work attempting such a comparison concluded "none of the traditional electricity generating technologies can be expected to be the cheapest in all situations. The preferred generating technology will depend on the specific circumstances of each project. The study indeed supports that on a global scale there is room and opportunity for all efficient generating technologies."[391]

15. Nevertheless, there are known general construction and operating parameters with all energy sources, some of which are relevant to this inquiry. In general terms:

— Nuclear electricity costs are dominated by capital costs and are very sensitive to the time taken for plant construction, interest rates on borrowed funds, explicit or implicit return on equity, changes to the regulatory regime, and price changes for equipment, material and labour during the construction period. They run on a fuel (uranium) that is expensive and limited and carries with it high costs of monitoring and security. The high up-front capital costs result in greater investment risk if there are construction delays or cost overruns.

— Once built, nuclear plants are in principle relatively immune to inflationary pressures, but their cost efficiency over a 30 or 40 year lifetime will depend on their capacity utilisation factor. Any lengthy shutdown, with attendant high-cost repairs, particularly if it occurs early in a plant's life, exposes reactor owners to financial exposure not faced by owners of low capital cost stations. In this regard, it is important to note that plant closures—for safety or security or other technical reasons—are an established and distinctive characteristic of nuclear power plants.

— Oil and gas-fired plants are less expensive to build, carry a higher risk on variable operating costs, such as fuel prices and availability of fuel.

[391] p 14, OECD/IEA, *Projected Costs of Generating Electricity,* 2005 Update.

— Coal-fired plants are less expensive to build, and are fuelled by a resource (coal) that is abundant, inexpensive, portable and reliably supplied through an extensive supply distribution network. Reinforcing the security of supply, coal production occurs in more than 50 countries around the world and is not specific to any particular geological or political region.

— In order to cope with the unpredictability and variability of wind generation, it is necessary to have reserve or stand-by conventional capacity to match and maintain balance in the electricity system. This could involve running the additional reserve plant at reduced output; that is, at lower efficiency. In essence, operating a wind generation capacity could involve the cost of the wind capacity, plus the cost of the reserve capacity, plus the cost of the reduced efficiency.

Clean Coal Technologies Offer Solutions

16. Clean coal technologies are available that can deliver substantial, large-scale reductions in CO_2 emissions in electricity generation. These include carbon capture and storage (CCS) technologies that allow fossil fuels to be used with minimal emissions—the CO_2 being put back underground from where it came. The UK Department of Trade and Industry is to be commended for the release (June 2005) of its Carbon Abatement Technologies Strategy. The £25 million funding announced is an important investment in realising the potential of CCS and can complement work being undertaken in a range of countries in this area from which the UK can benefit.

17. Researchers at Princeton University have made an assessment of CO_2 emissions might be stabilised over the next 50 years to skirt the worst consequences of global warming. Emissions would need to be trimmed by 7 billion tonnes per year (a total saving of 175 billion tonnes). From their assessment, they have identified 15 strategies, each of which could deliver carbon savings of at least one billion tonnes by scaling up technologies available today. Three relate directly to CCS:

— Capture and store emissions from 800 coal power stations worldwide.

— Produce hydrogen from coal at six times today's rate and store the captured CO_2.

— Capture carbon from 180 coal-to-synfuels plants and store the CO_2.

18. These three strategies alone could account for almost half the carbon savings needed by the world.

19. The implication for UK energy policy is that investment decisions should not divert necessary funds from this most important area of practical response to climate change.

Recommendations

20. All forms of low-carbon energy will cost money, whether coal or gas with carbon capture, renewables or nuclear. The Renewables Obligation has encouraged investment, particularly in wind farms. However, wind farms and other renewables—even with enormous investment—will never deliver the "heavy lifting" required during periods of peak demand required in modern economies like the UK. Their introduction can be greatly assisted through the base load capacity that can be provided through coal or nuclear and that alone indicates that energy investment must be sophisticated enough to encourage a mix of energy technologies and fuels.

21. As the relevant national coal association, the Confederation of UK Coal Producers (COALPRO) has in the past made recommendations to government in the UK. The World Coal Institute commends these to the Committee:

— Encourage investment in the existing fleet of coal-fired power stations to further reduce sulphur dioxide and carbon dioxide emissions:

  — By actively encouraging the use of flue gas desulphurisation.

  — By supporting a supercritical boiler retrofit project.

  — By reviewing the rules that limit biomass co-firing.

— Introduce a "Sustainables Incentive" to promote the construction of a fleet of new integrated gasification combined cycle (IGCC[392]) power stations where coal can be used cleanly and efficiently and, ultimately with near-zero emissions.

— Fund further research, development and commercial demonstration of clean coal technologies, including those that are needed to capture and store carbon dioxide.

  — The benefits for such investment can go beyond electricity generation eg hydrogen produced from coal at IGCC power stations can play an integral part in reducing emissions from the transport sector.

[392] IN IGCC systems, coal is not combusted directly, but reacted with oxygen and steam to produce a syngas composed mainly of hydrogen and carbon monoxide. The syngas is cleaned of impurities and then burned in a gas turbine to generate electricity and to produce steam for a convention steam power cycle. IGCC lends itself to carbon capture and storage technologies to ensure that carbon does not enter the atmosphere.

— Keep options for EC-allowable coal industry aid (investment, operating and closure) open and use them if necessary to maintain a secure base of indigenous coal production.

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