The INQUIRY **(Keeping the Lights on: Nuclear, Renewables, and Climate Change)**

MEMORANDUM 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.

Type of Power Station	*2003 (MW)*	*Probable remaining capacity in 2025*	
Existing Coal	*25851*	*2596*	
Oil	*3775*	*140*	
Gas (AGT + CCGT+ Others)	*24135*	*21672*	
Magnox	*2486*	*0*	
AGR	*8380*	*0*	
PWR	*1188*	*1188*	
Imports	*2000*	*2000+*	
Wind	*835*	*20000*	
Hydro	*1764*	*3000*	
Tidal/Wave		*8000*	
Other Renewables/Waste	*969*	*5000*	
Pumped Storage	*2787*	*2787*	
CHP	*4231*	*8000*	
		High Growth 2025 (MW)	*Low Growth 2025 (MW)*
New Capacity Required		*45697*	*28277*

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

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 miner's 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.

The Scenarios

Three fundament scenarios have been considered i.e. 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 205 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	% Nuclear in 2025	CO_2 Emissions Mtonnes		
	2005	2025	2005	2025	by 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 i.e. meeting Government Targets:

Scenario	Gas Requirement (bcm)		Coal Requirement (Mtonnes)		New Nuclear Stations	% Nuclear in 2025	CO_2 Emissions Mtonnes		
	2005	2025	2005	2025	by 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%**

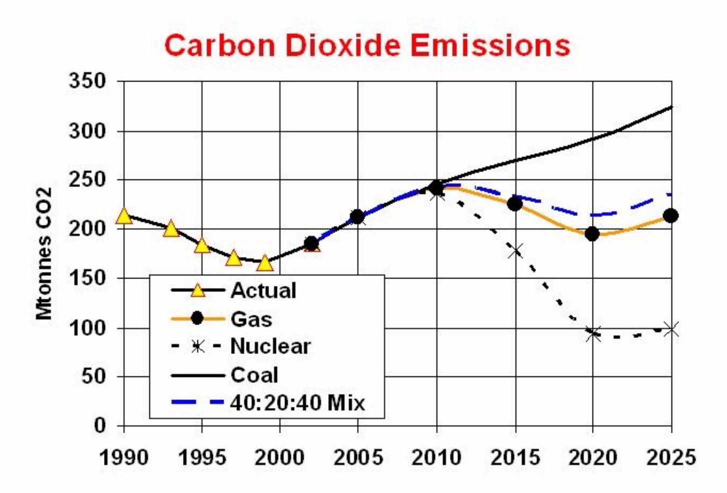

Fig. 1 Carbon Emission for different Scenarios – High Growth

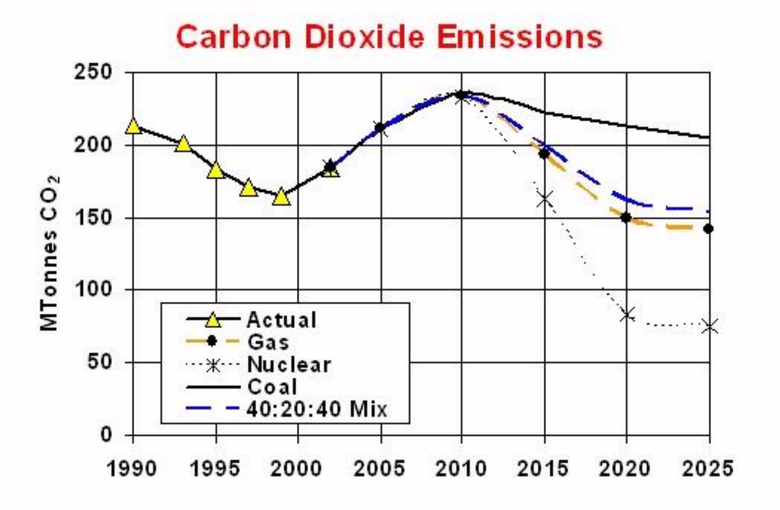

Fig. 2. Carbon Emission for different Scenarios – Low Growth

- 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.

- Fifty percent 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 be3 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.

Dr N.K. Tovey 18th September 2005

Appendix

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 M in 1971 to 59.987 M 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 M might be achieved as a lower estimate. A realistic estimate will place the figure somewhere between at around 64.6M 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 M – 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 bee a noticeable reduction in electricity demand per cooling appliance. However, there is now as trend towards larger such devices (e.g. 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 (e.g. 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 (i.e. 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 x 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 £ 1009 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 £1664 billion in 2025. If the average rate were to fall to 1.5%, the GDP would be £1422 billion or £1543 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.