Should the provision of renewable energy be a government priority, or can it be provided by the free market?

Third Prize – 3rd Year Undergraduate Category

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1. Introduction

The benign era of falling energy prices and natural resource abundance that helped fuel economic growth in the 20th century is set to end. The depletion of fossil fuel reserves, increasing fuel prices and concerns regarding rising Carbon Dioxide (CO_2) emissions and associated climate change, have raised the question as to whether free markets are able to invest sufficient levels of capital in renewable energy to mitigate such inevitability, or whether government intervention is necessary. Renewable energy has the potential appease CO_2 emissions while simultaneously fueling economic growth and creating employment opportunities. This essay will seek to explore this vital question by exploring potential impediments to renewable energy provision and proposing methods to overcome such shortcomings.

2. Climate Change

Scientists broadly agree that Earth is warming[1] and that this is mostly attributed to anthropogenic causes which are fundamentally altering the chemical composition of the atmosphere. As the Stern Report (2006) highlights 'before the industrial revolution level of greenhouse gases in the atmosphere was 280 Parts Per Million (PPM) of CO_2 equivalent (CO_2e); the current level is 430 PPM CO_2e'[2] (Stern, 2006, p.iii). Current energy policies cannot be maintained if severe climatic consequences are to be avoided (IEA, 2009b, p.1). Indeed, even if one were to dispute the vast quantity of scientific literature regarding climate change, global fossil fuel reserves are declining while demand is simultaneously rising, therefore, regardless of climatic implications it is evident that an alternative fuel source is needed. This essay shall not concern

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[1] See *Figure I & II*

[2] See Figure III & IV

itself in justifying the necessity of Greenhouse Gas (GHG) emission[3] reductions but will instead highlight if, and how Government should prioritise the provision of renewable energy[4].

3. Renewable Energy

Energy generated from renewable sources such as Solar Photovoltaic (PV), Wind, Hydroelectric, Geothermal and Biofuels produce little or no CO_2 emissions and thus make a considerable contribution towards alleviating climate change. Globally, this sector was worth $257 billion in 2011 (Frankfurt School UNEP, 2012), a figure that is rapidly growing given climate change concerns, high fossil fuel prices and increasing government support (UNEP, 2007). Approximately 3.2 per cent of global Total Primary Energy Supply (TPES) was generated from renewable energy sources such as hydropower, solar and wind, whilst conventional biofuels and waste[5] contributed a further 10 per cent to total energy production (IEA, 2012a). Iceland successfully generates 100 per cent of its electricity from renewable energy, thus demonstrating the potential for increased renewable energy provision. Renewable energy is a prime opportunity to reduce GHG emissions, meet rising energy demand and promote fuel security by reducing the dependence on the importation of fossil fuels.

4. Impediments to the provision of renewable energy

Despite the considerable advantages arising from the provision of renewable energy its uptake remains low. The chief barrier[6] to the widespread provision of renewable energy is that free market investment is not economically viable[7]. The cost of electricity generation from renewable sources is generally higher than that of conventional fossil fuels. Therefore, rational, profit maximising agents seek to invest capital such that it will generate the highest possible return. Since higher returns can be sought from conventional fossil fuels the renewable energy sector will suffer from low investment (IEA, 2012b).

However, the cost of generating electricity from renewable energy sources has fallen considerably in recent years with the advent of new technologies and increased capacity[8]. As illustrated by Figure X, technologies such as wind, solar photovoltaic and biomass have steep 'learning curves' thus suggesting that generation costs will likely fall further in future with increased capacity. Indeed, capacity expansion coupled with further research and development

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[3] The most prominent GHGs include Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O).

[4] See Figure V

[5] The green credentials for biofuels and waste energy generation are disputed.

[6] Additional barriers include social opposition due to visual and noise pollution and intermittency.

[7] See Figure VII & VIII

[8] See Figure IX

may ultimately result in a situation in which renewable energy is price competitive with fossil fuel generation.

5. Market Failure

Despite the well-documented evidence that GHG emissions are harmful to all, there is little incentive for any one party to reduce their personal emissions and thus conserve the environment. Such a phenomenon is known as *The Tragedy of the Commons* and was first documented by Hardin (1968) in his analysis where multiple individuals acting independently in their own self-interest can ultimately destroy a common resource, despite the fact that it is not in anyone's long term interest for this to occur. An agent will discharge waste into the *Commons* since it is less expensive than disposing of it safely. 'Since this is true for everyone, we are locked into a system of "fouling our own nest", so long as we behave only as independent, rational free enterprisers' (Hardin, 1968, p.1245).

The Tragedy of the Commons example serves to highlight the way in which the free market fails to provide sufficient quantities of renewable energy due to failing to capture the external costs and benefits to third party individuals within the price mechanism. Fossil fuels, as a result of pollution, impose a larger cost on society than private costs. Whereas renewable energy collectively benefits society through the utility gained by clearer air, thus generating a positive externality in supply. A positive externality occurs when the marginal social benefits of production exceed the private benefits by those involved in the transaction. Therefore, the societal optimal outcome in this situation is for an increased provision of renewable energy.

The case of a negative externality in supply is illustrated in Diagram I below. In the free market the equilibrium outcome occurs at the point 'P_1Q_1' where Private Marginal Costs (PMC) are equal to Private Marginal Benefits (PMB). However, given that fossil fuels impose a greater cost on society, the socially optimal outcome occurs at 'P_2Q_2' in which Social Marginal Costs (SMC) are equal to Private Marginal Benefits (PMB) and the social costs are internalised and faced by the producer. Thus one method, in which the deadweight loss, as illustrated by the red shaded area, can be avoided is to levy a tax equivalent to the distance 'P_1P_2' in order to shift the supply to the left to SMC from PMC, known as a Pigovian Tax.

Negative Externalities and Market Failure in Fossil Fuel Production

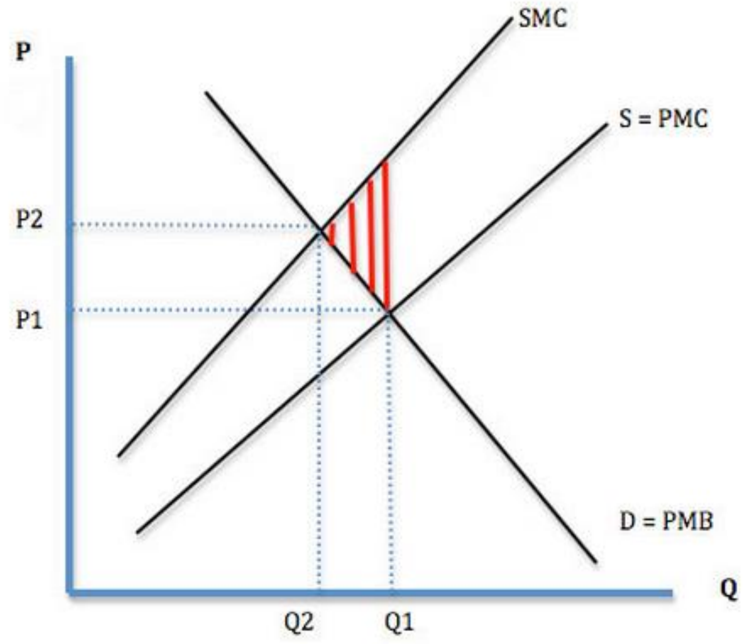

Diagram I

Ronald Coase (1960) adequately named Coase Theorem seeks to explain conflict resolution in the presence of property rights and externalities in the situation where trade in externalities is possible and there are no transaction costs. In this situation, when a third party is impacted by the pollution of others, Coase Theorem states that compensation from the polluter can be sought and as such a socially optimal level of emissions will subsequently result. Therefore, according to this theory, one need only strengthen property rights to internalise externalities and thus achieve a socially optimal level of pollution. However, in practice attempting to measure the cost of pollution and the affected parties is essentially impossible, thus highlighting the case for government intervention.

Attempts to reduce CO_2 emissions on a global scale can be modeled using game theory. Reducing GHG emissions and promoting the uptake of renewable technology is costly, therefore, there is an incentive for nations to free ride; if other countries make significant GHG emission reductions there is little incentive, or need, for other countries to reduce their own emissions. The game matrix below highlights this through the prisoners dilemma model:

Free-riding and emissions reductions

		Country 2	
		Cut	No cut
Country 1	Cut	3,3	0,5
	No Cut	5,0	1,1

Diagram ii

In the above diagram, the Nash equilibrium level of emissions occurs when neither country agrees to cut their emissions and they both derive a utility of (1,1), which is collectively worse than if both countries adopted the dominant socially optimal strategy of both cutting emissions (3,3). Hence, each country rationally pursues a self-interested policy, which paradoxically leads to a collectively suboptimal outcome. In other words, unless there is a global governmental concerted effort to jointly reduce GHG emissions by encouraging the use of low carbon renewables the market will fail to account for the provision of renewables.

In summary, it is evident that the free market will fail to provide sufficient quantities of renewable energy and that government intervention is necessary to combat market failure. Since the market only takes private costs and benefits into consideration when determining production, the social implications are ignored. Therefore market failure is endemic–and thus the need to 'internalise externalities' to ensure that such costs and benefits are fully accounted for by a 'polluter pays' principle' will lead to a pareto optimal outcome.

6. Government Policy

It is evident that in the free market, as long as renewable energy generation remains costlier than fossil fuels, renewable energy will be underprovided. Therefore, there is a need for Government to intervene in the market to ensure that a socially optimal equilibrium results. However, in doing so one must attempt to avoid the potential for government failure and its associated inefficiencies.

6.1. Taxation

As previously illustrated in *Diagram I* one such way to internalise externalities is to impose a Pigovian Carbon Tax, which would involve imposing an ad valorem tax for each tonne of CO_2 emitted. This tax will have the effect of both imposing a cost those that emit CO_2 and will have the secondary effect of rebalancing 'the electricity market towards greater low-carbon generation' (HM Revenue & Customs, 2011 p. 4) by reducing the price differential between renewable energy and fossil fuels. Therefore, this tax will thus make fossil fuels and renewables more price competitive with one another and is expected to 'drive £30-£40 billion' (HM Revenue & Customs, 2011) of investment into renewable energy sources[9].

While this tax will attach a greater cost of CO_2 emissions through the price mechanism, these additional generation costs will eventually be passed onto consumers through higher energy bills[10]. Furthermore, a simple carbon tax would not apply to other pollutants such as nuclear power, which generates nuclear waste.

6. 2 Emissions Trading

The European Union operates the world's largest cap-and-trade Emissions Trading Scheme (EU-ETS) in which a maximum limit, or cap, is placed on the total emissions of greenhouse gas emissions, calculated as CO_2 or equivalent for in excess of 11,000 factories, power stations and other installations within the EU. Permits that allow a specified quantity of emissions are issued and firms are able to freely exchange such permits among one another in much the same way that other financial products are traded. This system rewards those who make the largest efficiency savings and is costly to the heaviest polluters. Given that a fixed cap is imposed total emissions are guaranteed to fall unlike under a carbon tax regime. The EU-ETS also has the additional advantage of allowing firms to offset their own emissions by mitigating GHG emissions in developing countries by a greater amount.

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[9] The £30/tCO2 tax is expected to promote £30-40 billion of investment in low-carbon, increasing low-carbon generation capacity by 7.5 to 9.3 gigawatts (GW) by 2030; broadly equivalent to 5,000 wind turbines or five new nuclear power stations. Higher levels of investment will lead to an increase in capital investment. Total resource costs will increase by £6.1 billion from 2013 to 2030 (HM Revenue & Customs, 2011).

[10] Given the current electricity mix, the imposition of a Carbon Tax priced £15 per tonne of CO_2 is expected to increase domestic consumers electricity bills by £3.5 billion, which given current prices represents an increase of nearly twenty per cent on electricity bills, and given the escalating tariff, this would almost double bills by 2030.

The cost of buying emissions encourages investment; those who can reduce their investment below their allotted amount are able to sell their excess allowances to others. Thus the price that firm can sell on its permit to others is determined by the market and is based on the relative difficulty of emissions reductions and the availability of allowances. In theory, those with the ability to reduce their emissions the greatest, and at the lowest cost are incentivised to do so. There is however a problem of 'carbon leakage' in which pollutive firms choose to relocate operations to area outside the scheme. If located outside the EU, the firm may become even more pollutive since it is likely that additional environmental protections will be more lax. One potential way in the leakage of carbon could be accounted for is by calculating the carbon emissions of imported goods, known as 'border leveling agreements' however, this policy will fall foul of World Trade Organisation rules and is extremely difficult to negotiate on an international platform.

6.3 Subsidies

Subsidising energy production involves Government directly taking on costs through tax breaks or paying producers directly. Subsidisation can play a pivotal role in supporting fledgling renewable technologies by creating an incentive for further investment and thus reducing initial generation costs which are associated with increased capacity. However, it is important to ensure that subsidies are technology neutral, meaning that they do not favour one incumbent low carbon energy source over another potential future source, since this may ultimately prevent the development of new, more efficient technologies. The role of subsidies is diagrammatically illustrated in *Diagram iii*, a subsidy serves to shift the supply curve from S_1 to S_2 which has the effect of reducing the costs of renewable energy and thus the quantity consumed will increase.

Renewable energy subsidies

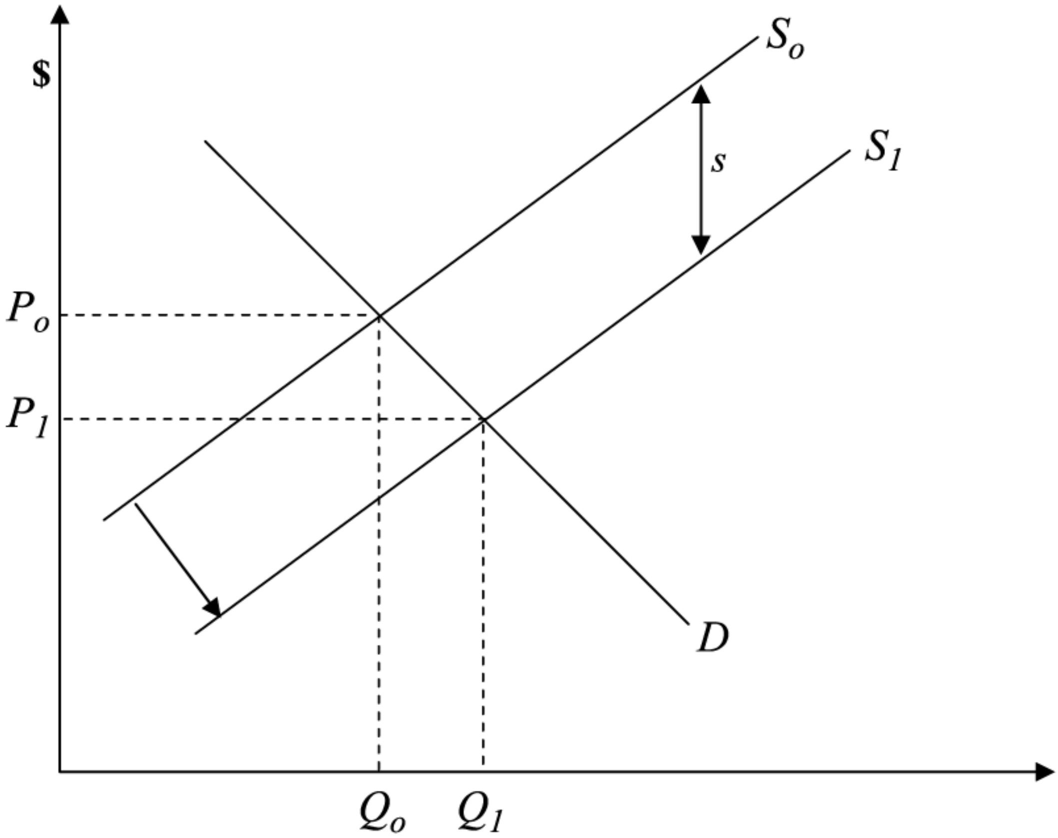

Diagram iii

Surprisingly, on a global basis fossil fuels in fact receive considerably more subsidies than their renewable counterparts; for example, petroleum is often subsidised in developing countries, and implicit subsidisation are granted through a number of tax breaks. Such subsidies for fossil fuels total $404 billion and are particularly significant given aid for biofuels, wind power and solar total a relatively mere $66 billion (IEA, 2011). Indeed, it is estimated that eliminating fossil fuel subsidies by 2020 would cut energy demand by 3.9% (IEA, 2011).

Subsidies, when implemented correctly help ensure that a socially optimal level of renewable energy generation is achieved. Conversely fossil fuel subsidies further distort the market and should therefore be removed to reinforce the price mechanism. Indeed whilst it is true that subsidies distort the market by restricting the price mechanisms ability to determine the most cost effective fuel source, they can help overcome the issue of market failure and externalities for the provision of renewables.

6. 4 Further Measures & Alternatives

In addition to market-orientated government intervention, such as that outlined above, intervention can take the form of direct intervention. Such intervention can include directly providing capital to firms that provide renewable energy, provide loan guarantees and may directly provide renewable energy itself.

The newly founded Green Investment Bank (GIB) in the UK seeks to provide affordable finance for renewable technology companies; 'Capitalised with £3 billion, the GIB will play a vital role in addressing market failures affecting green infrastructure projects in order to stimulate a step up in private investment' (Department of Business, Innovation, and Skills, 2012). It is hoped that the GIB will profitably invest capital in firms where the net present value has not been fully recognised.

Through increasing direct government spending by encouraging the consumption of renewables through schemes such as the GIB government is aiding and correcting the provision within the market. Whilst this is a highly interventionist approach one can take comfort from the Keynesian school of thought and the theory of the multiplier. The Keynesian consumption function of AD=C+I+G+(X-M) implies that consumption increases with after-tax income:

$$0 < dC/d(Y - T) < 1.$$

Therefore a debt-financed increase in government spending boosts total spending by more than one for one:

$$1 < dY/dG = 1/(1 - dC/d(Y - T))$$

Thus if government continues and expands schemes such as the Green Deal, and GIB further the potential long run benefit may exceed the initial endowment and have a secondary benefit of promoting the green economy and economic growth. Consequently even in these fiscally stringent times, government may deem this to be a low priority due to budget opportunity costs, the role of such fiscal stimuli may in fact boost economic growth in the long run.

However, government intervention, specifically the direct provision of capital may result in government failure. Government failure is analogous to market failure insofar as government intervention may distort incentives such that the markets distortion is larger after Government has intervened. In the case the GIB bureaucrats may invest in poor projects and thus allocate capital inefficiently.

6.5 Summary of policies

In summary, it is evident that the for the widespread adoption of renewable energy the following factors must be met (IEA, 2011):

1 Energy prices must appropriately reflect the true cost of energy so that the impact of energy consumption and production is considered.
2 Inefficient fossil fuel subsidies must be removed, while ensuring that all citizens have access to affordable energy.
3 Governments must develop policy frameworks that encourage private sector investment in low carbon technologies.

7. Conclusion

The past three decades have witnessed two major oil shocks, a severe accident at the Chernobyl power plant, the doomsday perspective of limits to growth, major concerns relating to climate change, severe energy supply constraints and widespread concern of energy security. Yet 95% of all world commercial energy comes from fossil fuels (Owen, 2005). Renewable energy is both underprovided and overpriced, while fossil fuels are overproduced and underpriced in the free market. To rectify this market failure Governments should seek to internalise externalities according to a 'polluter pays' principle though imposing taxes and market-orientated Emission Trading Schemes. Additionally, fledgling renewable technologies can be supported with subsidies to encourage their further uptake and the realisation of economies of scale. The free market must be encouraged to flourish through interventionist policy, as 'climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen' (Stern Report, 2006, p. 33).

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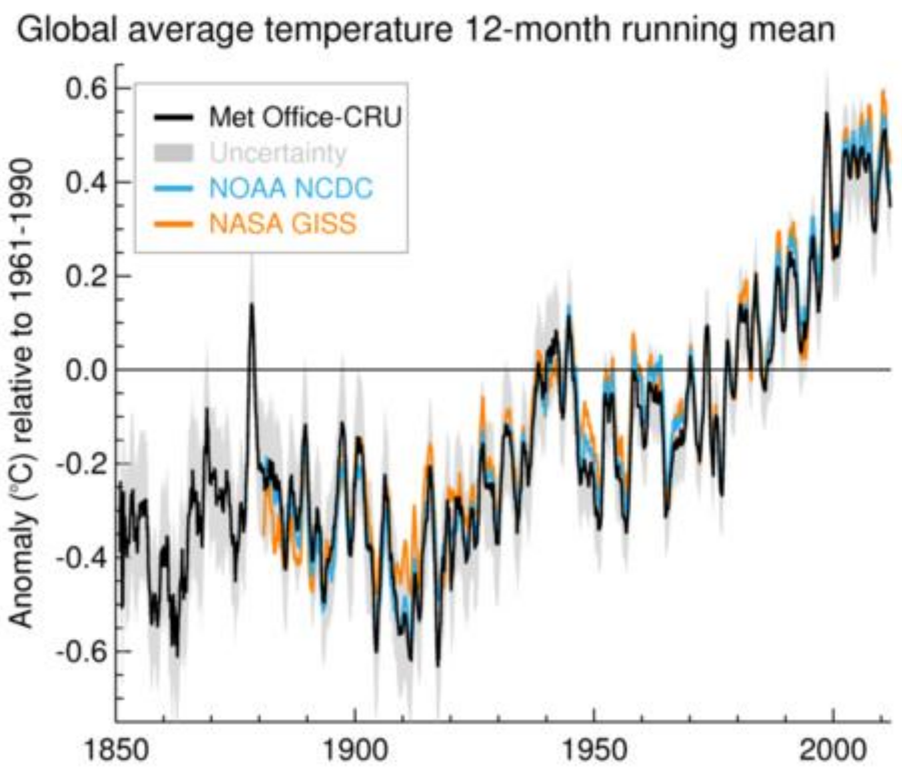
9. Appendix

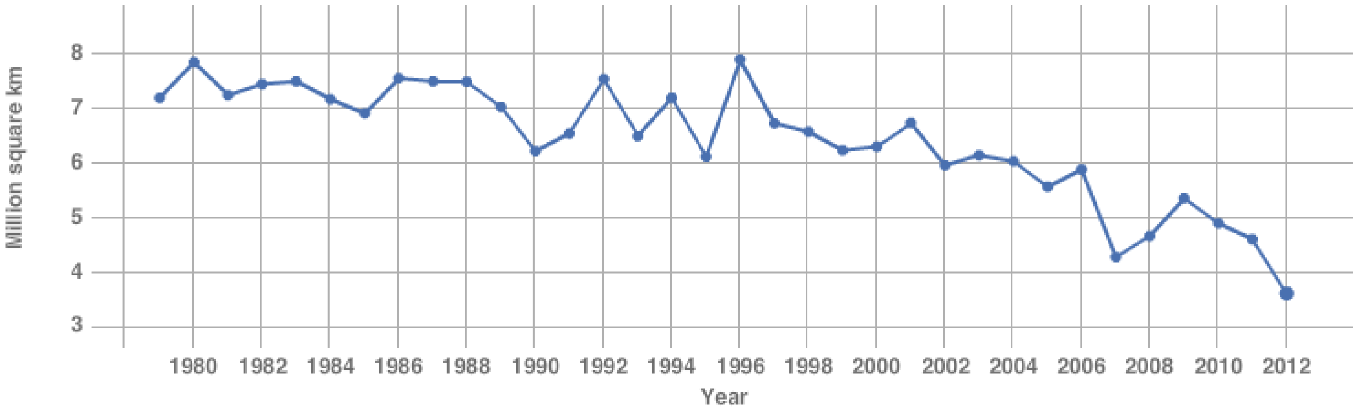
Figure I



Source: (Met office, 2010)

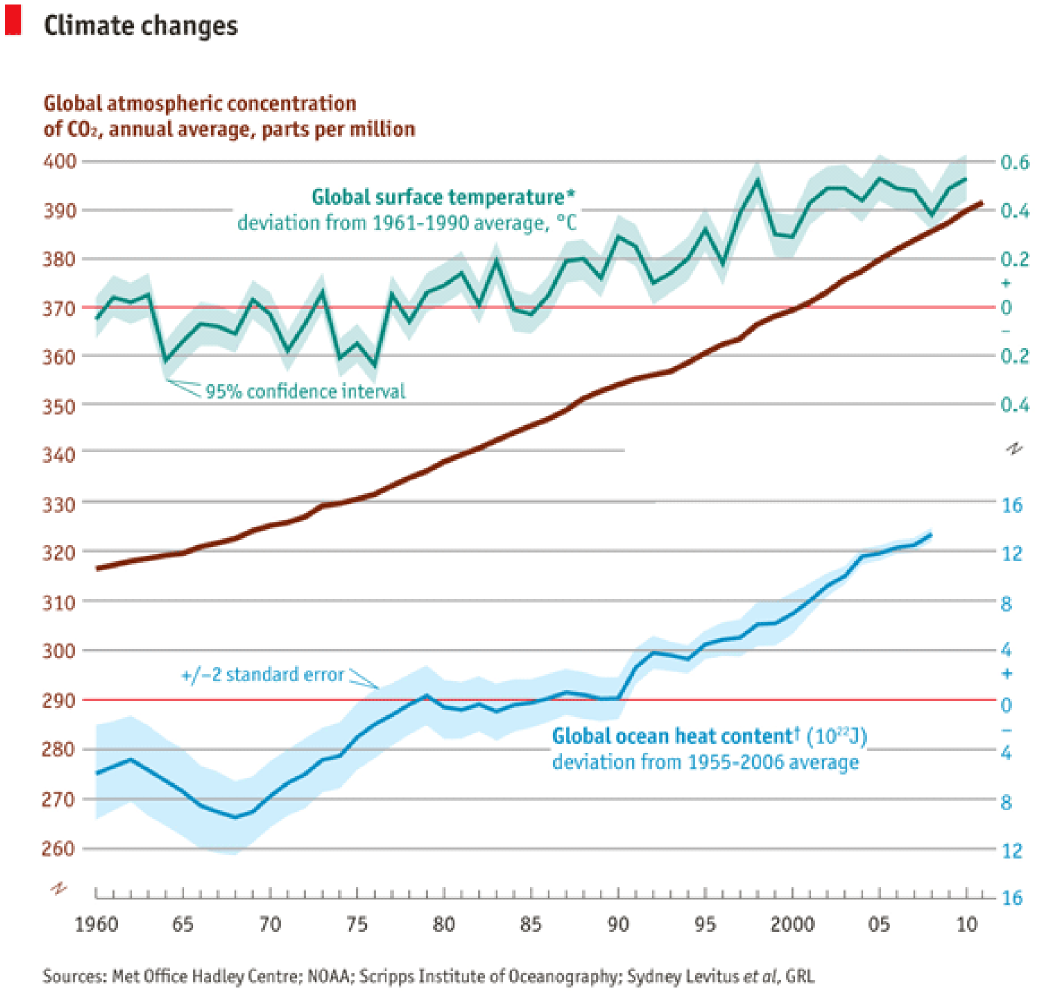
Figure II

Artic Sea Ice (September Average)



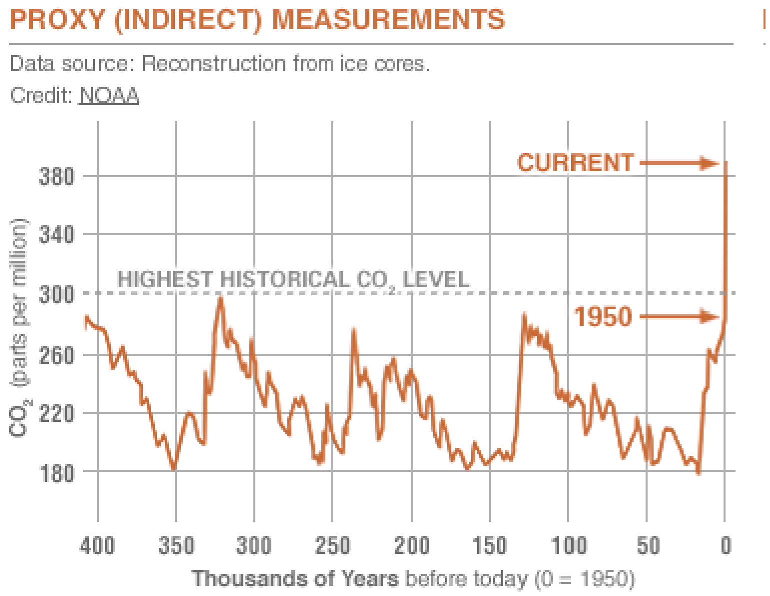
Source: (NASA, 2013)

Figure III



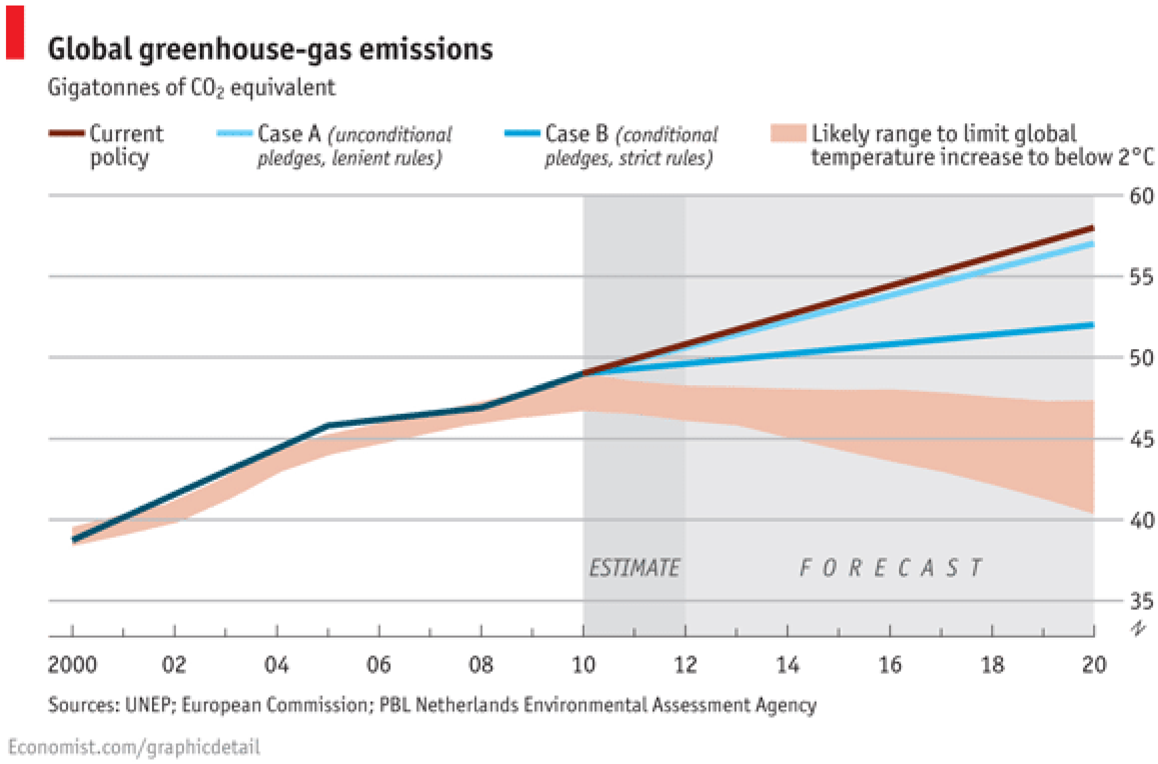
Source: (The Economist, 2012)

Figure IV



Source: (NASA, 2012)

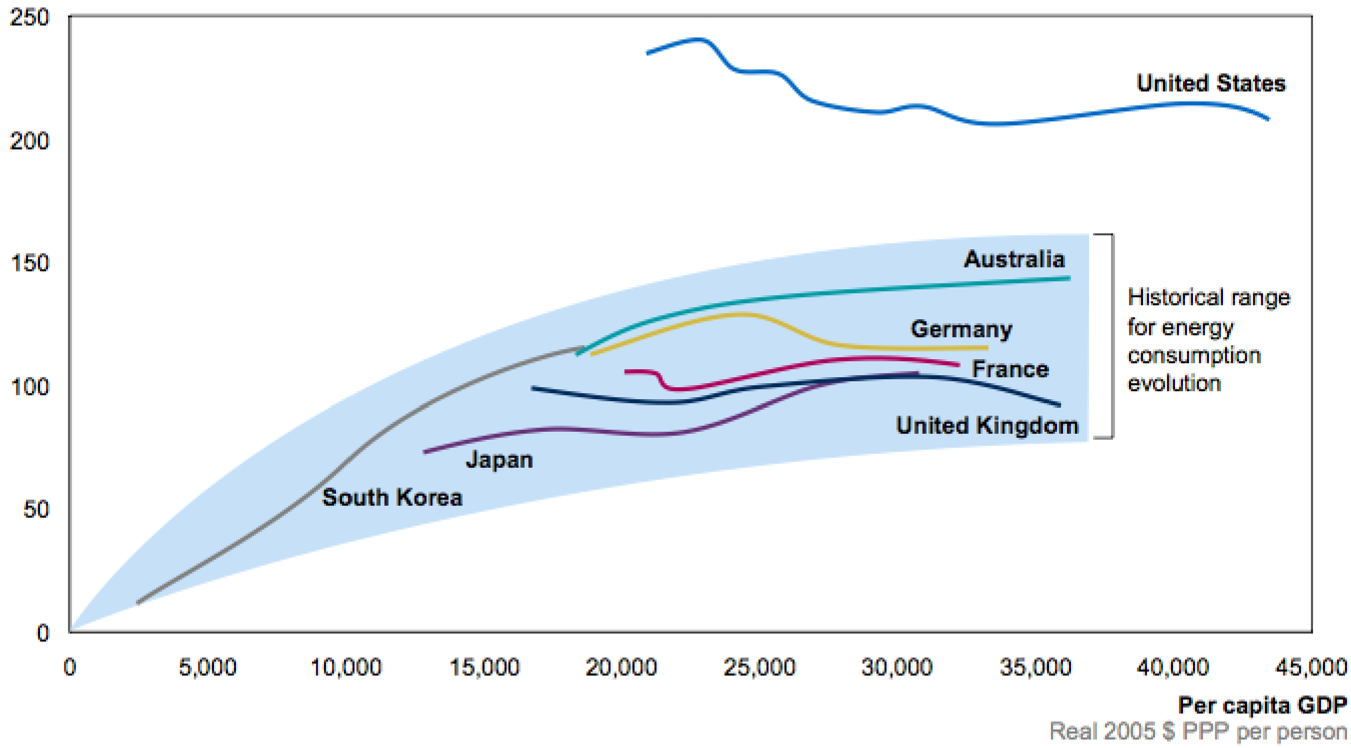
Figure V



Source: (The Economist, 2012)

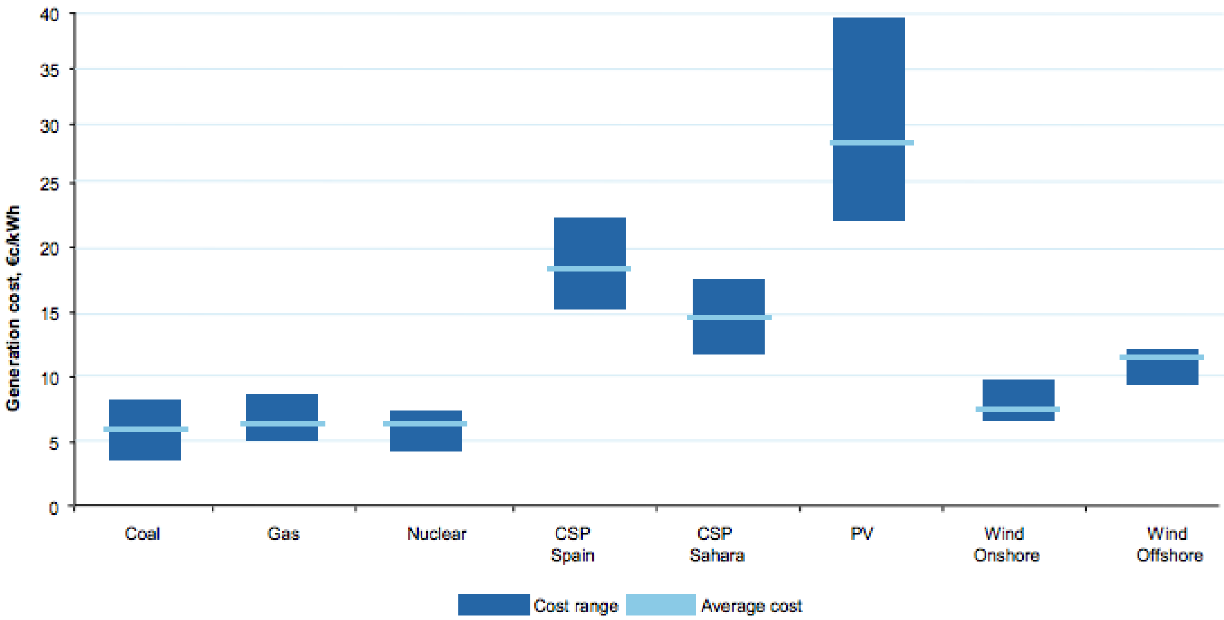
Figure VI:

Relationship between income and resource demand



SOURCE: International Energy Agency (IEA); Global Insight; McKinsey analysis

Figure VII



Source: (PWC, 2010, P.33)

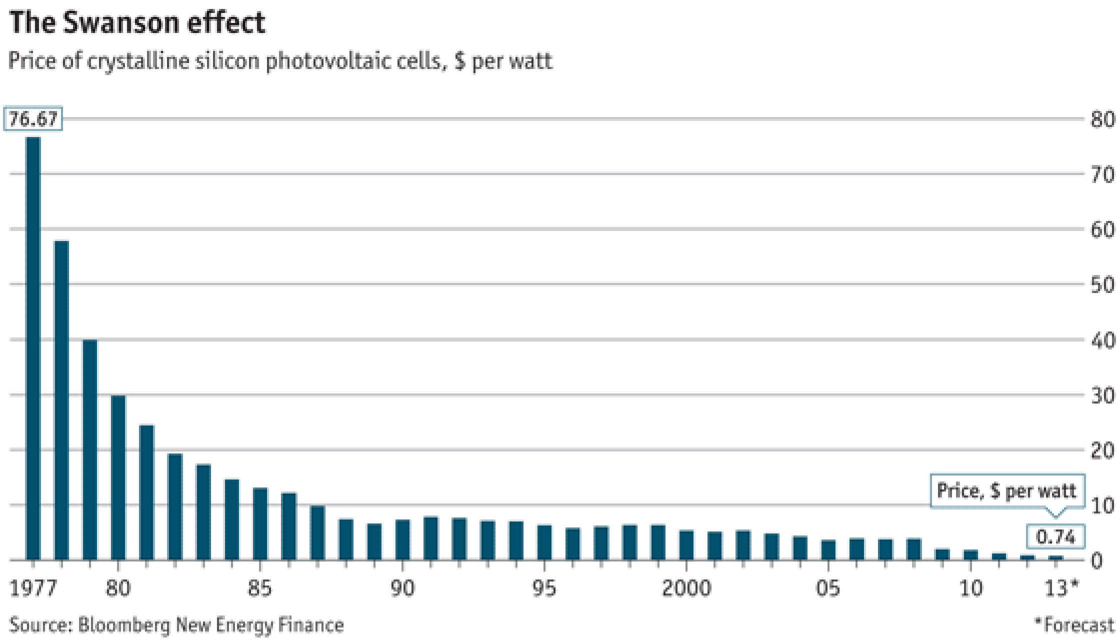
Figure VIII

Table 2
Cost of traditional and renewable energy technologies current and expected trends

Energy source	Technology	Current cost of delivered energy (Euro-¢/kWh)	Expected future costs beyond 2020 as technology matures (Euro-¢/kWh)
Coal	Grid supply (generation only)	3–5	Capital costs to decline slightly with technical progress. This may be offset by increases in the (real) price of fossil fuels
Gas	Combined cycle (generation only)	2–4	
Delivered grid electricity from fossil fuels	Off-peak	2–3	
	Peak	15–25	
	Average	8–10	
	Rural electrification	25–80	
Nuclear		4–6	3–5
Solar	Thermal electricity (annual insolation of 2500 kWh/m^2)	12–18	4–10
Solar	Grid connected photovoltaics		
	Annual 1000 kWh/m^2 (e.g. UK)	50–80	~8
	Annual 1500 kWh/m^2 (e.g. Southern Europe)	30–50	~5
		20–40	~4
	Annual 2500 kWh/m^2 (e.g. lower latitude countries)	40–60	~10
Geothermal	Electricity	2–10	1–8
	Heat	0.5–5.0	0.5–5.0
Wind	Onshore	3–5	2–3
	Offshore	6–10	2–5
Marine	Tidal barrage (e.g. proposed River Severn Barrage)	12	12
	Tidal stream	8–15	8–15
	Wave	8–20	5–7
Biomass	Electricity	5–15	4–10
	Heat	1–5	1–5
Biofuels	Ethanol (cf. petrol & diesel)	3–9 (1.5–2.2)	2–4 (1.5–2.2)
Hydro	Large scale	2–8	2–8
	Small scale	4–10	3–10

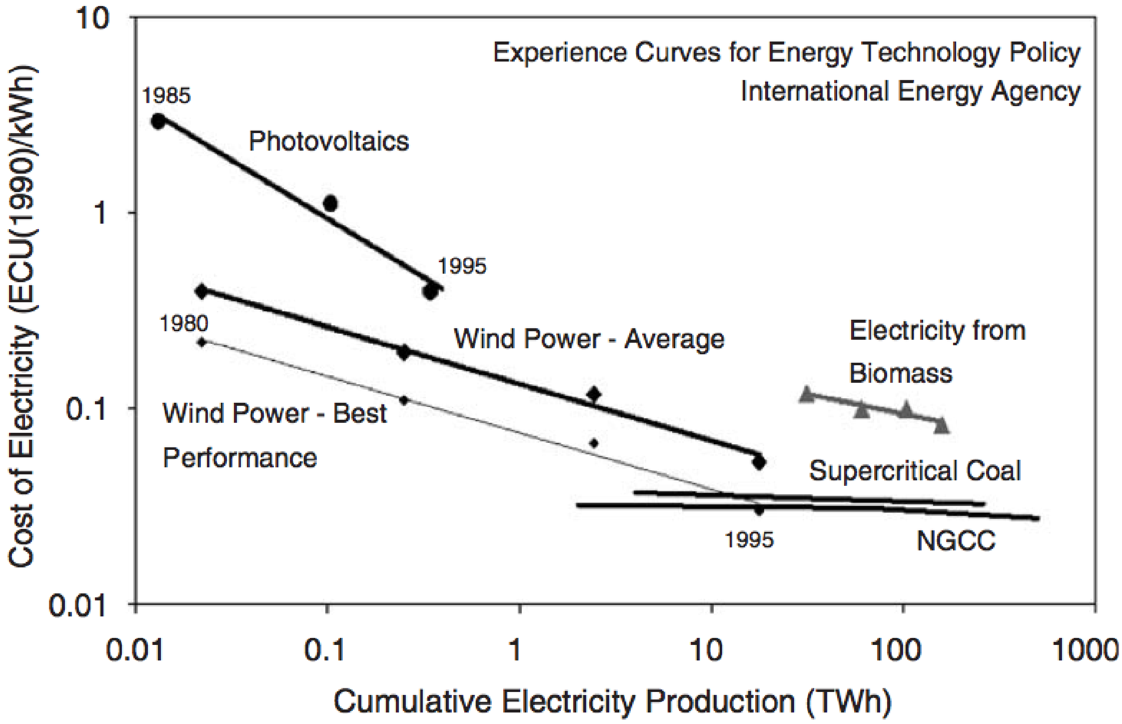
Source: (Royal Academy of Engineering, 2004)

Figure IX



Source: (The Economist, 2012)

Figure X



Source: (IEA, 2000, p.663)