RS policy document 08/06

The Royal Society's response to Department of Trade and Industry Review of UK Energy Policy

This response has been approved by Sir David Wallace on behalf of the Council of the Royal Society. It was prepared in consultation with members of the Society's Energy Policy Advisory Group, along with other experts in the field.

Summary

- Reducing the emission of carbon dioxide to the atmosphere, in order to mitigate the impacts on climate change and ocean acidification must be a primary driver for energy policy and requires urgent action. This must be achieved whilst providing a secure supply of energy.
- Collective international action is needed to reduce the emission of carbon dioxide and other greenhouse gases. The UK contributes about 2% global greenhouse emissions. A UK energy policy must be part of a wider international effort to reduce emissions.
- A cost should be associated with the emission of carbon dioxide to the atmosphere, irrespective of source – industrial, domestic, transport (including aviation). This should be passed on to all energy users in a way that is transparent and predictable over relevant investment timescales.
- Huge investment is required in clean technologies, such as renewables, nuclear power and carbon capture and storage, some of which require substantial long-term investment commitments. But first and foremost effort to reduce the demand for energy and increase end use efficiency must be increased substantially.
- Stable market conditions are essential to reduce investment risk. Any economic instrument must be introduced in a way that is stable operationally and predictable over relevant investment timescales, to encourage the investment in new technologies, many of which are capital intensive.
- A range of technologies will be required to meet these objectives. Some are mature, such as onshore wind power. Others such as wave power and carbon capture and storage require further investment in research, development and demonstration to bring them to market.
- There is a major lack of investment in energy research – both by private and public sectors. Current market conditions are not delivering the necessary rate of private investment in research and development in technologies that are far from market.
- We look forward to seeing further details about how the National Institute for Energy Technologies, announced in the recent Budget, will help increase investment in energy research, development and demonstration.

1 The drivers of energy policy

1.1 The Government have identified four imperatives for energy policy in the UK. The current review, and resultant government policies, intend to address:

- **Climate change**: the UK contribution to international efforts to reduce anthropogenic greenhouse gas emissions and to prevent their atmospheric concentrations rising to levels that are highly costly to human life, economy and society;

- **Security**: ensuring an adequate and stable energy supply and avoiding the potential problems of disruption resulting from excessive dependence on overseas energy sources in an environment of tight supply. In addition the avoidance of international conflict driven by competition for resources;
- **Cost**: ensuring that all consumers pay comparable costs so that UK industry is not disadvantaged by excessively high energy costs;
- **Fuel poverty:** ensuring that all citizens are able to afford adequate heating and lighting.

1.2 Climate change and ocean acidification, with their associated impacts, must be a primary driver of energy policy. Whilst security of supply may pose a more immediate threat, many of the actions required to reduce emissions of carbon dioxide to the atmosphere will also act to increase security of supply. The other concerns, cost and fuel poverty, should be considered as key constraints that need to be satisfied in any policy.

1.3 We see fuel poverty as an important social equity issue, but not one that should be allowed to distort the energy markets. Achieving the objectives of addressing climate change and providing energy security will and indeed should lead to an increase in the price of energy. In order to avoid penalising vulnerable members of the community, measures such as winter fuel allowances should be used to compensate them rather than shield them from increased costs. Social support mechanisms should, as far as possible, be targeted at capital investment in energy efficiency suited to the most vulnerable; thereby reflecting the need to reduce energy consumption by all consumers.

2 Climate change and emissions targets

2.1 The scientific understanding of climate change (Joint Academies 2005) and ocean acidification (Royal Society 2005) are now sufficiently clear to justify taking prompt action. Collective international action, led by the developed nations, is needed to reduce greenhouse gas emissions so as to reduce the risk of dangerous interference with the climate system and the oceans. We welcome the leading role that the UK government has taken to ensure that climate change is on the international agenda, including the establishment of the Stern Review on the economics of climate change.

2.2 Progress by the UK towards its 2012 Kyoto target of reducing greenhouse gas emissions by 12.5% below 1990 levels is largely a consequence of electricity production switching from coal to gas for fuel between 1990 and 1997. In the last 5 years UK emissions of carbon dioxide have risen, reflecting a steady shift back to coal in the face of rising gas costs, and increased emissions from transport. This is without the inclusion of international aviation, which is not included under the Kyoto protocol, whose rate of growth would make achieving the Kyoto targets much harder. The Government has recently admitted that it is unlikely that the UK will meet its domestic target of cutting CO_2 emissions by 20% by 2010. While the general trend over recent years indicates we are on course to meet our 2012 Kyoto target, the recent increases in carbon emissions emphasize the need for strong and immediate action to enable the target to be met.

2.3 It is vital for the UK to adopt an energy strategy that ensures emissions trends follow a downward trajectory towards the government's target of 60% reductions by 2050[1]. It should also be recognised that it is not the rate of emission that is important, but the total amount that has been emitted. Greater emissions now, or a delay in re-establishing a downward emission trajectory, will reduce the amount that can be emitted in the future and therefore significantly increase the rate of reduction that will subsequently be required.

[1] To a level of carbon dioxide emissions around 65MtC per year – see DTI, Energy White Paper 2003

2.4 We recommend that Government should:

- Show firm political commitment and identify and publish realistic targets for 2015, 2020, and regularly thereafter, that are designed to re-establish a downward trajectory of emissions and make achievement of its 2050 target credible
- Introduce policies to deliver the targets
- Ensure that they report annually on progress from policies, as indicated by the recent review of the Climate Change Programme. The reports must be publicly visible, so as to help achieve the public engagement and consent to what is likely to be a politically difficult process.

3 The market context for emissions reduction

3.1 The UK has one of the world's most liberalised energy markets. However, the market and associated government policy will need to be adapted in order to deliver the objectives of the energy policy outlined above. It will require a major shift in the pattern of energy generation towards non- or low-carbon technologies and the increased management of demand. In addition, it will require substantial investment in research and development in order to deliver the technologies required, as well as the development of an available skills base.

3.2 Delivering this will require a stable economic environment, so as to reduce the risks, and therefore the costs, of financing the substantial investments that are required. The following will be required from government:

- Clearly stated long term objectives, such as carbon emission reduction targets, with short to medium term targets to create a trajectory of change designed to achieve the objectives;
- Introduction of a clear stable framework of economic instruments that stimulate investment designed to achieve the targets; it is recognised that the instruments may need to be progressively adjusted to ensure that performance remains on track.
- Revise the planning system so that is provides greater stability and encourages support for clean energy technologies, and deliver a stricter approach to regional target setting.
- Buy-in across the political spectrum, so as to reduce political interference and therefore increase stability.

Economic instruments

3.3 As stated in the Royal Society report *Economic instruments for the reduction of carbon dioxide emissions*, the primary emphasis for any energy policy should be on the use an economic instrument that puts a price on the emission of carbon dioxide to the atmosphere, such as a carbon tax or tradable emission permits (Royal Society 2002). This provides the most cost-effective method of achieving emission reductions.

3.4 It is vital that whatever instrument is chosen should be the simplest that can be devised, so that it is comprehensible to all stakeholders and so that it facilitates international agreement.

3.5 A clear announcement of the long-term intention to increase the cost of emission of carbon dioxide, either by increasing the carbon tax or reducing the number of permits available, will reduce the costs of mitigation. In the anticipation of higher costs for energy and fossil fuels, investors will be encouraged to shift investment to long-lived low carbon technologies.

3.6 Whilst the current Climate Change Levy has been shown to deliver some benefits, it is an inefficient way to reduce carbon dioxide emissions, as it excludes certain users (including households and

transport) and because it targets energy use in general rather than carbon emissions in particular and therefore taxes nuclear power.

European Emissions Trading Scheme

3.7 A framework for a long-term permit system currently exists in the European Emissions Trading Scheme (EU ETS). As it stands, it is seriously flawed as the permits are given free of charge (grandfathered) not auctioned and therefore does not give the right economic signal about the costs of polluting activities. There is an intention to increase the auctioned component from 2008-12 but only to 10%.

3.8 There are currently no commitments to continue the EU ETS beyond 2012, at the end of Phase II of the scheme. In order to provide the stability required for the necessary long-term investment, the UK government should commit itself to the continuation of the EU scheme beyond the end of Phase II, or to a similar mechanism that ensures that the incentives for investment that the EU ETS creates are maintained.

3.9 Ultimately an economic instrument, such as the EU ETS, can only be effective if it embraces all sectors, whether industrial, domestic or transport (including aviation whose emissions have been steadily rising). This would also reduce the costs of delivering reductions in carbon emissions. Spreading the scope of the economic instruments across national borders would also reduce the impacts on competitiveness by helping to ensure that all consumers pay comparable costs so that UK industry is not disadvantaged by excessively high energy costs.

3.10 Additional economic instruments, such as the Renewable Obligation Certificates, are likely to be required to stimulate less developed technologies like offshore wind and marine energy.

4 Incentives for energy research and demonstration

Investing in the medium to long term technologies

4.1 The current market system in the UK does not provide sufficient incentive for research and development at the scale necessary to ensure the sustained growth of energy technologies. The spend by the privatised energy industry's on research and development has been declining and is a tiny percentage of its turnover. Moreover, the market does not differentiate between the different stages of development of the potential technologies.

4.2 Whilst economic instruments, such as the Renewables Obligation, could create a clear incentive for the market to innovate new low carbon technologies, the current scheme only provides funding for more mature technologies that are already close to or in the market, such as landfill gas, hydro and wind power. If industry is to be encouraged to invest or collaborate in research and development of technologies that are further from the market, such as marine resources, offshore wind and biofuels, then a new scheme will be required. Funding for the energy technology research of the Research Councils and the DTI should also be suitably increased.

4.3 The UK government should provide assurance that the Renewables Obligation, or a similar scheme, will be maintained will help to provide the stability required for investment in new technologies. In addition, provide assurance that all of the finite support provided by the scheme will not be taken by the initial successful market entrants such as wind power.

4.4 Government has a key role in fostering large scale research and development, either by direct funding or by creating incentives. There is a need for greater coherence led by Government in national

investment in energy research. We look forward to seeing more details about the National Institute for Energy Technologies, announced in the recent budget, and its role in acting as the main focus for such investment involving both public and private sector support. It should act as a coordinating hub as well as directly conducting energy technology research. Consideration is also needed to ensure effective collaboration with the already established UKERC.

Demonstration projects

4.5 Many partly developed technologies require large scale demonstration projects. Funding for such projects is often high risk and therefore unlikely to be funded by industry alone. In order to gain market confidence in such technologies additional support is required to fund large scale demonstration projects.

4.6 Carbon capture and storage could play a significant role in reducing carbon dioxide emissions, particularly with the anticipated increase in the use of coal in countries such as China, India and indeed the UK itself. Major demonstration projects, such as the one underway in Peterhead, are essential to demonstrate its technical and commercial viability, and could deliver emission reductions by 2010. The UK is well placed to take a leading role in the development of this technology.

Availability of skills

4.7 The development of a UK science and technology base provides an opportunity for the export of technology and skills. However, for many new technologies the UK is at risk of having to import the necessary skills and technologies in order to deploy the technologies in the UK. The main useful energy derived from renewable sources is in the form of electricity. Yet it is reported that in the past two years alone the number of electronic and electrical engineering students in Universities in the UK has fallen by more than 30%. This is of greater concern, because the power side of electrical engineering in Universities was already in a depressed state. In addition, more than half of all engineering doctorates awarded in Britain are to overseas students (Rose 2006). Only significant sponsorship of University places in these areas can reverse this trend in the near to medium term.

5 Energy security

5.1 In an international market the provision of energy security comes from the delivery of a secure supply of primary energy. With a further depletion of UK oil and gas reserves the cost and security of energy supply will become increasingly dependent on overseas energy sources. Competition for resources, such as fossil fuels, will increase as global energy demand is expected to increase by a factor of 3–5 by 2050, raising the risk of international conflict.

5.2 In part, the delivery of a secure, continuous supply is in the interest of the energy supply industry, so it will be delivered through the market. However, the level of security required at a political level may be higher than that provided by industry. This difference in objectives will have to be achieved through regulation and incentivisation of the market, or paid for through public funding.

5.3 Greater diversity in the supply of energy reduces dependence on one specific source of energy and therefore increases the security of supply. For example, gas currently accounts for 40% of our primary energy. As this will come increasingly from overseas sources, policies to increase security of supply should seek to reduce our use of gas. This could come from increased efficiency of use, as well as reducing its use for space heating, for example through greater use of waste heat. Diversity of supply could also come from the increased use of renewables, nuclear power and coal, provided that carbon

capture and storage can be established, and of course renewables add to security directly being a resource located within national boundaries.

5.4 The use of domestic energy sources will also aid long-term security of energy supplies. Hydrogen as an energy carrier could perhaps be used for transport in the longer term. It can be produced locally by a number of different routes and from a wide range of sources including a variety of renewable or sustainable energy sources: solar, wind, biomass, wave and tide energy as well as nuclear energy and carbon-based fuels. This variety of routes could provide much greater energy security and stability of energy prices.

5.5 The increased use of intermittent generation technologies, such as wind, wave, tidal and solar, may in the longer term require changes to the system to ensure reliable and stable operation. This is not an issue up to 2020 since the expected contribution can be absorbed by the system with only minor operational adaptation and minimal cost (UKERC 2006). However, the appropriate levels of conventional plant capacities need to be maintained at all times, so as not to breach established security of supply standards. As levels increase beyond 2020, there will be a need to adapt the plant mix and its operation. More research is required to determine how the electricity supply system might best evolve, but it is already clear that an increased use of demand side management will have an important role to play, particularly to alter demand patterns so they match more closely changes in supply. For example in households, an intelligent system would switch specified equipment and appliances on and off so as to restrict peak demand. Smart metering that shows current electricity prices, transmitted on a real-time basis using micro-processing and communication technologies, may encourage the shift of energy intensive use in industry and in households to periods of lower demand. The overall benefit of this would be to reduce the need to provide stand-by power supplies, which only operate at peak periods. Beyond 2020, if renewables meet their targets and their contribution to supply increases, then energy storage technologies would become important.

5.6 Hydrogen and also batteries can fulfil the vital storage function, smoothing fluctuations of electricity generated from intermittent resources such as solar, wind, wave and tidal power. In principal, electricity generated at times of low demand could be used to produce hydrogen from the electrolysis of water. During peak demand this could then be converted back to electricity in hydrogen-powered fuel cells. Energy storage associated with hydrogen or batteries, for transport and perhaps other applications, could contribute to security of supply in the electricity network, particularly when the use of intermittent technologies increases.

5.7 Capacity investment required to provide the operational margins needed for a reliable electricity supply are not automatically delivered by the market. One option might be to create a system of Capacity payments, which provide funding to ensure there is always a sufficient supply available in case of sudden demand or loss of some supply. Payments can be set so that they rise as the amount of spare capacity reduces providing a strong incentive not to get too close to critical.

6 Demand management

6.1 Reducing the overall demand for energy, through energy efficiency measures should be an essential part of any energy policy. Achieving the 60% cuts in emissions will be made more difficult by the increase in demand for energy, which in the UK is expected to increase by 50% by 2050. However, no country has yet succeeded in achieving a sustained reduction in energy consumption combined with economic growth.

6.2 Reducing the overall demand for energy can be achieved through a number of methods. The implementation and effective enforcement of building regulations provides an effective tool for reducing building energy consumption. However this is a long term measure as it has only limited impact on the existing building stock. Further incentives are required to motivate people to make efficiency investments to the fabric of their property that may only be realised after long periods of time, such as reflecting efficiency in the value of the property. Some technologies are available to improve the efficiency of existing housing stock, such as external insulation for walls. But awareness of these, and therefore an ability to install them, is poor in the UK compared to parts of Europe.

6.3 Substantial gains in energy efficiency have been seen in California where a range of aggressive policies have been implemented. These have included the requirement for utility companies to apply an $8/ton 'carbon adder' to any procurement decisions to reflect the likely cost of purchasing carbon dioxide offsets. This has had the effect of incentivising low carbon technologies. Other polices have focused on raising efficiency and emission standards and on public engagement programmes. Investments in energy efficiency have provided not only a cost-effective means for meeting growing power needs, but are also faster than building new power plant, which has much longer lead times.

7 Delivering the technological change

7.1 Over the next 50 years the entire existing energy infrastructure is likely to be upgraded at least once. During this time decisions will be made as to which technologies to deploy to deliver the 60% carbon dioxide emission reduction target. The choice of technology will depend on a number of factors including its availability, the cost of generation, public acceptability and the provision of enabling infrastructure. The importance of building an asset of trust with the public cannot be overstated.

7.2 Putting a price on the emission of carbon dioxide provides a good start towards achieving emission targets at minimal cost. But considerations of security of supply will constrain some of the possible choices.

7.3 The adoption of many low- or non-carbon technologies will depend on when they become available. The table below indicates the time-frames that relate to the maturity and availability of technologies. Much of the focus is on the electricity generation which currently provides the greatest potential for CO_2 emission reductions. In order to ensure these technologies are able to contribute there are a number of key issues that will need to be addressed, in addition to the economic instruments, in order to achieve the required shifts of the magnitude and speed that are required are to be achieved.

7.4 Several renewable technologies are currently available that could provide substantial capacity, if given the right incentives. For example, high costs mean that the installed capacity of photovoltaics (PV) in the UK, on current growth rates, is likely to be limited to about 3GW by 2020. If the UK were to respond to incentive schemes such as those in Germany, which has similar sunlight conditions to the UK, then 13.5GW might be installed in the UK by 2020. In Japan plans are being made to install about 100GW by 2030 (Barnham et al 2006). Deployment at this scale means two Japanese companies are leaders in manufacturing and exploiting these technologies, with BP, which no longer manufactures in the UK, third (Barnham et al 2006). Investments in research are capable of delivering much more cost effective and environmentally acceptable PV than is presently available, and thus dramatically increased market penetration. The UK lags well behind its competitors with respect to basic and applied research in these areas, despite the excellent materials science base available in this country.

7.5 Onshore wind is a reasonably mature technology. However, for offshore wind the increase in the size of turbines that are likely to be used to 5MW, requires significant basic research and development to make them more reliable and cost-effective.

Nuclear power

7.6 It is vital to keep the nuclear option open, as we cannot be confident that a combination of other clean technologies will be enough to meet the challenge of reducing carbon dioxide emissions, while providing a secure supply of electricity at an acceptable cost.

7.7 Evidence worldwide suggests that nuclear power stations can be built quickly and at reasonable cost. Indications from industry and from new build in other countries suggest that new power stations could be built without subsidy, although assurances will be required from government on long term policy support, in order to diminish regulatory risk. In order that new nuclear plant may be available within the next 15 years, a formal presumption should be made now, for the purposes of long term planning.

7.8 Planning consent has the potential to delay the deployment of new power stations, and thereby creates uncertainty and therefore increases costs. A process whereby reactor designs are pre-licensed and not considered during the planning stage, as is being adopted in the USA, should be considered to reduce delays. Decisions over suitable reactors should commence as soon as possible.

7.9 The UK will not be able to build new power stations on its own and will therefore have to purchase technology from abroad. Recent global demand for new nuclear power stations and limited shortage of suppliers for major engineering components could prove a limiting factor.

Table. Overview of technology issues overtime, related to the maturity and availability of technologies, and the issues that would need to be considered to enable their introduction. This not intended to be comprehensive and the timescales are only indicative, as they are subject to a range of views over details. Similarly the issues to consider highlight some of the key issues and constraints.

Period	Technology	Issues to consider
2010	Conventional energy efficiency	- Greater investment in existing energy efficiency technologies. Tightening and enforcement of building regulations
	Gas – Combined Cycle Gas Turbine (CCGT)	- Greater use of more efficient technologies in gas fired power stations
	Onshore and offshore wind	- Improved planning consents would accelerate delivery of onshore wind. Delivery of offshore wind subject to technical advances allowing bigger and more reliable turbines
	Combine Heat and Power (CHP)	- Requires greater incentives for the use of waste heat to improve uptake, such as a Heat Obligation on electricity generators
	Up-grading the transmission and supply system	- Including extension to accommodate renewables especially in the north of Britain plus more connections with other countries
	Conventional biofuels	- Biofuels in transport will require incentives to make economically viable
	Improvements in vehicle efficiency (including hybrid technologies)	- Greater incentives required to move towards lower emission vehicles both on the manufacturers and consumers (such as Vehicle Excise Duty).
2015	Clean coal and carbon capture & storage	- Carbon capture and storage will depend on proving technical viability with large scale demonstration plants
	Intelligent transmission and demand management technologies	- Widespread use of demand side management technologies and smart metering
	Wave and tidal power	- Major demonstration projects required to prove technology, particularly for wave
	Micro-generation (solar, wind, micro Combined Heat and Power (CHP) etc)	- Requires use of new distribution technologies; solar-photovoltaics and micro-CHP will require major cost reductions and incentives to be competitive. Micro-CHP may not deliver substantial emission savings.
	Advanced biofuels	- Advanced biofuels will offer greater and more cost effective reductions in greenhouse gas emission
	Hydro, including micro-hydro	
	More adaptable grid technologies	
2020	Nuclear power station new build	- First power plant expected to go on line. Could be earlier if approval and planning consents are not delayed
	Fuel cells	- Widespread deployment both for fixed and mobile uses, subject to lowering of costs

	Hydrogen	- Requires lowering the cost of hydrogen generation from renewable resources and the cost of fuel cells, solid state hydrogen storage, public acceptance, codes and standards
2030+	Largely unforeseen but possibly including nuclear fusion technologies	- Requires demonstration device (due to be built in France) followed by a prototype power plant. Fusion is pursued with very small research investment.

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