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The Royal Society's response to House of Commons, Environmental Audit Committee inquiry *Keeping the lights on: nuclear, renewables and climate change*

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This document is the Royal Society response to the House of Commons Environmental Audit Committee inquiry into nuclear, renewables and climate change.

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 25,000MW of wind generation capacity across the GB electricity supply was found to displace only some 5,000MW 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 40p/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 4p/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 1 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 (p45, 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.

References

DTI (1997). *Richard Page turns up the heat for renewable energy*. Press release P/97/116, 6 February 1997

DTI (2005). Press release 28 February 2005 – New international research agreement

Grubb M J (1988). *On capacity credits and wind-load correlations in Britain.* Paper presented to the 10th BWEA Energy Conference, London.

House of Commons Science and Technology Committee Report (2001). *Wave and Tidal Energy.* Seventh Report, Session 2000-2001, HC 291.

House of Lords Science and Technology Committee (2004). *Renewable Energy: Practicalities.* Fourth Report of Session 2003-04. HL 126-I.

House of Lords Science and Technology Committee (2003). *Oral evidence*
10 December 2003

IAG (Inter-departmental Analyst Group) (2002). *Long term reductions in greenhouse gas emissions in the UK.*DTI London

ILEX Energy Consulting (2002). *Quantifying the System Costs of Additional Renewables in 2020.* Report to the DTI.

IPCC (2001). *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK

IPCC (2005). *Special Report on Carbon dioxide Capture and Storage - Summary for Policymakers.* IPCC Geneva, Switzerland. http://www.ipcc.ch/activity/ccsspm.pdf

Royal Academy of Engineering (2004). *The cost of generating electricity.* ISBN 1-903496-11-X

Royal Society & the Royal Academy of Engineering (1999). *Nuclear Energy – The future climate.* Document 10/99 http://www.royalsoc.ac.uk/displaypagedoc.asp?id=11420

Royal Society (2000) *The role of the Renewables Directive in meeting Kyoto targets.* Document11/00 http://www.royalsoc.ac.uk/displaypagedoc.asp?id=11506

Royal Society (2002). *Economic instruments for the reduction of carbon dioxide emissions.* Document 26/02 http://www.royalsoc.ac.uk/displaypagedoc.asp?id=11309

Scottish Executive (2005) *The renewables obligation (Scotland) review 2005/6*. ISBN 0 7559 1219 5 http://www.scotland.gov.uk/Publications/2005/09/13105127/51293

Toft A J & Bridgewater A V (1997). *How fast pyrolysis competes in electricity generation market.* In Biomass gasification and pyrolysis; state of the art and future prospects, pp504 –515. CPL Press

Comments on this response should be sent to:
Mr Richard Heap, The Royal Society, 6-9 Carlton House Terrace, London SW1Y 5AG, United Kingdom
Email: richard.heap@royalsoc.ac.uk Tel: +44 (0)20 7451 2588 Fax: +44 (0)20 7451 2692