

Keeping the Lights on: Nuclear, Renewables, and Climate Change

An Institute of Physics response to a
House of Commons Environmental Audit
Committee Inquiry

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20 September 2005

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Mike Hennessy
Clerk to the Committee
Environmental Audit Committee
Room 118/119
7 Millbank
House of Commons
London SW1P 3JA

Institute *of* **Physics**

Dear Mr Hennessy

Keeping the Lights on: Nuclear, Renewables, and Climate Change

The Institute of Physics is a leading international professional body and learned society, with 35,000 members, which promotes the advancement and dissemination of a knowledge of and education in the science of physics, pure and applied.

The Institute welcomes the opportunity to respond to the Environmental Audit Committee's Inquiry, Keeping the Lights on: Nuclear, Renewables, and Climate Change. The attached annex highlights some key issues of concern to the Institute that have been linked to the general questions cited in the call for evidence.

If you need any further information on the points raised, please do not hesitate to contact the Institute.

Yours sincerely

Dr Robert Kirby-Harris CPhys FInstP
Chief Executive

Keeping the Lights on: Nuclear, Renewables, and Climate Change

1. Introduction

Within an approximate five- to ten-year time frame there are likely to be significant reductions in both coal-fired and nuclear fission capacity. As a consequence, despite reductions in energy demand resulting from increased energy efficiency and an increase in renewables capacity, there will be a shortfall in generating capacity. This will also be impacted by the intermittent nature of the primary, near-term, renewable energy sources.

Over this timescale, the shortfall can only be addressed by the construction of additional capacity from existing technologies. Such capacity must, however, be consistent with the commitment for reduction in greenhouse gases emissions. Policy and regulatory regimes must also ensure that both sustainability and diversity of supply are assured and that the UK does not become overly dependent on imported oil or natural gas.

2. Climate change

The objective of meeting climate change targets is fundamental, as the issue of stopping the growth (and preferably the reduction) of atmospheric carbon dioxide levels and other greenhouse gases is one of great importance. Realistically, emissions need to be reduced by about 60% to stop growth; however, that target at present appears to be unattainable.

The continuous use of fossil fuels will eventually result in carbon dioxide levels exceeding the recommended upper limit of 550 ppm which, as highlighted in the Royal Commission on Environmental Pollution's (RCEP) report, *Energy – The Changing Climate*, will probably lead to dangerous and destructive climate change.

The Institute has noted the Government's commitment to meet challenging environmental targets, such as a reduction in the emission of greenhouse gases of 12.5% by 2008-12 and of carbon dioxide by 20% by 2010. It is of concern to note that the RCEP report stated that the UK is poorly prepared to meet these long-term targets. Our concern is exacerbated by the fact that carbon dioxide emissions have risen during each of the past two years, and are now higher than at any time since 1997.

The Institute is of the view that, although a reduction in current levels of greenhouse gas emissions is achievable, this could be more than countered with large increases in emissions from developing countries like India and China, undergoing rapid industrialisation. Thus, the UK along with the rest of the EU, needs to continue to push for international progress in reducing emissions.

3. Natural gas

Natural gas is expected to fuel the production of over two-thirds of the UK's electricity by 2020. Such a dependence on what will increasingly be an imported resource is a major concern. The Institute published a report last year, *Gas supplies to the UK – a review of the future*, which clearly highlights the risks associated with a dependence on importing natural gas, to meet the UK's need for energy.

The report stated that from 2006 the UK was forecast to become a net importer of gas. However, it is of concern to note that the UK actually became a net importer in 2004. This has implications for the UK's security of supply, in terms of:

- potential threats to supply arising from political instability in gas-producing nations;
- price disruptions arising from risks associated with the supply and demand of gas;
- concerns relating to the transit of gas and the facilities through which it is delivered.

The report also stated that a greater demand across the EU for natural gas is forecast, with increased competition for the same gas resources as nations attempt to meet their own carbon and pollutant-reducing targets. Even though carbon dioxide emissions from gas-fired generating plants are significantly less than from previously dominant coal-fired plants, gas-fired electricity generation alone will struggle to help meet the UK's future climate change targets. Additionally, there are concerns over gas leakage during transit along long pipelines, which is of concern as natural gas (i.e. methane) is an even more potent greenhouse gas than carbon dioxide.

4. Nuclear fission

a) What nuclear offers

Nuclear fission has a major role to play in lowering carbon dioxide emissions, as it can meet base-load electricity demands and is practically a zero carbon dioxide emitter. Given that most EU nations are poorly prepared to meet their respective Kyoto Protocol emissions targets, the Institute believes that new nuclear power plants need to be commissioned to replace current plants as they reach the end of their lives. If new nuclear power plants are not constructed, then by 2020 there will be a power void which will most probably have to be filled by fossil fuel electricity generation resulting in more, not less, carbon dioxide emissions.

The Institute has in recent years welcomed both the UK Government's and the Scottish Executive's various initiatives to tackle carbon dioxide emissions such as the renewables obligation and the climate change levy. However, the Institute feels that the nuclear industry has been severely disadvantaged by not being exempted from the climate change levy, since nuclear power does not contribute to carbon dioxide emissions.

The Institute wholeheartedly agrees with the views of the UK Government's Chief Scientific Advisor, Professor Sir David King, that in order for the UK to meet its international targets to reduce carbon dioxide emissions, it must inevitably revive its nuclear power plant building programme.

Unless there is new nuclear build, the reliance on fossil fuel energy generation will be unabated. The decommissioning of nuclear plants in Scotland, for instance, will result

in the loss of approximately 55% of its current electricity generating capacity by around 2023. New nuclear plants are required in order to maintain and improve not just the UK's, but the EU's current diversity, security and environmental balance of electricity supply.

On the critical path of ensuring an extant option for nuclear power is the technical assessment or 'licensing' required by the regulatory authorities. This is a three-year process which does not pressure implementation but would ensure an option to move forward while nuclear is kept open.

b) Novel reactor designs

While the popular perception in Europe and North America is that nuclear power is an industry in decline, the reality worldwide is the reverse. Over recent years there has been a wave of new nuclear plant construction in the Far East, most notably in China. In addition, Finland and France are constructing new nuclear plant.

The Institute's technical report, *The future of fission power - evolution or revolution?*, published in April 2004, highlights the technical advances that are being made in reactor designs worldwide. New modular reactors are being developed, which have lower capital costs, are more efficient, safer to operate, produce significantly less radioactive waste and generate electricity at a lower cost unit than the current fleet of reactors.

The report reviews both evolutionary and revolutionary reactor designs. Evolutionary designs capitalise on existing technology and introduce system simplifications that improve safety while, at the same time, reducing costs. For example, the AP1000 design, a pressurised light water reactor from Westinghouse, already licensed in the US, and the European Pressurised Water Reactor, which is the design adopted by both Finland and France, are both ready to seek licensing in the UK. A key feature of the evolutionary designs, following 9/11, is that they meet ever more demanding safety and security requirements. A study sponsored by the Electric Power Research Institute, in the US, determined that current reactor structures are robust and protect the fuel from impacts by large commercial aircraft.

Revolutionary designs reviewed in the report include the development of High Temperature Gas Reactors and Pebble Bed Modular Reactors, which represent the first of a class of 'revolutionary' systems. These revolutionary designs will be inherently even safer and more efficient than the evolutionary class. The Pebble Bed Modular Reactor (PBMR) is being developed in South Africa by an international consortium. Key benefits of PBMR include the fuel's ability to withstand very high temperatures, and the fact that the concept is of a simple modular construction with consequential low capital cost of units, which may be produced in substantial numbers ensuring economy of scale. These systems also have the potential for duality of mission, i.e. electricity and hydrogen production, desalination, symbiotic process heat for energy intensive chemical processes.

The report concluded that both types are needed. The evolutionary designs are needed to plug the gap left by the retirement of current nuclear and fossil fuel plants, and to avoid the sizable increase in carbon dioxide emissions in the near future. Revolutionary designs could then follow, delivering safe, long-term competitive and sustainable energy.

One of the key problems of ensuring fission's future in the UK could be the lack of a skilled work force. The nuclear industry, at present, plays a key role in the UK

economy, employing 40,000 directly and supporting many additional jobs – new build would offer opportunities to maintain and grow the work force, while keeping alive the knowledge and expertise that has been built up. New build would also benefit the UK in terms of GDP. The benefit in GDP terms of a programme to replace the current nuclear fleet has been assessed in a recent independent study¹ at around £4 billion per year once the stations are all operational.

The Institute's report also makes reference to work that is jointly being carried out cooperatively by a number of countries on the US Department of Energy's Generation IV programme. This activity is aimed at developing advanced reactor systems and fuel cycles for deployment circa 2030. International collaborative work has selected candidate systems to be developed that further improve the economics, safety, environmental impact and security in order to meet the stringent challenges of sustainable development energy generation in the 21st century.

c) Legacy waste and new build

In considering the issues relating to managing radioactive waste, it is fundamental to separate those dealing with pre-existing radioactive waste from issues involved in the construction of new nuclear plants. Even if a decision were made not to construct new nuclear plants, the need to manage nuclear waste produced as a consequence of past and current electricity generation and plant decommissioning will remain. The new nuclear plants, highlighted in the previous paragraphs, will generate significantly lower amounts of waste. A fleet of ten new reactors would be enough to maintain the UK's share of nuclear electricity at around 25% and such a fleet, operated for their full design lifetime of 60 years, would add less than 10% to the volume of waste which already exists. The new waste would also be easier to deal with than much of the legacy waste. The UK should not use the challenge of dealing with some of the more difficult legacy wastes as a basis to delay the decision for a new nuclear build programme.

5. Nuclear fusion

Nuclear fusion has long been hailed as the ultimate energy source, mimicking on Earth the processes which take place deep inside the Sun and other stars, where light elements are fused to form heavier ones, releasing huge amounts of energy. Harnessing this energy on Earth would provide a virtually inexhaustible energy source with no greenhouse gas emissions.

The Institute is of the view that nuclear fusion potentially has an important role to play in low carbon energy generation in the long-term future. Despite the fact that commercial electricity generation from nuclear fusion is not likely before 2040, its benefits as an energy source for the long-term future are significant.

Fusion research is finally coming of age. Results from large machines like the Joint European Torus (JET), the world's largest magnetically confined fusion facility, mean that physicists have a deep understanding of the processes that will make fusion a reliable system for large-scale base-load electricity generation. The UK Government and their international partner Governments commitment to the International Thermonuclear Experimental Reactor (ITER), which it was recently announced is to be built in Cadarache, France, will hopefully lead to a demonstration of fusion energy production on a 20-30 year timescale.

¹ Macroeconomic Analysis of Nuclear Plant Replacement, Oxford Economic Forecasting; March 2005

6. Renewables

a) The challenge for renewables

The Institute wholeheartedly supports RD&D into new renewable energy technologies which potentially, may eventually reduce the UK's dependence on fossil fuel electricity generation. Renewables are an essential part of the future energy mix, but there is a need for increased research and innovation in the relevant RD&D sectors, in order for the UK to be in a position to respond to the challenges of the medium to long-term future.

The Institute notes that the 2003 Energy White Paper, *Our energy future – creating a low carbon economy*, aspires by 2020 to double the UK's renewables' share of electricity from the 2010 target of 10%. The equivalent targets for Scotland are 18% by 2010 and 40% by 2020. These targets represent a significant challenge given that, in the UK, only 3.6% of electricity was generated from renewable energy in 2004, coupled with the fact that renewables presently suffer from various barriers to exploitation, which in themselves demand greater RD&D.

b) Barriers to the deployment of renewables

Realising the large potential benefits that renewables and other advanced technologies, such as fuel cells, could make to a low carbon economy requires a number of technical, economic, institutional and social constraints to be overcome. Overcoming the technical and economic barriers requires substantial RD&D to improve performance and reliability, bring down costs, and resolve issues of grid integration. These measures need to go hand-in-hand with policy support to remove institutional and social barriers.

-Maturity

The maturity of renewables varies considerably. While a number are commercially proven, others are still at a pre-commercial stage, and some still require quite fundamental R&D.

-Cost

In the UK, at current gas prices and under current market structures, mature technologies are not yet competitive with existing gas fired Combined Cycle Gas Turbine plant without subsidy, although in the medium term (2020) some technologies (e.g. on- and off-shore wind) could be. Technologies such as solar photovoltaics are unlikely to be cost-competitive with centralised generation unless a step change in cost-effectiveness is achieved by the new types of photovoltaic cells currently under development. They may, however, become competitive in remote off-grid locations, where the cost of other stand-alone systems, such as diesel generators, is high. It is also worth noting that as Governments seek to reduce carbon dioxide emissions, the emissions will acquire an economic 'cost'. For example, the EU Emissions Trading Scheme which is now operational will determine a monetary value per tonne of carbon dioxide for the trade of carbon dioxide emissions. If this additional cost of emitting carbon dioxide from fossil fuel based power sources is taken into account in the future, then the competitiveness of renewables will improve.

-Intermittency

Many of the technologies, for example, wind power, are intermittent and thus require energy storage or backup generating capacity to be available on the electricity network.

-Distributed nature

Current renewable energy plants are generally small in scale – from a few kilowatts for individual PV installations to tens of megawatts for biomass plant – compared to conventional power stations (typically a gigawatt or so). The small scale nature of renewables has advantages for use in some situations, for example, for stand-alone applications, but in a country like the UK where the transmission grid is designed for distribution of power from a small number of large power stations, the incorporation of small, distributed sources raises some technical issues. The bulk of renewable energy resources may also occur in locations which are remote from regions with large energy consumptions (e.g. remote parts of Scotland), and where grid infrastructure to transport the power is limited or non-existent.

-Social and institutional constraints

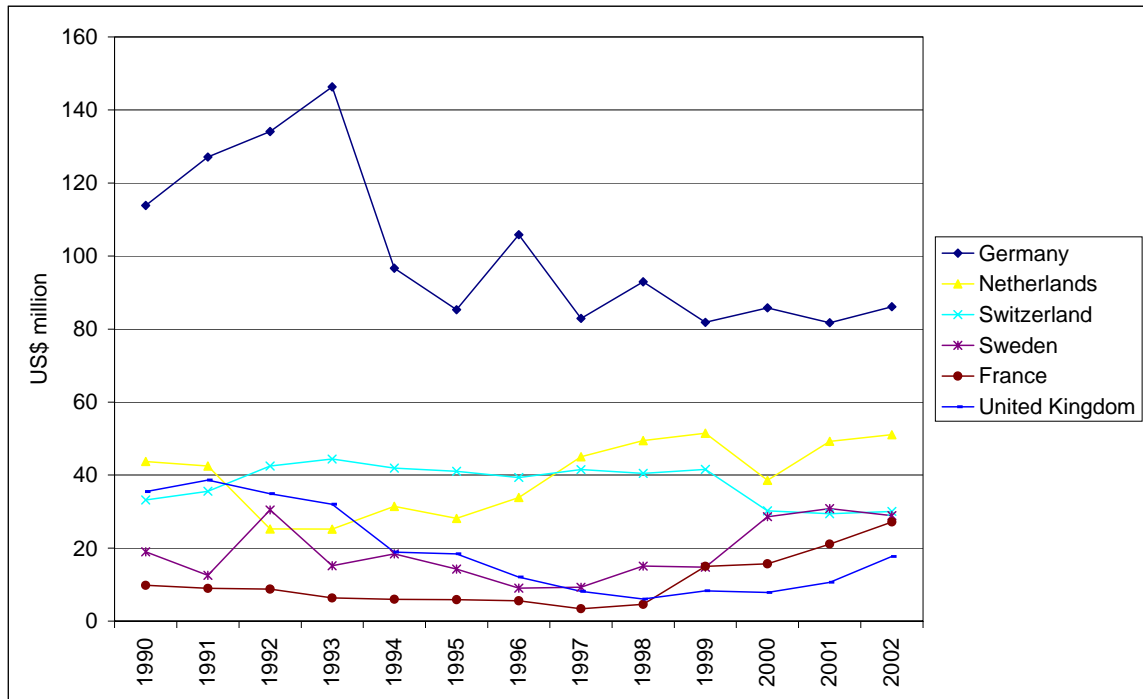
Issues which may hamper development include: public acceptability, planning constraints and institutional barriers, for example, lack of clarity over planning consents, permitting of plants, skills issues, and investment regimes. While most renewables are environmentally benign, in that emissions of carbon dioxide and other air pollutants associated with them are typically very low (even after allowing for their manufacture), they do have a number of other local environmental impacts. . For example, wind turbines may be visually intrusive, particularly if they are located in areas which are highly prized for their beauty or isolation. This can cause considerable local opposition, and care is needed to ensure that technologies are located sensitively, and that techniques to mitigate impacts are used where possible.

-Funding for RD&D

A significant problem facing renewables and other low carbon generating technologies is that, following the liberalisation of the UK energy market, the current price of electricity is so low that it is not economically viable to develop and introduce new generating technologies to the market, unless they can be developed at a low cost and can provide electricity predictably at competitive wholesale prices. The solution to date has been to subsidise RD&D; renewables have benefited from Government support for RD&D and, in the absence of any other solution, this will need to continue.

Renewable energy RD&D in the UK is funded through a number of routes; the main ones supported by the Government and the public sector, together with EU funding. In addition, there is industry funded RD&D, and commercial deployment of renewables in the UK is supported by the Renewables Obligation. The House of Lords Science and Technology Committee suggested in their report, *The practicalities of developing renewable energy*, that the level of funding for RD&D is not sufficient if the UK is to meet its renewable energy targets. While UK expenditure has increased in recent years, it is still lower than in several other European countries (see figure 1); US expenditure on renewables RD&D is about \$250 million per annum.

Figure 1
Annual RD&D Budget for Renewable Energy (Million US \$)
 [Source: International Energy Agency]



A recent DTI/Carbon Trust review² found that there appears to be a funding gap in moving renewables to the pre-commercial stage, and from the pre-commercial to the supported commercial stage. They also considered that the current landscape for renewables funding is complex, which suggests that a clearer overall strategy for UK RD&D in both renewables and other new energy technologies, together with a clearer map of RD&D funding and clearer demarcation of roles of different funding bodies could be useful. This could be a potential activity for the new UK Energy Research Centre. A clearer research ‘atlas’ indicating institutions and developers carrying out relevant RD&D could also encourage graduates and postgraduates to consider working in this field by clearly showing the variety of career opportunities available.

For physicists currently wishing to work in this area, the main source of public UK funding is the EPSRC’s SUPERGEN programme. The EPSRC has been tasked with taking a clear lead in driving forward the sustainable energy agenda and covering the full spectrum of energy research issues, and was given extra funds in the 2004 Spending Review to expand support for research and training necessary to underpin future energy options (including renewables)³.

However, the amount of RD&D spend available through SUPERGEN is far too small to drive the necessary research, let alone the far greater effort needed to transfer this into production. Renewables seem to have developed a ‘low cost’ view of their implementation, which will not drive the actual costs of developing energy sources on the scale needed.

² Renewables Innovation Review, DTI/Carbon Trust, 2004. www.dti.gov.uk/energy/renewables/policy/renewables_innovation_review.shtml

³ EPSRC, 2005. “Delivery Plan 2005/06-2007/08”, www.epsrc.ac.uk

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