

RCUK REVIEW OF ENERGY

PUBLIC CALL FOR THE SUBMISSION OF EVIDENCE

Please complete and return this form to **EnergyReview@rcuk.ac.uk** by **12th February 2010¹**. You must limit your submission to no more than 8 pages in length and no smaller than font size 11. You should address your comments to the issues flagged in the **evidence framework**. The headline questions only appear in this form.

All responses will be published on the website as part of the publication of evidence received by the Panel unless you state that there is confidential content for the Panel only.

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Statement of interest (please indicate your reasons for making this submission – 200 words max.):

The submission from the Institute of Physics (1) was prepared with input from its Energy Sub-group (2), Energy Group (3), and Nuclear Physics Group (4); note that some of the points we have made on nuclear power are applicable to other areas of the energy sector.

1. The Institute of Physics is a scientific charity devoted to increasing the practice, understanding and application of physics. It has a worldwide membership of over 36,000 and is a leading communicator of physics-related science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.
2. The Energy Sub-group reports formally to Council's Science Board and is responsible for the development of the Institute's energy policies.
3. The Energy Group, of the Institute of Physics, covers a wide range of energy-generating technologies and issues. It has membership and representation in academic research, engineering consultancy and major power generation.
4. The Nuclear Physics Group, of the Institute of Physics, covers all areas of nuclear science from fundamental research through applications to contacts with industry. It is involved in the organisation of a number of activities.

A. To what extent is the UK Energy community addressing key technological/ societal challenges through engaging in new research opportunities?

UK physicists are making significant R&D contributions to a range of energy generating technologies.

Nuclear fission: University nuclear physics groups around the UK are actively collaborating with colleagues in other disciplines – engineers, materials scientists,

¹ Unfortunately, no late submissions can be accepted.

particle and accelerator physicists, plasma and laser physicists, and computer experts, as well as those in the energy industry – in preparing for a future supported by a nuclear power option that is safe, economic and reliable. The Dalton Nuclear Institute at the University of Manchester, for example, brings together expertise in nuclear structure and reactions, and also reactor and waste-disposal technologies.

In addition to helping to develop more efficient reactors using uranium (and plutonium) as fuel, UK teams are also exploring reactor schemes based on thorium. One ingenious approach, developed at CERN, is to control the fission at a sub-critical level using a beam of neutrons generated in an accelerator complex. A new type of inexpensive, compact machine, the fixed-field alternating gradient accelerator, being developed by a UK consortium of universities, could provide the driving system. The fuel would not need enriching, as limited waste is produced and a lower potential for proliferation exists. Researchers at the University of Manchester are adapting the idea to create a novel design in which thorium-loaded fuel rods irradiated with a neutron beam could be introduced into existing nuclear power stations.

Fusion: 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 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) based at the UK's Culham Science Centre, 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 complex plasma characteristics and energy transport are being studied at Culham with the collaboration of many universities both in the UK and overseas. This is in preparation for the global test experiment, ITER, being constructed in southern France. Also of great interest is the testing, at Culham, of a compact, spherical tokamak design, MAST.

Another approach to fusion is to heat and compress simultaneously a pinhead-sized pellet containing the fuel, via the shock induced by a very high power laser pulse (inertially confined fusion, ICF). Teams from UK universities and RAL are using the Vulcan Petawatt laser (based at RAL) to explore ICF, in preparation for the proposed European High Power Laser Energy Research Facility (HiPER), which will investigate laser-driven fusion as a future energy source. HiPER may be located in the UK. Another version of ICF being studied employs a laser to release a beam of protons or heavy ions from a target, which then trigger fusion.

Renewable energy: Physicists are engaged in a range of renewable energy technologies, especially in R&D. In wind power, the research drivers include improvement in aerodynamic airfoils, greater understanding of wind meteorology for prediction and for wake analysis within wind farms, improved instrumentation and measurement (e.g. LIDAR and SONAR), and understanding the marine environment for offshore wind. The training and working experience of physicists gives them expertise in mathematical and computational modelling, measurement and instrumentation, heat transfer, environmental physics, solar energy, marine physics, aerodynamics, meteorology and materials properties; these subjects are central to energy R&D. Physics and physicists move readily into the interdisciplinary studies and applications that are so necessary in renewable energy. The UK is particularly well placed for a synergy of experience from wind energy and off shore oil rigs technology.

Photovoltaics (as a direct example of the application of physics) is an important area where physicists are contributing to R&D, carrying out much of the fundamental research required to develop novel types of cell that may result in step changes in the cost of photovoltaic generation. There is a strong research effort in the UK but to benefit fully from this vitally important technology, investment in the underpinning science needs to improve considerably.

Most physicists in photovoltaic R&D are now working on 'second-generation' solar cells, which are near market, with the aim of reducing costs by using thin films of crystalline silicon and other semiconductors such as amorphous silicon, gallium arsenide, copper indium diselenide and cadmium telluride, which are mounted on glass substrates. For the future, physicists are also working on 'third-generation' solar cells, such as dye-sensitised photochemical, and quantum/nanotechnology solar cells, which could potentially yield extremely high efficiencies and be as cheap as thin-film devices.

Energy efficiency: The quantitative, analytical and heat transfer training of physicists means that they move naturally into this area as a practical, quantitative and numerate task. In practice, monitoring and the resulting analysis relies on the principles and working practices of physics. Related to this is energy efficiency and some microgeneration at buildings; two key areas of the UK net-zero carbon strategy.

Carbon accounting: Carbon certificate trading is now an accepted aspect of the economy. The basic assessment of carbon flows relates to energy transformation and so is a natural field for those trained in physics.

In addition, the following issues are examples of where greater effort is needed in the UK.

Ground source heating: This technology involves shallow interaction with the ground extracting heat in the winter and 'depositing' heat back in the summer to provide building cooling as well as maintaining an intra-seasonal thermal balance in the ground. Successful utilisation of this technology involves full system engineering from the ground structure, heat exchangers, heat-pumps and building load above ground. The Netherlands is pioneering this work and the UK seems to be somewhat behind.

Peak oil: As a societal challenge, a shortfall of global oil supply to meet global oil demand will have significant implications both globally and in the UK. The UK situation is exacerbated by its recent change from net exporter to net importer of all fossil fuels. The subject of future oil supply appears to be highly political, so the UK first needs its own rigorous assessment of the situation. UKERC published a report in November 2009 and there is some research at the University of Reading, but otherwise there is virtually no other effort. If the conclusion of such an assessment is a shortfall of global supply within 10 years, this would then necessitate a major focus of effort to mitigate oil use at a rate much quicker than current low-carbon programmes.

B. To what extent is the Energy Programme bringing together disciplines to form a coherent Energy research community?

Concerning nuclear power, EPSRC has supported relevant research through the 'Keeping the Nuclear Option Open' programme. However, this programme is too limited. While nuclear research groups in universities have made some attempt in recent years to engage with the nuclear power industry through small-scale research projects and the delivery of MSc programmes in nuclear technology, there has been

little attempt to encourage or support academic researchers by the research councils. There are surely opportunities for stimulating more speculative research that is nonetheless focused on industrial issues.

With regards to renewables, UK research centres are not strong in comparison with those in Germany, the US, Australia and probably, now, China. This is partly because of weaker UK renewables industries and because research funding has not followed EU and UK government targets for rapid expansion of renewable energy in the economy.

On energy policy in general, the main research tool for testing economic feasibility is the MARKAL model. For such a critical aspect of energy policy, this approach appears to be putting all our eggs in one basket. Recently the Energy Research Partnership (ERP) investigated scenarios of new energy technologies in 2050. When questioned whether it was incorporating demand side, it stated that DECC had asked that only technology be considered since demand was being handled by others. However, there is a systemic interaction between energy technology, supply of energy, its demand, and its efficient use at all levels. This demands a multi-dimensional approach which is currently lacking.

C. What is the level of knowledge exchange between the research base and industry/policy makers that is of benefit to both sides?

Nuclear research is important to industry for three reasons:

- the quality of the UK's reputation for research sets the scene for our position on the world stage for nuclear advice and services;
- there are some direct opportunities for research to lead into opportunities for industry (e.g. fusion research leading into opportunities for the design and construction of ITER); and
- practitioners with research experience become the employees of the future for the UK nuclear industry.

The level of exchange is currently limited. An example of good practice is the role that UKAEA played on making opportunities on ITER known to UK industry. But this has been relatively *ad hoc*.

The Nuclear Development Forum, set up by DECC to advise its Office of Nuclear Development (OND) in building and maintaining the UK as the best market in the world for companies to invest in nuclear power, has been beneficial in encouraging the exchange of information between industry and government. Something along similar lines, again perhaps facilitated by government, could be advantageous for bringing the academic and industry communities together. Alternatively, the remit of the Nuclear Development Forum could be extended to cover research.

With regards to renewable energy, there are usually close personal links between researchers and industry because of mutual involvement in the renewable energy associations, conferences, exhibitions, etc.

D. To what extent is the UK Energy research activity focussed to benefit the UK economy and global competitiveness?

As described in response to question C, the quality of the UK's reputation for nuclear research is an important backdrop that enables UK companies to market and sell UK-led nuclear services internationally. At present, we have a good reputation, although this is undermined to an extent by decisions such as the funding cut to nuclear

physics research recently announced by STFC.

Greater co-operation between academia and industry could encourage more focus on areas that could have commercial benefits downstream. This would not only allow a greater involvement of UK companies in major opportunities, but also more researchers with skills and experience relevant to industry.

Beyond these points about competitiveness on nuclear-related services, security of energy supply is a pivotal component of a thriving economy. As nuclear power is now being considered as part of the solution to being able to generate low-carbon energy, it is important to ensure that the UK is sufficiently well placed to use existing expertise, as well as attract new talent.

E. To what extent is the UK able to attract talented young scientists and engineers into Energy research? Is there evidence that they are being nurtured and supported at every stage of their career?

Attracting talented young scientists begins with providing exciting degree programmes. Physics departments have struggled in the last couple of decades in the quest to increase student numbers. The downward trend in numbers is only now beginning to be reversed, in part due to the increased realisation that a degree in physics is a doorway to better employment prospects. It is now a matter of record that fundamental research in physics (e.g. astronomy, particle physics and nuclear physics) is one of the main inspirations for the new generation of students. The prospect of a revitalised nuclear power industry has provided an additional stimulus for recruitment into physics-based degree programmes at both undergraduate and postgraduate level. However, the continued difficulties in funding fundamental research, particularly by STFC, risks harming the recruitment effort as potential students question whether UK science is sufficiently well supported.

F. To what extent are UK researchers engaged in "best with best" science-driven international interactions?

Many research collaborations are international. European cooperation has been vital for RD&D in renewable energy, with major benefits to the UK from membership of the EU. In the case of UK nuclear physics research, all experimental work must be carried out abroad, as there is no national nuclear physics research facility in the UK.

G. What is the impact on a global scale of the UK Energy research community both in terms of research quality and the profile of researchers?

In renewable energy, the UK lack of manufacturing means that UK researchers have limited experience of application and so are handicapped in opportunities for applied research.

H. What evidence is there to support the existence of a creative and adventurous research base and portfolio?

For nations with significant fractions of electricity delivered by nuclear power stations, there is a significant correlation with healthy sized academic nuclear physics communities. The UK is a glaring exception to this. The size of the research community (less than 70 academics) is about 20 times lower than that of competitor nations. The UK nuclear physics community has been shown to be internationally leading in international reviews of physics and the last RAE, yet in absolute numbers it remains critically small. This has been severely hampered by the recent STFC cuts, which meted out a disproportionate 29% cut in nuclear physics research funding. During the process of deciding which areas should be cut, and by how much, STFC completely ignored the findings of a recent EPSRC/STFC review of Nuclear Physics

and Nuclear Engineering, which cautioned that any further cuts to this research community were likely to be terminal.

On a more general issue, there is a danger that the current emphasis on 'low-carbon' is constraining research agendas. Taking peak oil, as an example, a typical comment is that low-carbon and peak oil mitigation involve similar measures so the former strategy is sufficient. First, this view misunderstands the likely timeframe for peak oil which is much quicker than low carbon targets. Second, that peak oil is most specific to transportation whilst low carbon allows a pick-and-choose between all fossil fuels.

Any other comments

On a global scale, the UK has great potential for a wide range of renewable energy technologies (wind, solar, biofuels, building design, wave and tidal especially). It is of great importance that the research community is funded to work in these areas, not just for use in the UK but to support exporting industries. The use of renewable energy is growing rapidly and is of mainstream importance, yet there are too few researchers trained and active in these areas.

In addition, the UK was one of the first nations to develop nuclear power. It now risks losing a critical mass of research expertise that will allow it to support the development of new nuclear power opportunities if research councils continue to squeeze nuclear physics research funding. This does not seem like a sensible strategy, particularly at a time when nuclear power is seen as a vital component of low-carbon energy production.