ROYAL SOCIETY OF CHEMISTRY

INPUT TO THE AD HOC NUCLEAR RESEARCH AND DEVELOPMENT ADVISORY BOARD

The Royal Society of Chemistry (RSC) was pleased to hear of the instigation of the Ad Hoc Nuclear Research and Development Advisory Board (the Board) following the findings of the House of Lords Science and Technology Committee Inquiry 'Nuclear Research and Development Capabilities'.[1,2]

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 47,000 members worldwide and an internationally acclaimed publishing business, its activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public. This document represents the views of the RSC. The RSC has a duty under its Royal Charter "to serve the public interest" by acting in an independent advisory capacity, and it is in this spirit that this submission is made.

To provide input to the Board the RSC has performed a wide consultation with the chemical science community, including members of both our Radiochemistry and Energy Sector Interest Groups and also our Environment Sustainability and Energy Division.

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The Role of Chemistry in a Civil Nuclear Strategy

1 Introduction

Chemistry and chemical knowledge is essential in nuclear power generation and nuclear waste management. It is essential that a UK civil nuclear strategy recognises the crucial role that chemistry plays, both in research and innovation and in the development of a strong skills pipeline.

As the RSC previously articulated in our response to the House of Lords Inquiry, [3] nuclear power is an important component of our current energy mix. In 2010 it provided 16% of the UK's electricity needs and currently provides an effective reduction of UK carbon emissions of between 7% and 14%[4]. The Climate Change Act 2008[5] provides legally binding greenhouse gas emissions reduction targets (compared with 1990 levels) of 80% by 2050, and 34% by 2020; it will be extremely difficult to fulfil these obligations without the use of nuclear power. At present, however, our capacity to generate nuclear power is dwindling, with only 9 reactors currently in operation, 6 of which are due to be closed within the next 10 years.

In 2011 the Smith School of Enterprise and the Environment published a thorough analysis of 4 possible scenarios with regard to the future of nuclear power in the UK – from an open cycle of storage and disposal, to a closed fuel cycle with reprocessing of UK and foreign waste.[6] Chemistry is a central component of the toolkit, regardless of the specific route taken.

Sustainable maintenance, expansion, or even termination of the UK's capacity for nuclear power generation will require research and development (R&D). The building of new capacity, the safe decommissioning of old capacity, and the management of waste will all require a wide range of skills, including those that have a firm base in chemistry.

2 Examples of chemical applications in nuclear

Chemistry underpins the whole nuclear fuel cycle, contributing to fuel manufacture, spent fuel management (reprocessing and storage), waste treatment and clean up; chemistry also provides understanding for the mitigation of the effect of radiation on materials, the separation of isotopes, and the development of highly sensitive nuclear forensic techniques.

2.1 Materials for Nuclear Energy

Nuclear energy provides unique challenges in the field of materials. The effects of irradiation are broad, but there is also a consideration of the reaction of materials with high temperature water or steam.[7] Chemistry can provide unique insights into the reactions occurring, and advance the understanding of the physico-chemical effects of radiation on material fatigue and corrosion,[8] assisting in the design and development of new materials.

2.2 Nuclear forensics and environmental monitoring

Nuclear forensics is a highly critical field in which chemical analytical techniques are essential. There is a need to build UK skills, and to develop ever more sensitive methods and processes to make forensic analysis of samples taken from site inspections and intercepted materials. This is important from a security perspective,[9] but could also prove invaluable in the case of major nuclear incidents. For instance, if there had been a rapid method of aerial radiological surveying at Fukushima it might have been possible to not only direct emergency crews along routes which avoided significant radiological exposure, but also to determine the spread of different radioisotopes. This would have allowed a more accurate measurement of the risks posed by the nuclear incident and could have highlighted the most significant pathways for radionuclide escape into the environment - thereby informing clean-up strategy and highlighting safe evacuation routes for members of the public.

Our consultation also highlighted the importance of quality assurance in power stations and the field; in particular a need for certified standards and proficiency testing was noted.[10]

2.3 Waste management

Regardless of the future commitment of the UK to nuclear power there remains a significant amount of legacy waste which must be considered.

If long term geological disposal of nuclear waste is decided upon, then there will be a need for chemical, engineering, geochemical, and geological expertise in order to safely plan for the future of waste solids and liquids. Indeed, because of the number of possible interactions and the timescales involved, a holistic approach is required here, including understanding microbial biochemical interactions.

In our consultation we noted a distinct push against the concept of 'disposal' of nuclear waste, aligning in part with the Government's 'preferred policy' of reprocessing plutonium into mixed-oxide (MOX) fuel.[11] If the world continues to use nuclear power – and there are certainly suggestions that it will[12,13] – then the natural abundance of uranium will sustain us only for a limited time. The technology exists to utilise our waste stockpile of plutonium. This would enable the UK to be self-sufficient in fuel for nuclear power,[14] leading to an improvement in the security of energy supply for the country, and alleviating some of the issues with dealing with plutonium waste.

2.4 Future Developments

If the government decides to not only preserve, but expand the UK's nuclear programme then there will be benefit in expending R&D effort upon the development of Generation IV reactors and associated fuel cycles. This would, in turn, drastically widen the possible avenues for R&D. Significant research would be required into new technology, such as advanced fuel cycles, but there would also be an opportunity to consider the development of advanced aqueous and molten salt systems that maximise the utilisation of resources and reduce waste burdens on the repository, or alternatively, the utilisation of thorium. As other areas of the world move towards expanding nuclear power and introducing advanced fuel cycles (for example, the interest of India and China in fast reactors and thorium fuel cycles), a strength in relevant skills and technology could prove of significant economic benefit to the UK.

One suggestion put forward during our consultation was that a renewed UK nuclear R&D community would benefit significantly from long term support for a research reactor. The CONSORT reactor in Ascot is now being closed due to the financial burden upon Imperial College, London.[15] If the UK is to undergo a true nuclear R&D renaissance then a modern research reactor like that at ANSTO[16] would be of wide benefit. This would then be used to support training, provide a valuable source of neutrons for secondary applications, and would have the potential to produce isotopes for both medical and R&D purposes.

There also remains the continued promise of nuclear fusion reactor systems. As this technology matures there will be a need for chemical skills, including fuel processing with isotopic separation, refinement of gases, as well as decommissioning and disposal of irradiated plant components.

3 Supportive Framework

3.1 Skills

According to the Cogent report 'Power People – the civil nuclear workforce 2009-2025'[17] the civil nuclear industry employed 44,000 people in 2010, with 24,000 employed across the sectors of energy generation, decommissioning, and fuel processing. This highly skilled workforce is older than the UK workforce as a whole, and retires earlier. Many of the nationally and internationally regarded experts in the key areas are close to retirement,[18] with nearly 70% of the most highly skilled contingent set to retire by 2025.

It is therefore essential that the strong skills base that the UK has in the nuclear sector should not be allowed to disappear. Regardless of the nuclear energy options chosen, there will be a continued need for nuclear skills in the UK. With interest growing in nuclear power in several areas of the world, this expertise has the potential to be of significant economic benefit to the UK.

The largest barrier to maintaining the UK's skills in nuclear R&D is an education and training deficit. In particular, our community-wide consultation highlighted low levels of provision for radiochemistry, and nuclear/radiation chemistry, especially at undergraduate level. There are few universities currently engaging in research in these areas and that, in turn, impacts upon teaching provision.

One initiative that has worked very well in the United States is the Department of Energy funded Nuclear Chemistry summer schools. These are designed for undergraduate students and held in San Jose State University and Brookhaven National Laboratory.[19] Twenty four 'fellowships' are awarded annually for these intensive 6-week programmes, including a stipend, room, board, and necessary supplies. These schools were set up to boost the number of students with an interest in nuclear chemistry and radiochemistry, and provide 'considerable' assistance to help attendees find placements in future summer research projects and PhD programmes. Summer placements at Sellafield and the National Nuclear Laboratory (NNL) provide some aspect of this in the UK, but a Department for Energy and Climate Change sponsored programme would offer a broader, more publicly visible prestigious route into nuclear research.

At postgraduate level there is some provision, including recent initiatives at the Nuclear FiRST Doctoral Training Centre, through the Nuclear Technology Education Consortium (NTEC) or in the Empower scheme[20], and graduate schemes at places like NNL and Sellafield. However, those entering often lack education and skills that a thorough undergraduate basis in radiochemistry and radiation chemistry would provide.

A strengthening of our national nuclear skills pipeline would be of further benefit, both to the nuclear defence sector and to topics like nuclear medicine, where knowledge of radiochemistry and radiation chemistry is essential.

3.2 Funding and Coordination

The nuclear R&D landscape includes industry and academia. There is a wide range of stakeholders; from funders like Research Councils UK (RCUK) and the Technology Strategy Board (TSB), to governmental bodies like the Committee for Radioactive Waste Management and the Nuclear Decommissioning Authority, and scientists and engineers working in fields as diverse as chemistry, physics, materials science and biology. It is therefore not unexpected that the overall strategy for nuclear research is somewhat scattered. The formation of this advisory board is a significant development, but there will need to be on-going coordination beyond 2012.

The ad-hoc Nuclear Advisory Board on Research and Development has an opportunity to propose the future form of a body for centrally coordinating these various stakeholders and providing on-going identification of gaps in research. We propose that the Board engage in dialogue with RCUK and the TSB to identify the appropriate working relationship and to address coherent oversight of research council funding, and the translation of academic research into new or improved industrial plants or processes. The outcomes of the board's review are likely also to link with aspects of the current work of the Research Councils UK Energy Programme Strategy Fellowship team in developing a roadmap of energy research, skills and training needs.

3.3 Public Engagement

One of the key challenges in building a civil nuclear strategy will be to work on engaging and educating the public. Public and scientific opinion about nuclear energy remains divided, though currently opinion is significantly more favourable than unfavourable.[21] An important strand of the nuclear R&D roadmap should be to engage the public in openly exploring the need, benefit and risks involved in nuclear energy. There is a clear correlation between knowledge and support,[22] and those involved in both research and implementation of nuclear research would be powerful spokespeople.

4 Conclusion

The development of a coherent UK civil nuclear strategy will be of great benefit contributing to the environmental health, sustainable energy security and economic prosperity of the nation.

The importance of chemistry in all areas of the nuclear cycle cannot be underestimated; it is essential that the UK maintains capacity in research and development in a wide range of fields including radiochemistry, radiation chemistry, materials chemistry and analytical chemistry.

A secure nuclear skills pipeline must be developed to meet short and long-term UK requirements and to support the implementation of a coherent civil nuclear strategy.

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