Maintaining nuclear skills

Dr Mark R Levy, KNOO Research Manager at Imperial College London, advocates nuclear power as a future low carbon energy…

The UK Government recently published its energy review. Two key challenges were identified, those of security of energy supply and climate change. The report further stressed that the UK should 'power our economy and way of life in a cleaner, greener and more efficient way'. It went on to state that one of the ways we can achieve such goals was via the renaissance of nuclear power generation.

Nuclear power has always been an emotive subject, now more than ever with the prospect of new-build high on the Government's agenda. Timely decisions on energy policy are critical for our economic future and must be based on a calm appraisal of the technologies available. If the building of new nuclear reactors is to be successful, there are a number of hurdles that must first be cleared. One of the most significant of these is the acute shortage of people with the skills to pursue a career in the nuclear industry.

A four year research initiative called 'Keeping the Nuclear Option Open' (KNOO) is aimed at addressing the challenges of increased safety, reliability and sustainability of nuclear power generation. It will also begin to remedy the shortage of people with the relevant science and engineering backgrounds necessary to lead technology development in a regenerated nuclear energy sector.

The KNOO consortium was awarded £6.1m by the Research Councils' UK programme 'Towards a Sustainable Energy Economy', and represents the single largest commitment to nuclear fission research for more than thirty years. KNOO is an interdisciplinary research programme incorporating seven universities within the UK: Imperial College London, The University of Manchester, The University of Leeds, Cardiff University, The University of Sheffield, The Open University and The University of Bristol.

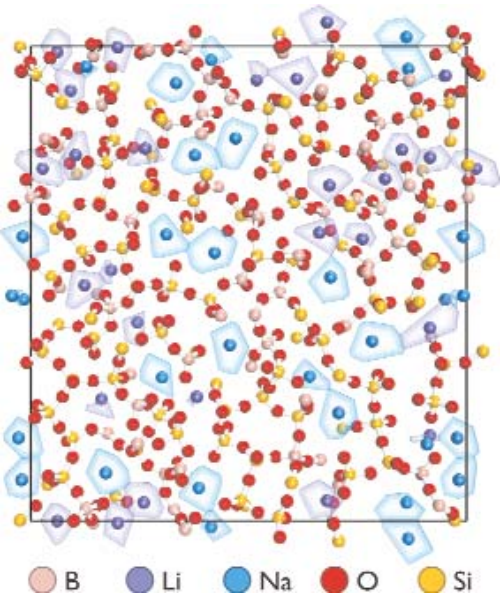
The consortium has two principle objectives: firstly, to carry out internationally leading research, and secondly, to use this research (and associated teaching) to develop the knowledge and skills of post doctoral researchers and PhD students, such that they may choose a career within the nuclear industry. Both objectives are fundamental to the stated objective of the UK Government of keeping the nuclear option open.

Short-term issues are concerned with existing reactors, whilst maintaining a keen eye on future systems. Researchers investigating such studies will help fill the immediate skills gap as identified in the UK Government White paper of February 2003 'Our Energy Future – Creating a Low Energy Economy'. Projects with a longer-term focus will contribute to the development of the tools and understanding necessary for new whole system design – including those for advanced reactors (called Generation IV).

The programme brings together researchers with considerable prior industrial and academic experience, each with extensive links to national and international collaborations. The research focus is necessarily wide-ranging, reflecting the requirement to maintain and develop a sustainable nuclear generation industry. The timescales being investigated are important for dealing with the full range of Britain's nuclear portfolio. Legacy issues concerning previous waste types are given equal attention, as are the monitoring and operation of current reactor systems, and design implications of future generations of reactor technologies.

Although nuclear power is a low carbon technology, it does generate carbon emissions associated with the initial plant construction, fuel mining and processing and final decommissioning (with very little emission from the electricity generation itself).

However, new reactor designs aim to target these issues. Proposed reactors use far less material in the initial construction, in terms of concrete, steel and cabling. The fuel will be taken to higher burn-ups, meaning that more energy is extracted from the fuel, leading to reductions in mining, reprocessing and waste. Nuclear plant operators are also looking to diversify. Where previously they were confined to producing electricity, there are proposals for the future use of excess heat from the reactor as process heat for other industries such as the generation of hydrogen for transport applications.



Schematic cut-through of Magnox waste glass

Courtesy of Michael Rushton

One area of expertise identified as lacking in the UK research community is that of fault studies and associated reactor modelling. KNOO will investigate the safety and operational issues arising from the deployment of advanced pressurised water reactor (PWR) systems whilst simultaneously extending studies to the behaviour of next generation systems. With reactor efficiency becoming increasingly important, a robust understanding of fuel performance will become ever more crucial. Increasing the fuel burn-up is desirable in new advanced reactor systems for both economic and operation reasons, whilst minimising the subsequent wastes.

The operation of existing nuclear plants, the development of potential new facilities and the management of the nuclear waste legacy require an in-depth understanding and predictive capability of the phenomena limiting the lifetime of the plant. These require consideration of structural, fuel and waste materials exposed to hostile environments. It is therefore vital to improve the characterisation of the key factors (including defects, residual stress and irradiation damage) that influence the long-term materials performance.

Guided ultrasonic waves will be used to monitor safely the in-reactor materials properties and defects. Measurement of the local stress variations, physical/mechanical properties and residual weld stresses in nuclear components are key in providing an improved understanding of the materials degradation which limit the lifetime of the reactor. KNOO will undertake fundamental research to establish new methods for condition monitoring and for predicting materials performance that will enhance the design and operation of nuclear facilities in the future.

A major factor affecting the public perception of nuclear power is the issue of nuclear waste. A multidisciplinary team will develop fundamental knowledge, refine key aspects of waste handling procedures, and improve confidence in the long-term containment of radionuclides. Using specific systems, representative of both likely future wastes and existing legacy wastes, multi-scale modelling is being combined with experimental studies of engineering properties and waste reactivity to develop a fundamental understanding of the underlying physical processes within the wasteform.

The demonstration of a robust and durable wasteform capable of retaining contaminants for long timescales (centuries to millennia) may enhance public confidence and limit objection to nuclear power. The adaptability of wasteforms to accommodate greater waste concentrations (and hence reduced final volumes and disposal costs) will be evaluated with respect to the Nirex (who are tasked to research, develop and operate radioactive waste disposal facilities on behalf of the nuclear power industry) Phased Geological Disposal Concept, part of the Nirex safety assessments. The research is sufficiently generic to allow the knowledge to be used directly on both near-term legacy waste issues as well as longer-term future waste issues.

Studies into the next generation of reactor technology – Generation IV reactor systems – are pooling expertise from across KNOO. Much of this work will focus on computer simulation of reactor components and will consider fault studies, linking materials behaviour and heat transfer processes into safety considerations as well as fuel performance and design. Due to the nature of advanced reactor systems research, specifically interaction through the Generation IV International Forum, KNOO is working closely with both UK industry and international bodies.

In summary, through a combined, interdisciplinary programme of groundbreaking research and training, the KNOO programme aims to maintain the feasibility of keeping the nuclear option open for the UK. This will allow for the safe construction and operation of the UK's current and future generation of nuclear reactors and associated activities. The advance of nuclear technology will facilitate the much needed low carbon economy of the future and aid the UK with its emission targets in a safe and sustainable manner.

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