Nuclear Engineering

House of Commons Committee on Innovation, Universities, Science and Skills

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0.0 The following response was prepared in consultation with Fellows of The Royal Academy of Engineering with expertise in the area of Nuclear Engineering. The response argues that there is good evidence that nuclear power is economically viable and thus there is a pressing need to build up the UK skills base in nuclear engineering in order to support the running of a new generation of nuclear power plants.

0.1 Underpinning all of the comments below is the observation that the current crisis of skills in the area of nuclear engineering, and the uncertainty regarding the UK's capacity to forge ahead with a new generation of nuclear new-build, could have been avoided if a nuclear strategy had been put in place 10 years ago. The need is now pressing for a strategic Government policy on nuclear engineering.

1) The UK's engineering capacity to build a new generation of nuclear power stations and carry out planned decommissioning of existing nuclear power stations;

1.1 The UK could by no means be self-sufficient in the building of a new generation of nuclear power stations in the timescales required. The bulk of detailed design for the systems being considered for the UK has already taken place in France and North America. Many major components will be sourced from the existing global supply chain. The issues for the UK are the tensions between global demand and supply; the UK's position in the queue; and the extent to which UK industry is mobilized to participate in this marketplace.

1.2 There have been extensive studies carried out on the UK's ability to build new designs of station. The Nuclear Industry Association (NIA) led such a study in 2005[1]. The NIA took an optimistic view of the fraction of the capability that could be sourced from the UK, suggesting that UK industry could satisfy about a half of this requirement without further investment but that this could increase if confidence existed in a continuing need. Two principal reasons underlie this optimism. One is that the initial stages of new build will take several years, providing the UK industry with time to respond. The second lies in the fraction of the resource that is truly nuclear specific. Much of the hardware and engineering associated with a nuclear power plant is not nuclear engineering per se. The so called 'nuclear island' only represents a certain percentage of the overall plant. The balance of plant, including the turbine island, will comprise heavy engineering assets in use across the power sector internationally.

1.3 Nevertheless this 'balance-of-plant' still requires specialised engineering. Nuclear plants have to be designed not only to deliver high levels of reliability, but also to meet stringent external hazard safety requirements such a seismic loading that other normal structures do not have to meet. Hence, it is still far from 'run of the mill' engineering. But this means that it could, with sufficient investor confidence, present significant opportunities for reinvestment in the UK's manufacturing base as part of the supply chain supporting the international reactor vendors. Confidence that the UK will actually embark on a major nuclear programme could provide the opportunity to reinvigorate the UK's engineering industry, eg by entering into partnerships with Japanese, Korean, French or US companies to build high quality steel making, precision forgings and nuclear pressure component factories to supply the UK and other international markets. The pressure on fossil fuels is likely to see a significant world demand for nuclear reactors over the next 30 years. With some imagination the UK could become a major supplier to this market.

[1] http://www.niauk.org/images/stories/pdfs/MAIN_REPORT_12_march.pdf)

1.4 Planned decommissioning represents a quite different situation and requires a different skill set from new build. The UK already has significant experience in decomissioning redundant nuclear facilities, particularly those used in the early atomic energy development by the UK Atomic Energy Authority (UKAEA) and British Nuclear Fuels (BNFL). In addition decomissioning of the early Magnox graphite reactors has been successfully undertaken by British Nuclear Group (previously BNFL) and there is considerable capability and knowledge in this area.

1.5 There is nothing technically difficult in the decommissioning of the UK's graphite reactors. It does not require nuclear engineering because once the reactors have been defuelled there is no fissile material and hence no nuclear or criticality threats. The expertise required to decommission involves instead knowledge of radiation protection and industrial dismantling and demolition. The time period over which decommissioning of existing operating and past power stations will be carried out depends on a number of factors, including the disposal of waste, for which the UK has still to determine a site and repository timescale. There is no fixed or mandated timescale. Accelerating the process increases the radiation hazard and, as a result, increases the costs of the activities. Extending the timescale allows natural radioactive decay to reduce the hazard and allows time for detailed careful planning of the activities. Hence, there is no urgency requiring the diversion of nuclear engineering expertise to the task of decommissioning.

1.6 Arguably of more concern than the capacity for decommissioning is the adequacy of the staffing of the Nuclear Installations Inspectorate (NII) to provide the generic safety assessment of each of the competing designs required by Government. While conducting this urgent task, the NII will also be continuing its regulation of operating nuclear power stations and of decommissioning and waste storage activities throughout the industry. The NII cannot recruit enough inspectors to carry out their statuary duties never mind license new reactor designs. More attention is needed by Government to ensure an adequately resourced nuclear regulator to inspire public confidence.

2) The value in training a new generation of nuclear engineers versus bringing expertise in from elsewhere;

2.1 It would be wholly unrealistic to consider the possibility of sustaining a new nuclear power programme in the UK without UK expertise and engineers. Whilst the design of a new build will be procured from overseas vendors, its deployment will be local, requiring UK engineers to complete detailed design and site specific works, regulate, build, commission, operate, maintain and support a fleet of new nuclear power plants over their projected 60 year lifetimes.

2.2 The Royal Academy of Engineering and companies within the sector remain concerned about the projected availability of UK engineers generally – particularly in heavy electrical, mechanical, control and instrumentation and power engineering. Therefore, the training of new nuclear engineers is a part of the wider issue of the need to train more engineers in these sectors. Highly skilled engineers, technicians and practitioners who understand what is required to make nuclear reactors work safely and reliably will be required in significant numbers. Not enough is currently being done to address this issue.

2.3 Nuclear engineers generally have a background in mechanical, chemical or structural engineering and undertake work experience and further development on nuclear engineering specifically. In the past, the sector relied upon scientists and

engineers within main-stream engineering courses having some nuclear training as modules within their standard degree courses.[2] The sector also relied heavily upon the then Central Electricity Generating Board and UKAEA providing nuclear-specific training to graduates joining from universities across the UK. At their peak these two organisations employed between them over 8000 engineers and scientists in multiple labs across the UK and provided significant post graduate training. They also sustained a vibrant academic research base in several of the UK's top universities. However, this declined to almost zero by the end of the 1990s. Only BNFL's technical support organisation Nexia remains; and the bulk of their expertise is in the waste management and disposal area rather than reactor systems. The supply chain serving British Energy including BE's own engineers maintains expertise for the current operations but is already finding it difficult to recruit trained personnel given the overall industry decline over the past two decades.

2.4 The result of this decline and the reductions in the Royal Navy nuclear training programmes is a serious lack of nuclear engineering development opportunities across the sector. Competences such as criticality assessors, reactor physics, reactor transient analysis, reactor fault studies, thermal hydraulics, heat transfer, fracture mechanics, irradiation embrittlement of steel, nuclear chemistry, health physics, human factors, risk analysis, control and instrumentation, computer protection and many more are core to both new build and decommissioning and in short supply across the UK.

2.5 BNFL, EPSRC and key university self investment especially at Manchester have begun to reverse the situation but The Royal Academy of Engineering is of the opinion more needs to be done. There is a need for a more coordinated approach to the provision of nuclear reactor design and operating education and training. It is not sufficient to fund MSc courses; new staff at post doctoral level, and a research culture at PhD level, are also required to sustain internationally competitive research groups and a new knowledge base from which research results can "trickle-down" to MSc and undergraduate teaching.

2.6 In the longer term engineers should be making significant inputs to developing the overall strategy for the electrical and related energy sectors. The next generation of nuclear plant for electrical power generation is available. However, there will be a need to address the future both for fission and, in the longer term, fusion. The engineering knowledge base should be retained and developed to allow the UK to have as a minimum an informed customer base and, beyond this, skills to operate, regulate and, indeed, participate in future international collaborations of research and development.

3) The role that engineers will play in shaping the UK's nuclear future and whether nuclear power proves to be economically viable

3.1 Whilst the size of the nuclear component of the UK's electricity generating mix is open for debate, the Government has already indicated nuclear energy has a key role in sustaining security of supply of low carbon electricity at affordable cost. And evidence suggests that nuclear power is economically viable – nuclear power is

[2] Recruitment into nuclear science and engineering degree programme in the US is significantly stronger than in the UK with programmes operating alongside mechanical and/or chemical engineering disciplines or as part of a specialised option within the programme. Such choices are no longer offered in the UK.

comparable in cost with fossil fuel generation and generates electricity at roughly half of the cost of wind turbines.[3]

3.2 There is mounting evidence that declining global oil and gas production, coupled with increasing global demands and the inevitable impact this will have on cost, will mean that the success of the UK economy and our standard of living will become increasingly dependent on secure electricity generation. The requirement for the UK to have secure electricity supplies, at affordable cost, will inevitably mean that the UK will become increasingly reliant on nuclear generated electricity.

3.3 Increased global use of nuclear power means that the pressures to increase uranium utilization will lead to the use of the "Generation IV" nuclear reactors. This will require nuclear fuel recycling. The UK will need to maintain its capability in this area and should be participating fully in international R&D efforts in this area. This will enable UK engineers to inform policy options and to develop a skills base in this area.

3.4 The financial viability of nuclear power, or any other part of the power sector, depends to a great extent on the availability of skilled engineers and technicians to ensure plants are regulated, built and commissioned to time and cost, and run safely, reliably and efficiently. Hence, ensuring that there is an indigenous supply of trained nuclear engineers will help to ensure that nuclear power in the UK is economically viable and matches modern global norms.

4) The overlap between nuclear engineers in the power sector and the military.

4.1 In the early days of the UKAEA there was an element of flow of talented personnel between the civil and military sectors, especially Aldermaston, Harwell and Winrith being geographically close. However, the civil and military programmes have diverged since the 1960s and for a long time they have effectively been different industries.

4.2 Historically, there was some interchange between the Central Electricity Generating Board/British Energy/Magnox employment and the MoD's nuclear propulsion programme. Similarly, Royal Navy engineers and technicians experienced in nuclear submarine plant acquisition, construction, operation and maintenance have been attracted into the civil nuclear power programme particularly in time of expansion of the latter.

4.3 The potential for two way flow is greater within the nuclear propulsion/nuclear power fields. Historically, there was some interchange between the Central Electricity Generating Board/British Energy/Magnox employment and the MoD's nuclear propulsion programme. Similarly Royal Navy engineers and technicians experienced in nuclear submarine plant acquisition, construction, operation and maintenance have been attracted into the civil nuclear power programme particularly in time of expansion of the latter. In this regard, it should be remembered that the nuclear submarine programme continues to represent the largest body of UK experience with with Pressurised Water reactors (PWRs) the type of reactor most likely to be built in the UK.

[3] See pages 8 and 9 of The Royal Academy of Engineering report, 'The Costs of Generating Electricity':
http://www.raeng.org.uk/news/publications/list/reports/Cost_of_Generating_Electricity.pdf

4.4 Today there is untapped synergy between the civil and military missions. As the UK seeks to embark on a post-Trident era, and to maintain its capability in the years running up to this, there is much it could learn from practice in the civil sector in efficient 21st century project management, systems engineering and manufacturing in a contained environment. There are also significant synergies in the area of radioactive waste management and residue processing and recovery.

4.5 The basic engineering requirements in both of these industries are the same and there would be obvious benefits in having a national education and skills programme that supported both industries. There is a need to ensure that the necessary engineering skills for both sectors are available. The further development of university undergraduate and post graduate courses in both core and specialist engineering and science should be encouraged, as it will provide a pool of graduates who are able to choose which part of the industry they wish to develop their careers.

Submitted by:
Mr Philip Greenish CBE
Chief Executive
The Royal Academy of Engineering

Prepared by:
Dr Natasha McCarthy
Policy Advisor
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natasha.mccarthy@raeng.org.uk