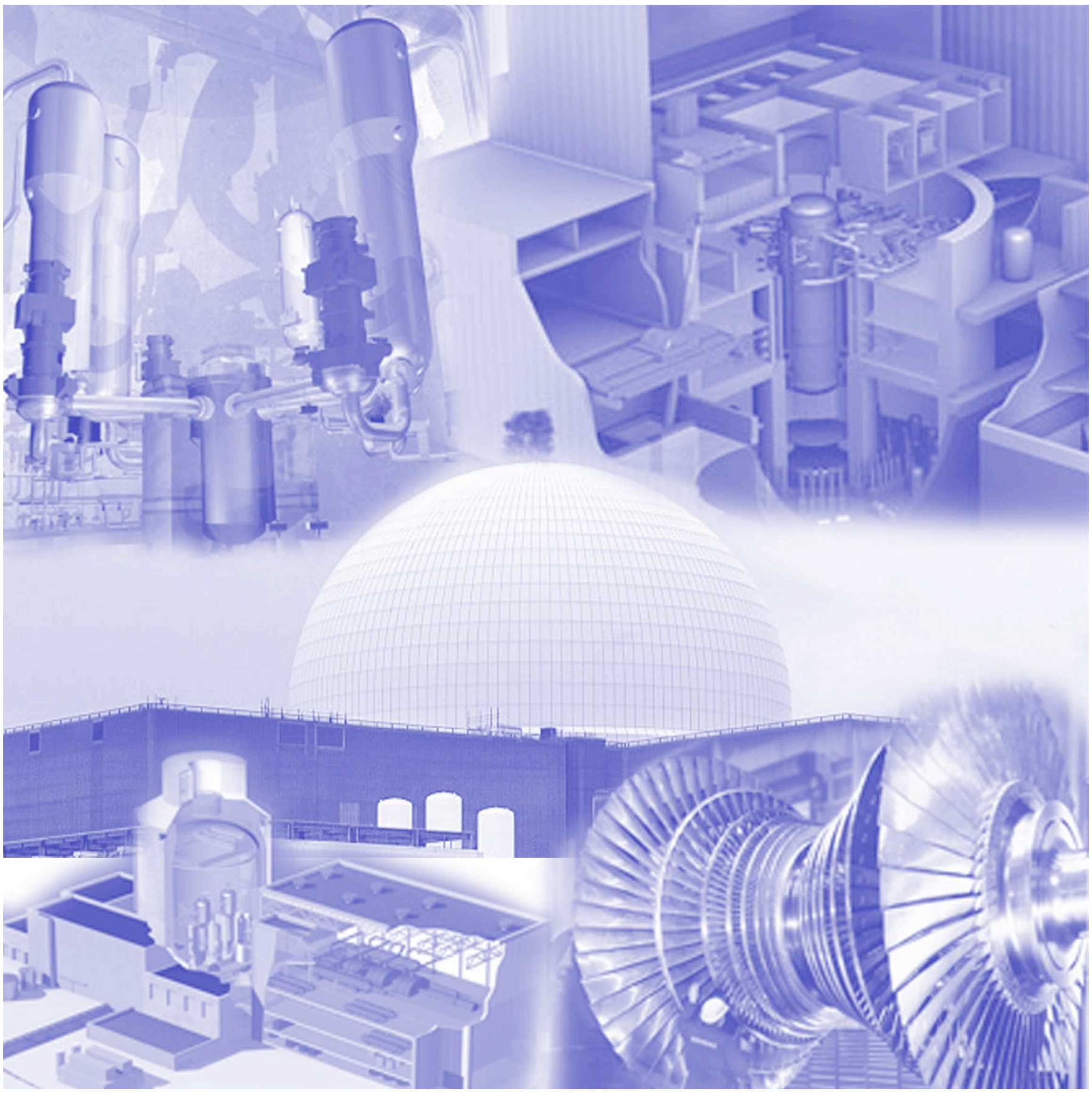
The Supply Chain for a UK Nuclear New Build Programme



A report submitted to the Department for Business Enterprise & Regulatory Reform (BERR) by the National Metals Technology Centre (NAMTEC)

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Executive Summary

Aims

This report gives a brief summary of information available regarding both the capability and capacity of the supply chain(s) relevant to a UK new civil nuclear build programme, including aspects of the planning, construction, operation, maintenance, waste management, and decommissioning of a nuclear power station or nuclear industry.

In addition, the report indicates: (a) where some of the more valuable elements of the supply chain may lie, for both a UK nuclear new build programme and for opportunities for export, and (b) the potential issues within the supply chain, both UK-based and global, which may threaten a UK new build programme.

Thus, the major aims of the work may be summarised as follows:

- To identify the scope (capability & capacity) of the nuclear supply chain;
- To give an initial view of where the UK has expertise and/or the potential to compete for UK nuclear new build and in overseas nuclear builds;
- To give a preliminary, qualitative assessment of some of the most valuable elements of the supply chain (ie, to identify the value chain); and
- To give a brief view of the critical points (gaps or ‘pinch-points’) within the supply chain, both UK based and global, which could threaten a UK new build programme.

The work forms part of a significantly larger, and more detailed ongoing activity aimed at identifying:

- Where the UK has either existing expertise and resources, or potential opportunity, to feed into a nuclear new build programme;
- The value chain in a nuclear new build programme – ie, what is the value of each element of the supply chain, in a rank order of what adds most value;
- Where and how UK-based companies can best obtain market share in a UK nuclear new build programme ?;
- Which aspects of a nuclear new build programme will provide the best UK / community benefit through, for example, the creation of incremental skills and high value, sustainable jobs based within the UK ?;
- What can the UK best export to other new nuclear power programmes, either new build or decommissioning ?;
- What would the UK need to develop or produce, which currently (or in future) cannot be obtained from overseas suppliers without long delays, which could ultimately threaten both the security and affordability of energy supplies ? In this case, the capability may not be value-added, but may be important to UK energy policy; and
- What investment is needed in any UK capability and capacity ?

Approach

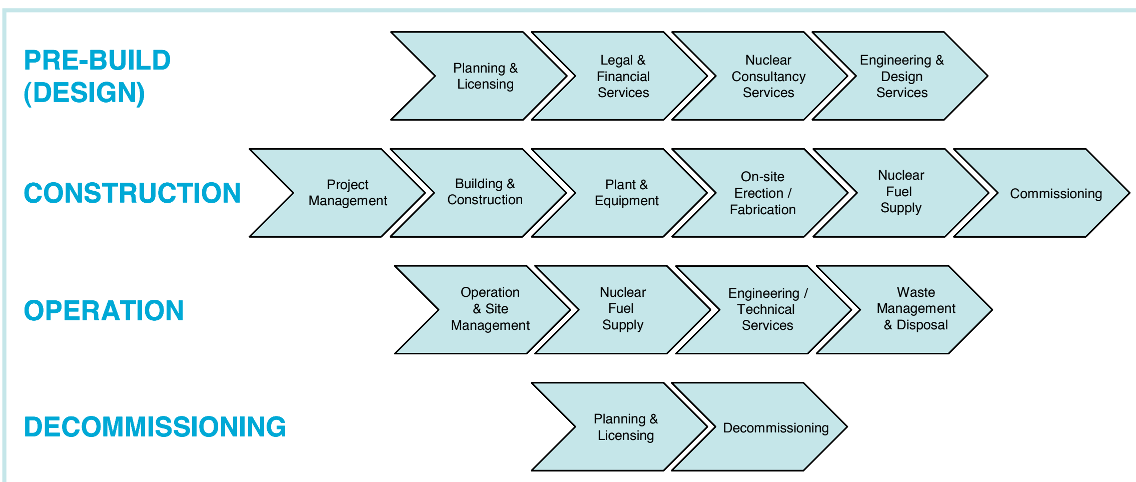
The approach has been to draw upon key published documents to develop the necessary understanding of the supply chain. In addition, NAMTEC has supplemented the largely secondary data gathering and analysis by drawing upon the expertise of a number of key individuals within BERR, the nuclear reactor vendors undergoing the Generic Design Assessment, GDA (AREVA, GE-Hitachi, and Toshiba-Westinghouse), the Nuclear Industry Association (NIA), UK Trade & Investment (UKTI), selected utilities and selected other companies with either aspirations to supply into, or provide services to, a nuclear new build programme or with ongoing nuclear-based activities, both UK-based and global.

It should also be noted that for this report, only limited first-hand discussion has been carried out with potential suppliers, service providers, etc. However, the intention is to seek very broad input to an assessment of ‘readiness’ of the UK’s supply chain to respond to a UK nuclear new build programme, and this work will be carried out by the Office of Nuclear Development (OND) over the coming months.

The following supply chain elements are considered, to a greater or lesser extent:

- Planning & licensing;
- 'Up-front' services – infrastructure, professional services (legal, insurance, finance, etc.);
- Engineering and design services;
- (Nuclear) consultancy services;
- Project management;
- Civil construction ('civils');
- On-site erection/fabrication ('mechanicals');
- Nuclear island plant and equipment (eg, reactor pressure vessel, steam generators, heavy forgings, pressure pipework, pumps, valves, etc.);
- Non-nuclear island plant and equipment (eg, steam turbines, generators, switch gear, transformers, etc.);
- Balance of Plant (BoP);
- Nuclear fuel supply;
- Plant commissioning;
- Plant operation;
- Nuclear waste management and disposal (and/or recycling);
- Plant decommissioning; and
- Skills (or a skilled workforce), which underpins all other supply chain elements

The main elements of the nuclear new build supply chain are shown in the diagram below:



Notes:

i. *There are clearly overlaps between the various supply chain stages: 'Pre-Build', 'Construction', 'Operation', etc., some of which are shown. For example, 'Project Management' is a supply chain element of both the 'Pre-Build' and 'Construction' phases.*

ii. *There are a number of concurrent elements in the supply chain.*

iii. *Each supply chain element could be broken down into sub-elements or activities. For example, 'Plant & Equipment could be divided into Nuclear Steam Supply System (NSSS), Non-Nuclear or Turbine Island Plant and Components, and Balance of Plant (BoP).*

Summary

The following gives a summary of the status of the UK's nuclear industry and its supply chain for a UK nuclear new build programme:

- The UK's manufacturing base is highly enthusiastic regarding the opportunities which a UK nuclear new build programme may offer.

- There will be significant opportunities for UK-based companies to supply into, and provide services to, a UK nuclear new build and global new build programmes, and the supply chain has capability in most of the areas required to support such programmes.

- The extent of UK company involvement in the supply chain will depend on the structure of new build consortia and the choice of reactor design. However, there are likely to be opportunities for UK-based companies to become part of the vendors' global supply chains.

- UK-based companies can provide services which cover all aspects of the 'Pre-Build' (Design) phase of a nuclear new build programme.

- There is a significant number of UK-based companies which could provide Project Management Services for individual projects forming the overall new build programme.

- All elements of the civil construction (ie, Building & Construction of the nuclear and turbine islands, balance of plant and supporting infrastructure) and On-site Fabrication could be undertaken by UK companies.

- There are several UK-based companies with manufacturing facilities and experience capable of supplying a large number of the components (Plant & Equipment) required for a nuclear power plant

- All elements of the Operation and Decommissioning of a Nuclear Power Plant (NPP) can be provided by UK-based companies, although some investment would be needed to supply Nuclear Fuel from within the UK.

- However, there are a number of supply chain issues ('pinch-points'), related to global capacity, as in the case of ultra-large forgings for the manufacture of Nuclear Steam Supply System (NSSS) equipment and turbine generator rotors, and the fabrication of NSSS equipment itself. This relates to both new build projects and to nuclear fleet lifetime extension programmes which require replacement parts.

- In addition, there are significant issues associated with the availability of skilled workers, across the whole supply chain, and there will be strong competition from overseas new build programmes for nuclear skills (eg, in engineering/technical consultancy).

- Perhaps ***the*** major threats currently to supply chain development, and UK-based companies developing both capability and capacity for a nuclear new build programme, are those related to the timeliness of the various Government facilitative actions, in particular the Generic Design Assessment (GDA) process.

- In addition, clear signals (and certainty) are needed by the supply chain before investment in capability and capacity, and skills development, will be made.

- The proposed supply chain development activities of the Office of Nuclear Development and partner organisations such as the Nuclear Industry Association (NIA) are key to engaging with potential supply chain companies, to build on existing areas of strength, and to develop areas where there is the potential for value to be created.

SWOT Analysis for the UK Supply Chain

The Strengths, Weaknesses, Opportunities and Threats of/for the supply chain for a UK nuclear new build programme are given below. Note: the lists are certainly not exhaustive, but highlight some of the major findings from a review of the relevant literature and from discussions with representatives of companies from within the nuclear energy sector, or with aspirations to supply into, or provide service to, the sector.

Strengths

The UK's key strengths in the nuclear new build supply chain include:

- A highly skilled and experienced resource base, active across all aspects of the nuclear energy sector;
- Proven major project management and engineering capability;
- Expertise in operating nuclear assets (for power generation and nuclear processing) and in plant lifetime extension;
- Design, manufacture and installation of advanced equipment;
- World renowned academic institutions, leading-edge research and development; and
- A strong link between the energy sector and The City of London (financial and trading centre), which together with a full range of professional services, make the UK a key location for new energy development.

Weaknesses

Weaknesses in the UK's nuclear new build supply chain include:

- There are few UK-based Engineering, Procurement & Construction (EPC) contractors with recent new nuclear power plant experience;
- There is no UK-based capability for the production of the largest forgings required for the manufacture of Reactor Pressure Vessels (RPVs), steam generators and primary circuit pipework, as well as large steam turbine and turbine generator rotors;
- There is no UK-based civil Nuclear Steam Supply System (NSSS) manufacturing capability;
- There is no UK based supply of major equipment for the non-nuclear (turbine) island;
- The relatively high UK labour costs, noted by the vendors, which would make the labour content of a new build programme greater than for other regions of the world (including W. Europe); and
- There is currently a nuclear engineering skills gap.

Opportunities

Opportunities in UK and overseas markets for the UK's nuclear supply chain could include the following, some of which would require investment:

- Consultancy: technical and commercial feasibility studies and evaluation;
- Detailed understanding and development of the Nuclear Safety case.
- Project management of new plant construction (which can account for up to 15% of overall project value);
- Supply of raw materials (eg, steel, cement, etc.);
- Civil engineering and construction ('civils') (accounting for up to 25% of project value);
- On-site erection / installation ('mechanicals'):
- Reactor plant sub-system module and product definition;
- Supply chain management;
- Specialist equipment supply (instrumentation & control, and electrical);
- Electrical, on-site installation;
- Supply of large forgings for Nuclear Steam Supply Systems (NSSS);
- Supply of other forgings and castings for the nuclear island:
- Specialist component supply (valves, pumps, cables, etc.);

- Manufacture of nuclear island equipment, including steam generators, pressurisers and primary circuit pipework, and its engineering support (with some investment);
- Manufacture of reactor pressure vessel (RPV) internals (with some investment);
- Operational and asset management and plant life extensions;
- Integrated decommissioning project management and site management;
- Decommissioning specialist equipment; and
- Integrated fuel and waste management / services and disposal.

As well as nuclear new build programmes, UK and global, there will be opportunities to supply into Nuclear Power Plant (NPP) lifetime extension programmes involving consultancy services, the supply of major equipment, etc. (replacements, spares, etc.).

It should not be forgotten that UK companies can (and do) contribute significantly to non-nuclear island plant & equipment, most often not as Original Equipment Manufacturers (OEMs), but through component supply to steam turbines and generators, etc.

Threats

The threats (or risks) to development of the supply chain for deployment of a UK nuclear new build programme include the following:

- Perhaps the major threats to supply chain development, and UK-based companies developing both capability and capacity for a nuclear new build programme, are those related to the timeliness of the various Government facilitative actions (set out with indicative timelines in the Nuclear White Paper).
- In particular, the timely completion of the facilitative actions is threatened by a shortage of skilled inspectors and engineers engaged in the GDA process (within the NII), such that delays in the completion of this process and the possible knock-on effects of delays in the planning and licensing processes would affect confidence throughout the supply chain.
- Significant and early activity in other markets which could result in resources and skills required for a UK nuclear new build programme being 'pulled' from the UK-based resource pool.
- The growing skills gap in the nuclear industry not being closed or narrowed within the required timescale (for new build start).

In addition to the above, it should be noted that any delays in the Strategic Siting Assessment and subsequent identification of suitable sites may also affect UK-based supply chain development, as utility companies and vendors may seek alternative markets.

Recommendations

From the work carried out to date, a number of recommendations can be made to develop the UK-based supply chain for UK nuclear new build and global new build programmes, as follows:

- Supply chain development activities should be initiated, which make potential supply chain companies aware of the opportunities of a nuclear new build programme, and help companies develop capability and capacity to relieve supply chain 'pinch-points'.

- Additional supply chain 'mapping' should be carried out, including to lower Tiers of the supply chain, to understand where the UK has expertise and/or the potential to compete for UK nuclear new build and in overseas nuclear builds.

- To provide certainty to the nuclear industry and development of the supply chain, the Government facilitative actions must remain on schedule to ensure that the indicative timelines presented in the Nuclear White Paper are met. Recruitment of the appropriate number of skilled inspectors will be important to ensure that the Generic Design Assessment (GDA) process runs to time.

- Targeted support should be provided to companies seeking nuclear accreditation and qualification. Thus, companies seeking accreditation or, as will be the case in a considerable number of cases, seeking to re-establish lapsed accreditations will need to commit considerable resources, both in terms of time and money, to secure nuclear qualification.

- Companies must have access to education and training programmes, and a supply of high quality graduates, which meet their needs in the development of a skilled workforce across all aspects of the nuclear supply chain, which will include the development of non-nuclear specific skills.

Contents

1.0 Introduction

1.1. Rationale for a Nuclear Supply Chain Study

The growing concern regarding energy security, increasing fossil fuel pricing and rising CO_2 emissions has put nuclear power back on the power generation agenda in a number of countries, and the need for additional nuclear energy capacity has been recognised in the United States and Europe, and in the rapidly growing Asian economies (China and India in particular). However, the implementation of new capacity programmes could be constrained by potential shortages in major equipment components, including specialist pressure vessels (ie, Reactor Pressure Vessels (RPVs) and steam generators), pipework and valves, and main Engineering, Procurement and Construction (EPC) contractor and plant management capacities.

Historically, the UK's nuclear energy programme has led to the construction of a series of unique nuclear reactors, with no useful export capability – the Magnox reactors, Advanced Gas (cooled) Reactors (AGRs) and Sizewell B (a Pressurised Water Reactor (PWR) based on a Westinghouse design). The proposed nuclear new build programme will utilise generic, so-called Generation III or III+ nuclear reactor designs from overseas vendors (see below). However, the expectation is that UK-based companies will still benefit significantly from the planning, construction, operation and maintenance, waste management and decommissioning of any new build nuclear plant.

Whilst the Generic Design Assessment (GDA) is ongoing, it is worthwhile for the Government to understand details of the capability and the capacity of the UK supply chain for a UK nuclear new build programme as a means of quantifying the value-added component (the value chain) of such a programme. Thus, it is important to understand the potential for UK-based content of a new build programme, the potential to export services and products, and the potential to create long-term, highly skilled jobs within the UK-based supply chain.

In this respect, on 12 June 2008, the Secretary of State for BERR announced the creation of the Office of Nuclear Development (OND) and the Nuclear Development Forum (NDF). The OND, whose staff will be drawn from both the civil service and from industry, will bring together the Government teams and resources focused on facilitating new nuclear investment in the UK. The OND model will be based on the Offshore Supplies Office, which was established in 1973 to develop the UK supply chain to exploit the oil and gas findings in the North Sea. The NDF, to be chaired by the Secretary of State for Business, will bring together the key players from across Government into a joint forum, with key delivery partners from across industry. Similar to the successful North Sea oil and gas sector forum PILOT, the Nuclear Development Forum will keep industry informed of activity and developments, enable HMG to listen to sector needs and provide an opportunity for joint assessment of HMG's delivery.

To aid the OND's work in the supply chain area, it is important to know: what services and components/products UK-based companies can provide or supply now; where there are supply chain 'gaps'; and what could be supplied with some investment by UK-based companies in either skills or equipment (capability and capacity), etc.

UK-based companies may also have a role to play in global nuclear deployment, the extent of which will be vendor specific (eg, through the ability to participate in a vendor's global supply chain), but could also be influenced by the willingness of the UK to invest in nuclear skills, services and manufacturing capability.

It is important that issues associated with the supply chain for a new nuclear build programme are understood. Thus, there are existing global supply chain issues, such as the availability and/or lead times of critical components, which could lead to delays in a UK nuclear new build, and/or to cost escalation. In addition, the expectation is that there will be a significant increase in global orders for new nuclear plant, which will stretch the supply chain still further, with significant programmes either expected (USA, Europe, South Africa, Russia and the Middle East) or ongoing (eg, China).

In addition to capability and capacity in nuclear services and products, manufacturing and construction, the availability of skilled employees will also be critical, and a new nuclear build programme will have to compete with the demand for skilled workers in the growth areas of nuclear decommissioning and long-term waste management and disposal, and other major infrastructure and process engineering projects.

1.2. Description of the Nuclear New Build Supply Chain

The rationale for the study has been described above and in this section of the report, the various elements of the supply chain for a nuclear new build programme are given. Thus, the following supply chain elements have been considered, to a greater or lesser extent:

- Planning & licensing;
- 'Up-front' services – infrastructure, professional services (legal, insurance, finance, etc.);
- Engineering and design services;
- (Nuclear) consultancy services
- Project management;
- Civil construction ('civils');
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- Plant decommissioning; and
- Skills (or a skilled workforce), which underpins all other supply chain elements

The main elements of the nuclear new build supply chain are shown in Figure 1 below:

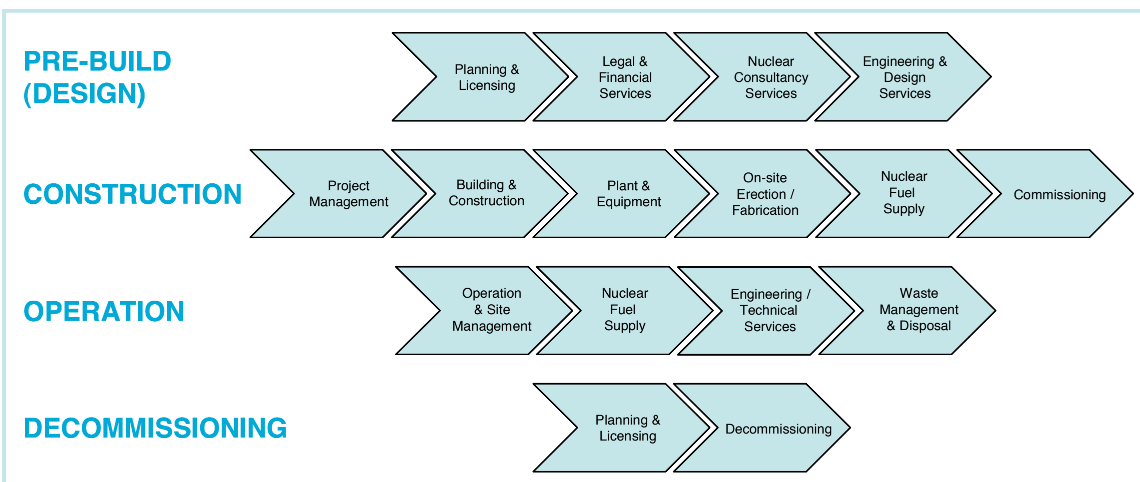

Figure 1 – Elements of the nuclear new build supply chain.

Notes:

iv. *There are clearly overlaps between the various supply chain stages: 'Pre-Build', 'Construction', 'Operation', etc., some of which are shown. For example, 'Project Management' is a supply chain element of both the 'Pre-Build' and 'Construction' phases.*

v. *There are a number of concurrent elements in the supply chain.*

vi. *Each supply chain element could be broken down into sub-elements or activities. For example, 'Plant & Equipment could be divided into Nuclear Steam Supply System (NSSS), Non-Nuclear or Turbine Island Plant and Components, and Balance of Plant (BoP).*

1.3. Overview of the Nuclear Energy Market

Currently, nuclear energy provides approximately 16% of the world's electricity, as base load power, from 439 operational reactors in 30 countries and with a total installed capacity of approximately 372 GWe. In addition, 36 new reactors are under construction, equivalent to approximately 30 GWe net or 8% of existing capacity, whilst 93 are either on order or planned, equivalent to approximately 101 GWe gross or 27% of present capacity [1].

There are a number of useful reference sources which give forecasts for electricity generation from nuclear power and for proposed new nuclear plant builds [eg, 2-8]. It is clear that nuclear power as an energy option is back on the agenda globally (the so-called 'nuclear renaissance'), with new construction programmes likely to commence in USA, China, Russia, India and the UK [7-9], such that of the estimated US$11.6 trillion investment in electricity generation to 2030, approximately US$200 billion will be invested in new (and replacement) global nuclear capacity [9]. However, a more optimistic estimate of the global, civil nuclear market has recently been made by Rolls-Royce, which estimates that by 2023 the global civil nuclear market, currently worth around £30 billion a year, will be worth approximately £50 billion a year, with £20 billion in new build, £13 billion in support to existing nuclear plant, and £17 billion in support for new reactors.

There is considerable variability in the projections of future nuclear generating capacity and new reactor builds. However, based on current International Atomic Energy Agency (IAEA) projections [5,6], there may be a global build rate of approximately 10-20 GWe of new capacity per year (equivalent to perhaps 8-16 new reactors per year) and that up to 50 reactors may be under construction at any given time up to 2030 (ie, double the current build rate).

Various projections of global nuclear generating capacity and power generated are summarised below in Figures 2 [10] and 3 respectively [6]. AREVA has also analysed the various projections of new build and lifetime extension programmes to 2030, and this information in shown in Appendix A).

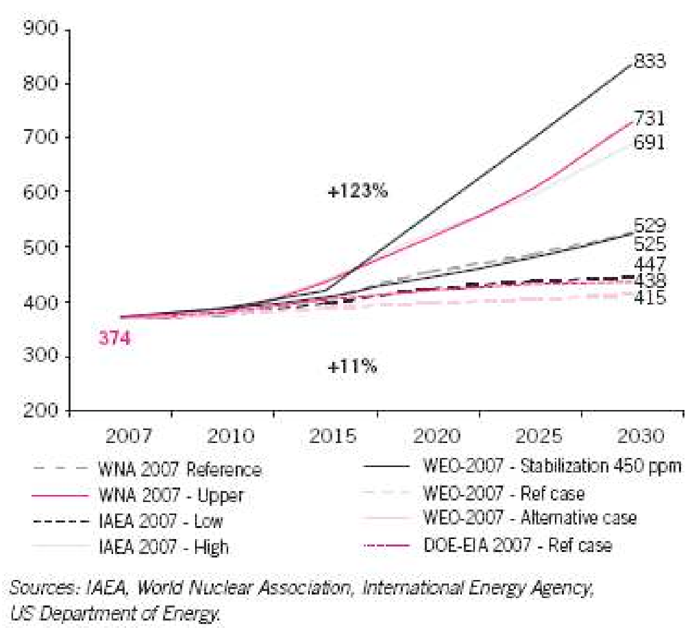

Figure 2 – Outlook for nuclear power generation (net GWe).
(From: 'AREVA Reference Document 2007' [10]).

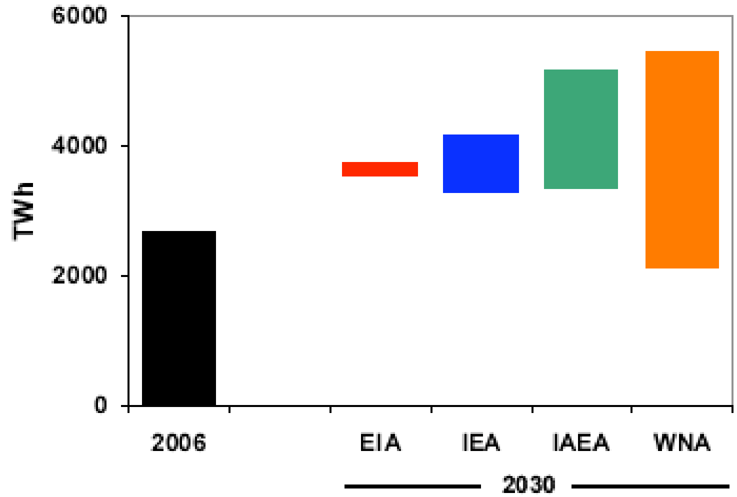

Figure 3 – Comparison of nuclear power projections by the EIA, IEA, IAEA and WNA. [6].

If an average reactor life of 40 years is assumed, approximately three quarters of the current operational reactors, with an average operational age of approximately 30 years, will have to be replaced by 2030 to maintain overall installed generating capacity. Furthermore, even with life extension programmes (to 50 or 60 years), approximately 120 GWe net would have to be replaced by 2030 [10].

Approximately 50 reactors are currently designated for decommissioning globally, although this number could rise substantially with 353 reactors reaching an operating life in excess of 40 years by 2030. Many of these are located in OECD Europe, with 57 GWe of installed capacity designated for decommissioning, including the UK's Magnox reactors and AGRs, which represent closures of an installed capacity of 9.8 GWe [9].

From IAEA projections [6], in the 'low case' (low projected nuclear generating capacity) 145 operational reactors will have been retired by 2030 and 178 new reactors will have been built, with 85% of these retirements in Eastern and Western Europe. In the IAEA 'high case' (high projected nuclear generating capacity), 82 operational reactors will have been retired by 2030 and 357 new reactors will have been built, with most of the retirements in Europe.

In 2007, nuclear plants generated 15.1% (approximately 63 TWh) of UK electricity supplied, compared with 42.5% from gas and 33.9% from coal [11]. This is the lowest level of nuclear generated electricity since 1987 and is down from approximately 18% in 2006. The 2007 figure was affected by a high level of outages for repair and maintenance, as well as the closure at the end of 2006 of the oldest Magnox stations at Dungeness and Sizewell.

There are currently 19 UK reactors totalling approximately 11 GWe of capacity, although the actual operational capacity is lower. In addition, approximately 1% of UK electricity demand was met by imports of nuclear power from France in 2007, and so the overall nuclear contribution to UK electricity consumption was approximately 16%. Thus, nuclear power provides a significant proportion of the UK's 'baseload' electricity generation capacity.

As mentioned above, many of the UK's operational reactors are now reaching the end of their life and are due to be decommissioned. It is estimated that by 2020 the electricity generated via nuclear energy will be reduced to just 7% of the UK total if no new capacity is installed, and based on published lifetimes, all but one plant, the Pressurised Water Reactor (PWR) at Sizewell B, will be retired by 2023 (see Figure 4). However, as also mentioned above, it is possible that the lives of the existing nuclear power stations could be extended and this would help mitigate the decline in nuclear generating capacity. In this respect, in December 2007, British Energy announced that it will extend the lives of the Hunterston B and Hinkley Point reactors until at least 2016.

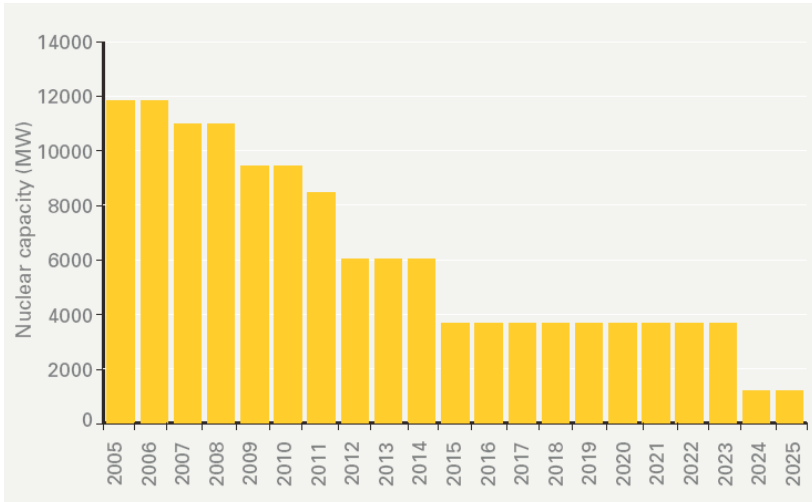

Figure 4 – Expected decline in nuclear generating capacity in the UK (from 'The Role of Nuclear Power in a Low Carbon UK Economy: Consultation Document', Department of Trade & Industry (DTI), May 2007 [13]).

Relatively few power stations have been built in the UK over the past 10-15 years and there is now a need to replace closing coal, oil and nuclear power stations and meet expected growth in electricity demand. Thus, the UK will need substantial new investment in electricity generation capacity over the next 20 years or so. Thus, in addition to the more than 10 GWe of the UK's nuclear power stations which will close by 2023, approximately 13 GWe of the UK's fossil fuel-fired power stations must close no later than 2015 as a result of EU environmental legislation, the 'Large Combustion Plant Directive' (LCPD) [12]. In total, the UK is likely to need around 25 GW of new electricity generation capacity by 2025, equivalent to more than 30% of today's existing capacity, and up to 35 GW of new capacity in the next 25 years.

1.4. Nuclear Energy's Contribution to the UK Economy

Research by Cogent, the Sector Skills Council, suggests that the UK's nuclear industry and its supply chain employs 56,000 people directly, across 200 employers, although this figure includes those employed in the defence sector (eg, constructing, refitting and refueling of nuclear submarines and the Atomic Weapons Establishment (AWE), Aldermaston) [13]. Thus, assuming 7,000 are employed in the defence sector, the civil nuclear sector currently employs approximately 49,000 people, with about half this number located in the Northwest of England [14]. Also, if indirect employment is considered, approximately 80,000 people are employed in the nuclear sector (civil and defence) [15].

The combined civil and defence nuclear sectors earns the UK approximately £700 million a year from overseas business [15] and the civil sector alone currently contributes approximately £3.3 billion to UK GDP [14]. The UK's nuclear industry is a major exporter of technology and skills and UK companies are actively engaged in collaborative projects with overseas bodies. UK companies are also playing an increasingly important role as owner, operator, engineer, consultant, contractor, supplier and investor in the global nuclear energy industry [15].

Of interest as regards the economic benefits of a nuclear new build programme is an assessment by Nuclear Electric, the forerunner of British Energy (created in 1989 following privatisation of the non-nuclear assets of National Power), and the (then) operators of the Sizewell B PWR, of the benefits to the UK of its construction [16]. Sizewell B, which was constructed between 1987 and 1994, is the only PWR to have been built in the UK, and is a 1,183 MWe station, with a Nuclear Steam Supply System (NSSS) based on a Westinghouse design.

Some of the summary findings of the Nuclear Electric report were:

- Over 3,000 UK-based companies participated in the construction of Sizewell B (which are listed by region in an Appendix to the report).
- At a time of sharply declining orders, the project helped UK manufacturers retain both the design capability and the skilled manpower necessary to compete in global markets.
- Investment in capability to supply to Sizewell B provided the opportunity for some UK-based companies to compete in the global nuclear power market.
- More than 90% of the value of the hardware contracts was placed directly or indirectly with UK-based companies.
- Over the seven year construction period, it was estimated that 70,000 man hours of work were expended directly on the project, and at the peak construction period (end of 1991), the on-site workforce stood at 4,385.

1.5. The Future of Nuclear Energy in the UK

As regards the future of nuclear power in the UK, in 2006, a review of the UK's energy policy was undertaken, which put the possibility of new nuclear power stations in the UK back on the national agenda, resulting from energy security concerns and the need to limit carbon emissions. Also, subject to the outcome of further consultation to October 2007, the Government gave a preliminary view that nuclear power could play a significant role in UK's energy future. The review also stated that any new plants would have to be financed and built by energy companies.

Following review and public consultation [17], the Government's position on nuclear power was published in its White Paper on Nuclear Power in January 2008 [18], which stated that "The Government believes it is in the public interest that new nuclear power stations should have a role to play in this country's future energy mix alongside other low-carbon sources; that it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to open up the way to the construction of new nuclear power stations. It will be for energy companies to fund, develop and build new nuclear power stations in the UK, including meeting the full costs of decommissioning and their full share of waste management costs."

In June 2006, the UK's Health & Safety Executive (HSE), which licenses nuclear reactors through its Nuclear Installations Inspectorate (NII), suggested a two-stage licensing process, similar to that in the USA. Since then, the following have applied to the NII for generic design assessment (GDA, or pre-licensing) to be carried out by experts belonging to the nuclear regulators:

- Westinghouse Electric Company LLC (majority owned by Toshiba, Japan, with 20% ownership by The Shaw Group Inc., USA) for its 1,150 MWe, AP1000™ Pressurised Water Reactor (PWR) design, based on its 2005 US design certification and supported by E.ON UK plc, Electrabel-Suez, Endesa, Iberdrola, RWE and Vattenfall.
- AREVA NP (66% owned by AREVA, France and 34% owned by Siemens, Germany), in conjunction with EDF (France), applied for GDA of its 1,600 MWe European Pressurised water Reactor (EPR) design, which received French design approval in 2004. AREVA will also involve other European utilities interested in building it in the UK: E.ON UK plc, British Energy plc, Centrica, Iberdrola, RWE, Scottish & Southern Energy, Endesa, Suez, Union Fenosa and Vattenfall.
- GE-Hitachi Nuclear Energy for its 1,600 MWe Economic (or European) Simplified Boiling Water Reactor (ESBWR), supported by Iberdrola, RWE npower plc and British Energy plc.
- Atomic Energy of Canada Ltd. (AECL) for its 1,200 MWe ACR-1000 design.

However, in April 2008 AECL announced that it will defer participation in the UK's GDA process to focus on its home market in Canada.

It should also be noted that the design and construction of the different reactors is likely to effect the participation of UK companies in the supply chains, which will be addressed further below. On a related note, we understand from BERR that one of the Government's objectives is to have more than one operator, given that different sites favour different technologies - some are more suitable for a particular technology than others. But this is a matter for operators, taking account of their operational and economic assessments of the technologies, and their views of what best suits different sites."

British Energy plc, which owns land adjacent to existing nuclear plant, supported all GDA applications for the first phase of GDA and that it is conducting its own review of reactor designs from the vendors above. In addition, EDF has said that it wants to build several EPR plants in the UK and that it could build new nuclear plants by 2017, if Government successfully takes forward the facilitative actions identified in the 2008 Nuclear White Paper.

In this respect, there is significant global experience to show that modern nuclear reactors take around 5 years to construct, commission and hand-over ready for commercial operation. This 'construction' period follows activities which will include the GDA, nuclear justification, site selection, environmental impact assessment and the planning process (see the Nuclear White Paper for indicative timelines [18]). Thus overall, it is estimated that it would take approximately 10 years to construct and commission a new nuclear power station [19].

2.0 UK Capability and Capacity for Nuclear New Build

In this section of the report, a brief overview of UK capability in nuclear power, civil and defence related, is given, together with summaries of the most significant reviews of the UK's capability and capacity to deliver a new UK nuclear build programme. The most significant reviews, in the public domain, of UK capability in nuclear new build are those of: the 'New Build Working Group' (NBWG) of the Nuclear Industry Association (NIA) [19] and IBM Business Consulting Services [20], which were carried out at similar times (2005-06) and, perhaps not surprisingly, involved discussion with many of the same nuclear reactor vendors, nuclear site operators and supply chain companies.

In addition, a review of the capacity requirements and constraints for a new US-based civil nuclear build programme is summarised [21, 22].

2.1. Overview of UK Capability

UK-based companies have been active (leading) in the development of civil nuclear power for more than 50 years, and the UK maintains a significant capability in the construction and operation of nuclear power plant, and in full fuel cycle facilities, nuclear plant decommissioning and nuclear waste management. As mentioned above, the UK's nuclear industry is a major exporter of technology and skills [15].

With regards to construction, maintenance and operational support, the UK industry has almost complete design, manufacture, construction and operational support capability for nuclear power and fuel cycle facilities. British contractors, manufacturers and engineers have gained extensive experience from the building, operation, maintenance and upgrading of nuclear plant and facilities in the UK and abroad. In addition, state-of-the-art inspection techniques have been developed which have been applied in the lifetime management of many reactors worldwide [15].

The primary nuclear industry operators are supported by a wide variety of supply chain companies, such as engineering and construction contractors, fabricators of specialist equipment, manufacturers and specialist service providers. However, some elements of the UK's supply chain(s) for nuclear power plant and equipment has been eroded quite considerably over the past 15 years or so, a consequence of the majority of UK's nuclear power 'fleet' now being between 20 and 50 year old, and the most recently built nuclear power station (Sizewell B) was started up in 1995.

The UK has a decade of world-leading experience in the decommissioning of nuclear power reactors and is currently engaged in an extensive decommissioning programme, which is the responsibility of the Nuclear Decommissioning Authority (NDA). A well trained and highly skilled workforce of approximately 15,000 people is employed in the operation and decommissioning of the UK's nuclear power stations, and UK companies are also involved in decommissioning projects overseas (including Eastern Europe, Canada and the USA) [9].

In addition, the UK has full fuel cycle facilities including major reprocessing plants and from the very early days of nuclear power generation in the UK, the UK has been self-sufficient in conversion, enrichment, fuel fabrication, reprocessing and waste treatment of imported Uranium. Approximately 20,000 people in the UK are employed in the production, reprocessing and storage of nuclear fuel and in waste handling in the UK, and UK industry provides the processing of spent nuclear fuel from several countries.

Although not considered in any detail here, it should be noted that a capability associated with nuclear defence complements that of the current civil nuclear capability. In particular, the BAE Systems shipyard at Barrow-in-Furness, Cumbria is a licensed nuclear site employing around 3,000 people, which concentrates on submarine construction. In terms of nuclear engineering capability, this is the only site in the UK where nuclear reactor construction is undertaken. Thus, although there are major differences between propulsion and power generation reactors, there is a core capability of 90-100 people involved in reactor design and a further 100 employed as nuclear qualified welders, pipe fitters, commissioning and installation experts [14].

In addition, Rolls-Royce plc's submarines business has been the principal turnkey contractor for the Nuclear Steam Raising Plant (NSRP) for all British submarines since the inception of the programme approximately 50 years ago. Existing Rolls-Royce capabilities include about 1,000 nuclear engineering and safety staff and three UK manufacturing sites dedicated to producing nuclear components. Rolls-Royce also manages all aspects of the nuclear supply chain for submarine propulsion involving 260 suppliers, which are primarily UK-based [23].

Also, the Atomic Weapons Establishment (AWE), Aldermaston (Berks.) is responsible for the design, manufacture and support of warheads for the United Kingdom's nuclear deterrent.

However, the prime purpose of the Rolls-Royce, BAE Systems and AWE nuclear activities is currently the supply of military equipment, although the skills which exist with these organisations are almost certainly relevant to a civil nuclear new build programme. In this respect, it is worth noting that in July 2008, Rolls-Royce announced that it was establishing a new business unit to address the global market for civil nuclear power, but added that the work that it currently undertakes for the Royal Navy's submarine programme would be unaffected by the changes [23].

2.1.1. Brief Overview of the UK Nuclear Supply Chain

The nuclear power supply industry in the UK is dominated by British Energy plc, which currently operates eight nuclear power stations in the UK, with a total capacity of 9,568 MWe. However, the actual supply chain involves a large part of UK industry, from major construction firms through engineering service companies, to nuclear clean-up and radioactive waste management companies. The supply chain involves the following industrial sectors, major companies and governmental bodies.

- Major construction and engineering companies which will build any new nuclear plants, and which are involved in maintenance work on existing plants.

- British Nuclear Fuels Ltd. (BNFL) and its subsidiary Sellafield Ltd. manufacture and transport nuclear fuel in the UK, primarily to British Energy. BNFL is based mainly at Sellafield, but it has 17 other sites in the UK. BNFL is also involved in the processing of spent fuel, the decommissioning of nuclear plants and generates and sells electricity.

- Engineering and service companies, which provide a very wide range of services covering design, manufacturing, procurement, plant upgrading, life extension, site installation, commissioning and operational support. These companies provide services to a very wide client base, which includes BNFL and British Energy.

- British Energy manages and operates nuclear power stations in the UK, many of which will close down over the next 10-20 years.

- The Nuclear Decommissioning Authority (NDA), a non-departmental public body set up under the Energy Act 2004, ensures that the UK's civil public nuclear legacy sites are decommissioned and cleaned up efficiently and effectively. United Kingdom Atomic Energy Authority (UKAEA) is responsible for decommissioning nuclear facilities used for the UK's research and development programme and for restoring the environment of contaminated sites.

- As mentioned above, the Atomic Weapons Establishment (AWE), Aldermaston (Berks.) is responsible for the design, manufacture and support of warheads for the United Kingdom's nuclear deterrent. AWE plc, owned by BNFL, Lockheed Martin UK and Serco through AWE Management Ltd., is responsible for the day-to-day operations of AWE.

2.2. Nuclear Industry Association (NIA) Nuclear New Build Capability Review

A relatively recent, and by far the most comprehensive, review of the supply chain capability of UK industry to support the delivery of a UK nuclear new build programme has been carried out by the 'New Build Working Group' (NBWG) of the Nuclear Industry Association (NIA) [19]. The review has subsequently been updated [24], although this most recent review found that the conclusions from the original study remained valid.

In the NIA's review, some key assumptions were made, which included the following:

- The AREVA NP European PWR (EPR) and the Westinghouse Advanced Passive PWR (AP1000) were selected as the reference reactor designs.

- A programme of five twin Nuclear Power Plants (NPPs) would be built over approximately 20 years on or adjacent to existing nuclear power station sites to replace the current nuclear generated electricity supply capacity of around 10 GWe.

The report focused on the UK's capability in three broad areas:

- Programme Management and Technical Support;
- Civil Engineering Construction; and
- Plant and Equipment.

Of the above, 'Plant & Equipment' typically comprise approximately 55% of a nuclear power plant build, with 'Civil Engineering and Construction', and 'Project Management and Technical Support' accounting for approximately 30% and 15%, respectively. However, it should be noted that these percentages are based on 'volume' (% of total activity), rather than the value of the different aspects of a new build nuclear plant.

The NIA study assessed UK capability against the delivery of approximately 60 'packages' of equipment or services, which comprise a complete nuclear power plant. The study also considered current (early 2006) capability with that which may be available in approximately five years time, with sufficient investment and training to regenerate capability lost over recent years. A period of five years was chosen as this was the likely (envisaged) timeframe prior to the initiation of any new build programme. A summary of the findings of the analysis is shown in Figure 5 below.

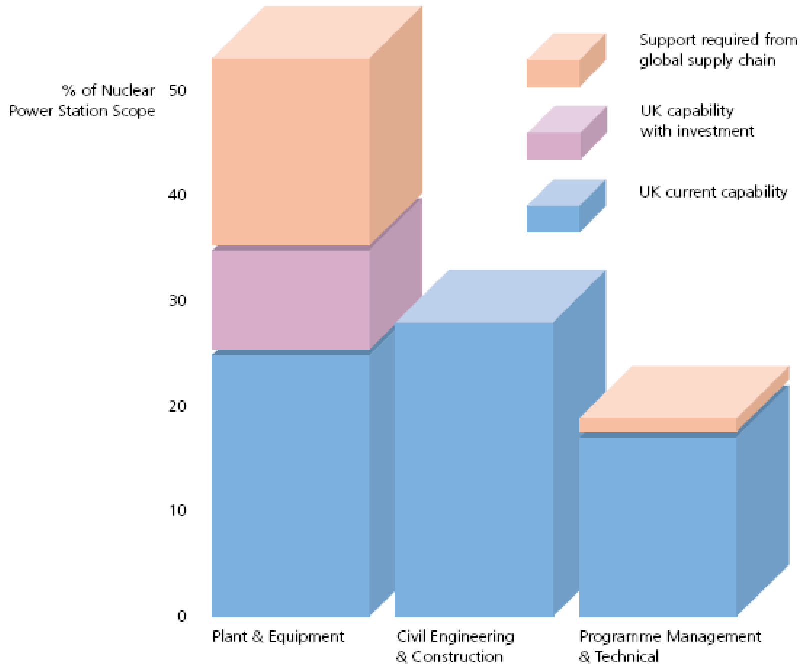

Figure 5 - NIA NBWG analysis of UK industry capability to support a new nuclear power plant build. From 'The UK Capability to Deliver a New Nuclear Build Programme, the NIA, March 2006. (Courtesy of the NIA).

In a very detailed appendix to the review, the NIA New Build Working Group considered each of the 60 or so work packages in turn, in terms of the UK experience and capability, previous UK experience, current UK-based and required resource levels, competition from overseas and any significant issues.

The NIA analysis suggested that the UK supply chain has a strong capability in most of the areas required to support a new nuclear build programme, and UK industry could supply around 70% of the total requirements for such a programme. Furthermore, the study estimated that with some investment in facilities and the training of new personnel, this capability could be increased to a little over 80%. This capability is currently being used to support existing nuclear power plants and new fuel cycle plant, and in decommissioning and waste management activities. In addition, it is being applied to non-nuclear projects which utilise similar skills, and the construction activities and much of the plant and equipment are similar to those of a nuclear power plant.

However, the NIA study also noted that in an internationally competitive environment, the capability to supply does not necessarily mean that UK companies will supply. In addition, the study identified some significant gaps in UK capability, which will be discussed below.

The specific UK capabilities in the three broad areas indicated above are described in the following sections.

2.2.1. Programme Management and Technical Support

Programme Management and Technical Support covers activities such as the overall management, commercial and technical direction and regulatory and planning activities required to deliver a new nuclear power station from inception through to commissioning and operation readiness.

Regarding the UK's capability in this area, the NIA study concluded the following:

- Less than 2% of the UK capacity for Programme Management and Technical Support would be required for a new nuclear build programme.
- The capability and resources required to project manage and technically support the new nuclear build programme can readily be provided by UK industry.
- Resources would likely not be provided by a single company, but by a grouping of companies.
- A nuclear new build programme would provide continuity of work for UK industry rather than overstretching UK capability, following the completion of major infrastructure projects such as those associated with the 2012 Olympics.

2.2.2. Civil Engineering and Construction

The NIA's NBWG recognised that there are differences in the quantities of materials for construction and in the approach to construction between the two reactors considered. Thus, the Westinghouse AP1000 uses a modular construction approach which involves remote production of structural modules followed by shipping to site and assembly, whereas the AREVA EPR is built on site.

However, regarding the UK's capability in this area, the NIA study concluded the following:

- A new nuclear build programme equates to less than 0.5% of the annual value of UK construction industry output.
- All elements of the civil construction (nuclear and turbine islands, balance of plant and supporting infrastructure) could be undertaken by UK companies.
- As above, a nuclear new build programme would provide continuity of work for UK industry rather than overstretching UK capability, following the completion of major infrastructure projects such as those associated with the 2012 Olympics.
- Materials required for the civil and structural aspects of the construction of the new power plants are readily available within the UK market.
- A relatively small percentage of normal UK annual outputs would be required, for example less than 1% of cement and aggregate output and less than 4% of structural steel production.
- The availability of large capacity cranes and self-propelled transporters, for the lifting and transportation of either individual components such as reactor vessels, steam generators, turbine rotors, etc. and reactor modules will need extensive forward planning.

2.2.3. Plant & Equipment

Plant and Equipment for a nuclear power plant includes the reactor pressure vessels and ancillary equipment such as tanks, pipework, and the more conventional turbines, generators and switchgear. Much of the ancillary equipment is similar to that required for non-nuclear (eg, fossil-fuelled power and chemical plant) and significant experience has been developed and maintained through these non-nuclear projects.

A simple schematic of a Pressurised Water Reactor (PWR) is shown below in Figure 6 and a schematic of the AREVA EPR is shown in Figure 7, and an overview of the main components of the AREVA EPR can be downloaded as a brochure from its website (http://www.AREVA-np.com/).

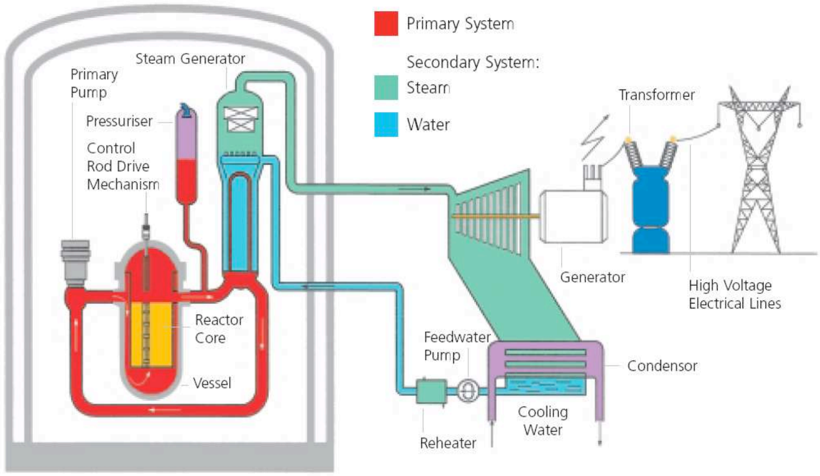

Figure 6 – Operational diagram of a typical PWR (from 'The UK Capability to Deliver a New Nuclear Build Programme', the NIA, March 2006. (Courtesy of the NIA).

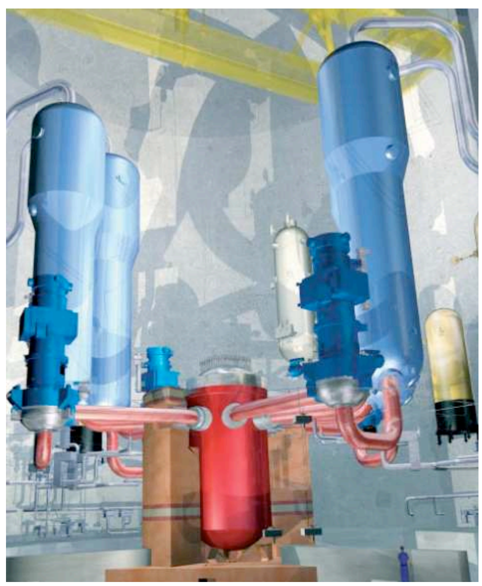

Figure 7 - Schematic of the AREVA EPR. (Courtesy of AREVA NP).

Regarding the UK's capability in Plant and Equipment, the NIA study concluded the following:

- UK companies could supply approximately 50% of the Plant and Equipment with current facilities and resources; with some investment, this could increase to approximately 70%.
- With increasing world demand, it is possible that some UK companies would invest to increase their scope and capacity for a UK new build programme and for potential export.
- Companies which have redirected their efforts since the last nuclear build could reinstate facilities and skills if the business case justifies.
- Limited world capacity to produce critical components such as forgings and reactor pressure vessels (see, for example, Figure 8), and the associated long lead times for such components, may effect the ability to deliver a UK new build programme.

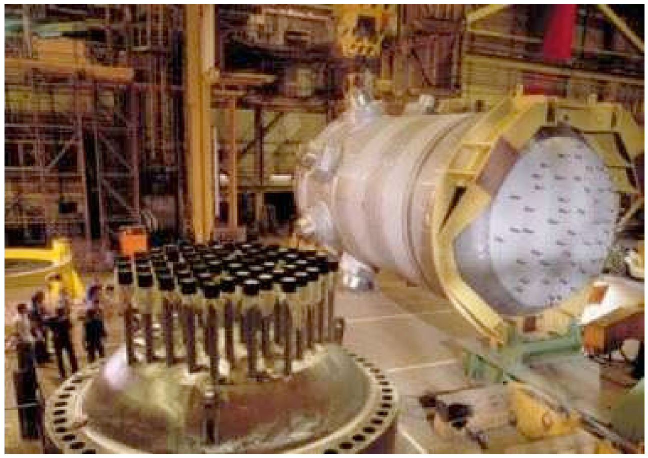

Figure 8 – Reactor Pressure Vessel (RPV) and integrated head manufacture (courtesy of AREVA NP).

Almost all of the Plant and Equipment for the Sizewell B PWR could be supplied by UK companies, although not all components were supplied by UK companies. In fact, from the Nuclear Electric report referred to above [16], more than 90% of the value of the hardware contracts was placed directly or indirectly with UK-based companies. As will be discussed below, the components / plant which could not be supplied by UK companies at that time were some of the very (or ultra-) large forgings and the reactor pressure vessel.

As regards current capability, there are several UK-based companies with manufacturing facilities and experience capable of supplying a large number of the components required for a nuclear power plant. For example, some UK companies are world leaders in the supply of equipment to overseas nuclear industries and there are also world leading UK companies currently supplying Plant and Equipment to the non-nuclear energy and civil engineering projects, both within the UK and overseas.

The NIA review concluded that the manufacture and supply of steam turbines, generators and reactor pressure vessels will likely be from overseas, at least for the first of any new nuclear power plants. However, an investment in new forging capability at Sheffield Forgemasters International Ltd. (Sheffield), would create UK capacity, as will be discussed below [25].

The NIA has also produced a list of member supply chain companies in 2005 [26], which it is currently updating. In addition, the NIA has a 'Nuclear Trade Directory', which gives an overview of the activities of member companies, and which is available on CD [27].

As mentioned above, a further, recent review by the NIA has updated some of the detailed analysis of the original study, with particular emphasis on capability in plant & equipment requiring a 'high materials manufacturing content' [24], including pressure vessels, other large forgings, pipework, pumps, valves, etc.

In addition, significant content regarding UK nuclear supply chain capability, in a House of Commons Trade and Industry Committee report [28], is taken from evidence based on the NIA capability review.

2.3. IBM Nuclear New Build Capability Review

A review of the capability and capacity of the UK and global supply chains to support a UK new nuclear build programme was carried out by IBM Business Consulting Services [20] and which, as mentioned above, was carried out at a similar time (2005-06) to the NIA review.

In the IBM review, the following assumptions were made:

- A programme of approximately ten reactors delivering 10-15GWe capacity would be built with 18 months between start dates;
- On-site construction of the first plant would start around 2010, with the first station to come on line in about 2015;
- All stations would have a similar design using an unspecified, but international reactor design technology; and
- The licensing and planning consents processes would be concluded to meet the assumed construction start date.

The report focused on the UK and global capability and capacity in three broad areas:

- Nuclear island (specific equipment and activities associated with construction of the nuclear reactor): 45% of construction costs;
- Non-nuclear island (all equipment and activities required to support construction of the non-nuclear specific elements of a nuclear power station – cf, a conventional non-nuclear power station): 40% of construction costs; and
- General (items required to support both the nuclear and non-nuclear island activities, such as general programme and site management, provision of modular construction facilities and key raw materials including forging capacity): 15% of construction costs.

The IBM study broke the supply chain to support a new nuclear build programme down into approximately 40 systems and sub-systems, each representing either a major plant item (eg, reactor pressure vessel, steam generator or turbine generator), or a package of work (eg, the main civil engineering works). The system breakdown was consistent with systems and sub-systems required to construct either Westinghouse AP1000 or AREVA EPR designs. As part of the system breakdown, an approximate value was calculated for each system and sub-system, expressed as a percentage of the overall build cost for a typical PWR. Information was then presented which summarised the supply chain capability and capacity, the approximate value and the expected level of competition for the top 18 systems and sub-systems, which represent over 80% of the typical new build value.

The IBM study concluded that there appeared to be sufficient capability and capacity within the UK and global supply chains to support a new nuclear build programme in the UK, provided that there was some appropriate investment in staff and facilities. In addition, the study concluded that the UK supply chain has the capability to deliver many of the elements of a new nuclear build programme, particularly the non-nuclear systems and infrastructure, but would require investment in facilities and staff in some of these areas. Also, the study concluded that the UK supply chain would be unable to deliver a new build programme alone and, therefore, support from the global supply chain would be required.

However, the study raised concerns regarding a risk of the global supply chain being capacity limited by the ability of reactor design owners to support multiple concurrent new build programmes, and by specific availability of low alloy steel forgings for the reactor pressure vessels.

2.3.1. Summary for the UK Supply Chain

The major conclusions of the review of the UK supply chain capability and capacity are summarised in Figure 9 below, and the following major conclusions were drawn:

- Whilst the UK has a strong capability in many of the areas required to support a new build programme, support from the global supply chain will be required in a number of critical areas (eg, reactor design, turbine generator, reactor pressure vessel, and the supply of forgings).

- To support a new nuclear build programme in the UK, the UK supply chain will need to recruit additional staff in many areas.
- The UK retains a strong capability, and is likely to be well placed against global competition for general construction works (including civil engineering, and mechanical and electrical installation), construction of radioactive waste facilities, fabrication of smaller nuclear specific components, design validation, inspection validation and inspection.
- In addition, the UK retains some capacity to support provision of nuclear specific systems and sub-systems, including the control room equipment, reactor protection systems and site installation of the primary circuit.
- The UK has the potential to be competitive in the typically labour intensive, construction site based activities.
- For other major items such as the primary circuit pressure vessels, the UK only retains a very limited capacity. Limited forging capacity still exists in the UK, but it is unclear whether this can credibly support the scale of ring-forgings required for the construction of the major plant items.
- The UK does not retain a UK-based design owner, or currently have the capability for fabrication of the turbine generators and reactor pressure vessels.

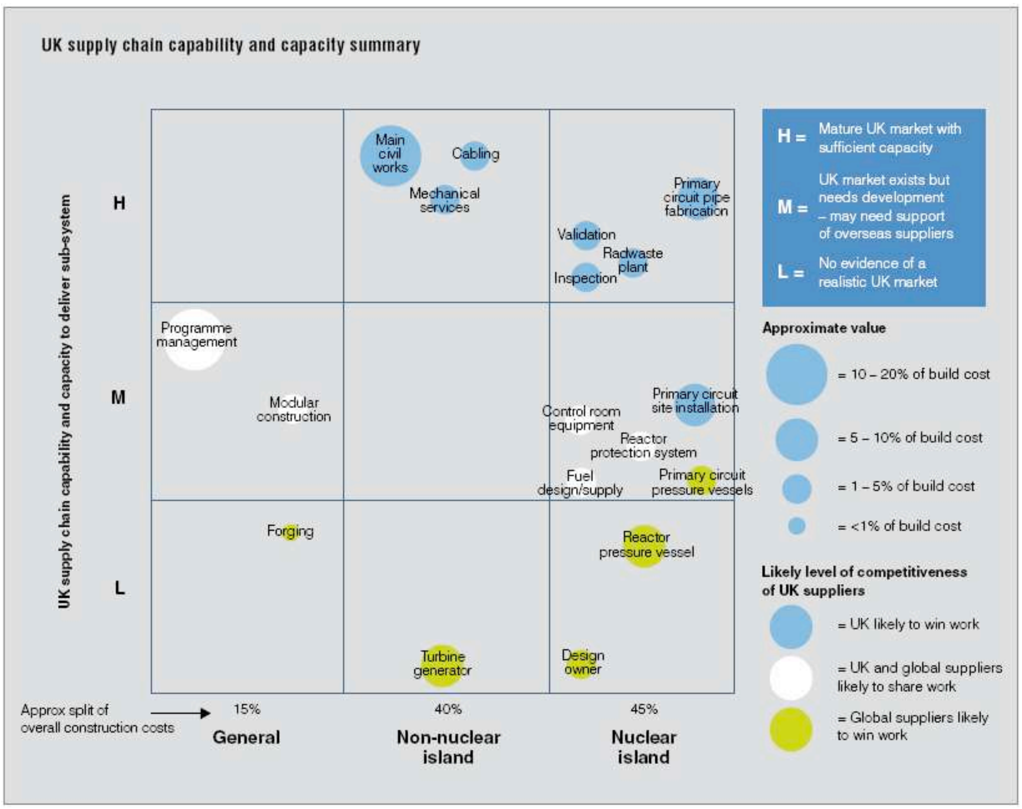

Figure 9 – UK Supply Chain Matrix (from 'An Evaluation of the Capability and Capacity of the UK and Global Supply Chains to Support a New Nuclear Build Programme in the UK', IBM Business Consulting Services, 2005 [20]). (Courtesy of IBM).

Specific supply chain issues and barriers associated with the availability of skilled and experienced staff were identified in the IBM study. Thus, the UK supply chain identified availability of skilled staff, especially those with nuclear experience, as a key issue, with many companies indicating that recruitment would be needed to allow them to fully support a new nuclear build programme.

2.3.2. Summary for the Global Supply Chain

The major conclusions of the review of the global supply chain capability and capacity are summarised in Figure 10 below, and the following major conclusions were drawn:

- There appears to be a strong global market for most systems and sub-systems to support a new nuclear build programme in the UK.
- The global capacity for a small number of key items appears to be limited, and may constrain the UK's ability to proceed with a new nuclear build programme (eg, the provision of low alloy steel forgings for the reactor pressure vessels).
- UK suppliers are likely to be competitive with the global market in some areas, primarily those which are site-based, or which require specific UK knowledge such as design validation. However, the role of the UK supply chain will be determined in part by the consortium structures and the choice of reactor design. There is a risk that a design owner may have an existing global supply chain, which may limit participation by the UK-based supply chain in a new build programme.

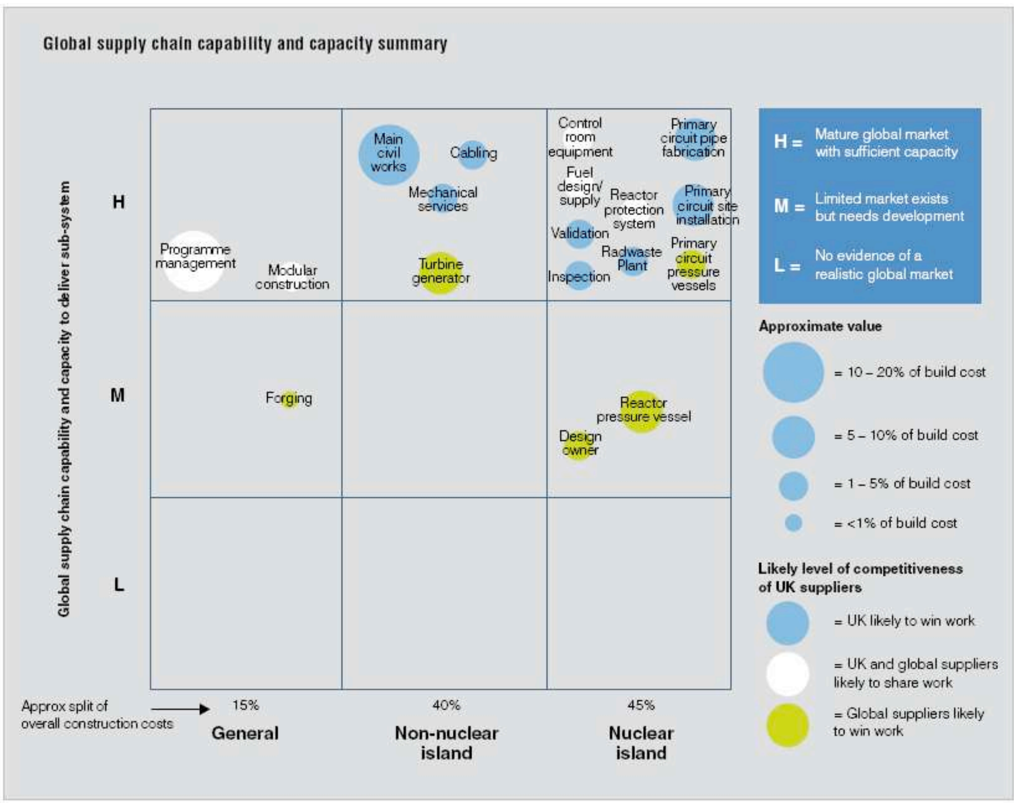

Figure 10 – Global Supply Chain Matrix (from 'An Evaluation of the Capability and Capacity of the UK and Global Supply Chains to Support a New Nuclear Build Programme in the UK', IBM Business Consulting Services, 2005 [20]) (Courtesy of IBM).

Specific supply chain issues and barriers associated with a significant increase in new build activity were identified (potential capacity issues), which were related to the total global reactor build capacity of the vendors, the specific global capacity for large steel forgings, and the relatively limited scale of the UK new build programme (in global terms).

2.4. US Department of Energy (DOE) Nuclear Infrastructure Assessment

For comparative purposes, a summary of the infrastructure assessment (capacity requirements and constraints) for a new US-based civil nuclear build programme, carried out by the US Department of Energy (DOE) [21], is given below. Some of the major findings from this work were also summarised in a Nuclear Energy Institute (NEI) Fact Sheet [22].

As background to the review, US based companies and consortia are currently pursuing plans to build more than 30 new nuclear power plants to meet the projected increases in US electricity demand. However, the infrastructure for building new nuclear plants has diminished because few recent US plants have been built. As a result, the industry may face difficulties obtaining components necessary to build new nuclear plants, as well as experienced construction management, engineering personnel and skilled workers.

Within the US, the industry anticipates that construction may begin on as many as 17 new nuclear plants in the United States and 30 overseas over the next six years, causing a dramatic increase in demand for components, but that the necessary manufacturing capacity is available or can be readily available to support the construction and commissioning of only up to 8 reactors between 2010 and 2017.

The study identified several potential manufacturing constraints which could hinder the construction of new nuclear power plants: component design and engineering, supply of raw materials and sub-components, work force, qualified suppliers of nuclear plant components, specialized equipment and machinery, and global infrastructure for heavy forgings. Specifically, the DOE study evaluated key components which could be 'pinch points' as new plant construction accelerates, and which include:

- Reactor pressure vessels;
- Steam generators;
- Turbine generators;
- Nuclear-grade pumps, heat exchangers, valves and mechanical insulation;
- Transformers; and
- Large diameter seamless piping.

In addition, the study outlined the following categories of constraint:

- Component design and engineering;
- Raw material and sub-component supply (eg, for steam generators, pumps, heat exchangers, valves, and alloy and stainless steel piping);
- Specialised training and supervision of the manufacturing work force;
- Limited suppliers of nuclear-grade plant components;
- Specialised equipment and machinery; and
- Forging capability (for ultra-large forgings that are used mainly for reactor pressure vessels, etc.).

The DOE study identified ultra-large forgings as the first major 'pinch point' which the industry will encounter before 2010, but constraints on supplies of nuclear-grade pumps, valves and heat exchangers in safety-related systems could arise in subsequent years. In addition to forgings for reactor pressure vessels, no US-based company has the capability to produce the large forgings necessary for manufacturing steam turbine rotors and large turbine generators for nuclear plants.

2.5. Brief Review of the UK's Nuclear Fuel Cycle Capability

The reliable operation of a new fleet of nuclear reactors in the UK would require a stable and secure source of uranium fuel supplies for the next 50 to 60 years. Thus, although there has been considerable debate surrounding the subject, the global reserves of Uranium are considered to be sufficient to meet the growing demand for nuclear power [18, 28]. Most of the UK's uranium supplies come from Australia, but currently, the World's largest producer is Canada. [A simple overview of the processes involved in nuclear fuel production is given in a Nuclear Energy Institute Factsheet [29]].

The International Atomic Energy Agency (IAEA) and the OECD estimate that approximately 4.7 million tonnes of known uranium resources can be mined for less than $130/kg, together with further reserves which would be more expensive to recover. Based on 2004 levels of nuclear electricity generation, these reserves would last for approximately 85 years, and rises to approximately 270 years if all reserves are taken into account [28].

The quantities of fuel involved for a nuclear plant are much lower than for conventional, fossil-fuelled power stations. Thus, whereas a coal-fired power station could consume several million tonnes of coal per annum, a modern 1,000 MWe nuclear station will typically require a few tens of tonnes of fuel for each re-fuelling operation, which takes place every 12-18 months.

As mentioned above, the UK has full fuel cycle facilities for conversion, enrichment, fuel fabrication, reprocessing and waste treatment, and the UK should (or could) be capable of supplying fuel(s) for a new build programme.

2.6. Nuclear Decommissioning and Waste Management

The UK has extensive experience in the decommissioning of nuclear power reactors and is currently engaged in an extensive decommissioning programme, which is the responsibility of the Nuclear Decommissioning Authority (NDA), and UK companies are also involved in decommissioning projects overseas [9].

Regardless of a decision on new nuclear build, the UK has a significant radioactive waste legacy requiring a long-term solution. Advances in technology mean that the decommissioning of new reactors should be cheaper and simpler than for the current and retired fleet of reactors, where total decommissioning costs are currently estimated at £41 billion discounted. The volume of waste generated would also be smaller; thus, 10 new reactors would only add 10% to the existing volume of radioactive waste in the UK, although the radioactivity of this waste would be substantially greater than that of current waste [28].

There is extensive UK and International experience of managing reactor wastes, such that waste management and decommissioning is not a barrier to a new nuclear build [30].

The British nuclear industry offers extensive capabilities in the area of radioactive waste management, including waste segregation, categorisation, handling, encapsulation, minimisation, stabilisation, packaging, storage and disposal for all types of radioactive wastes [9]. Most low-level waste (LLW) arising in the UK is disposed in shallow concrete vaults at the low level waste repository at Drigg. Intermediate-level wastes (ILW) encapsulated in cement in stainless steel containers and high-level waste (HLW), vitrified in stainless steel seal-welded containers are currently held in engineered surface stores, pending final disposal. Note: the containers are supplied from within the UK. The Committee on Radioactive Waste Management (CoRWM) has recommended deep geological disposal for these higher level wastes and the British industry has acquired considerable expertise, knowledge and understanding in this area.

A summary of the status of waste management for a UK nuclear new build has been given by the NIA [30], as follows:

- The technology already exists, and is being deployed today, to manage waste and spent fuel from nuclear reactors;
- Decommissioning has been demonstrated for nuclear reactors; a number of countries, including the UK, have achieved this in practice;
- The UK can build on the successful approach to waste disposal which is being implemented in a number of other countries;
- Existing UK, and any future new generation reactors, satisfy international objectives in terms of environmental performance;

- Quantities of waste from 10 new reactors operating for 60 years would add less than 10% to the UK nuclear waste inventory;

- If all the electricity required in their lifetime by a person living in the UK was generated from nuclear power the volume of waste would fit into a small waste paper bin; 80% of this waste already has an existing disposal route (low level waste repository at Drigg); and

- The UK could adapt financial models, which have already been successfully implemented in other countries, to fund the disposal of waste, including spent fuel.

Whatever the direction of the UK's waste management policy, a sustainable long-term solution will require significant investment in both facilities and supporting expertise and skills, which could present a considerable export opportunity for UK companies [9].

2.7. Summary of Supply Chain Capabilities for a UK Nuclear New Build Programme

2.7.1. Overview

Although not surprising, the most significant reviews of UK capability in nuclear new build by the Nuclear Industry Association (NIA) [19] and IBM Business Consulting Services [20], and the US DOE review of the capacity requirements and constraints for a US new nuclear build programme [21] reach almost the same conclusions.

Thus, for the UK-based studies, the major conclusions are that:

- The UK supply chain has the capability to deliver many of the elements of a new nuclear build programme, particularly the non-nuclear systems and infrastructure, but would require investment in facilities and staff in some of these areas.

- The UK has a strong capability in many of the areas required to support a nuclear new build programme, but support from the global supply chain will be required in a number of critical areas including the reactor pressure vessel, turbine generator and the supply of forgings for other critical components.

- The global supply chain may itself be capacity limited in some areas as global demand increases, and so, if the UK wishes to proceed with a new nuclear build programme, action would need to be taken to ensure that the UK is an attractive market for global suppliers, operators and investors.

- To support a new nuclear build programme in the UK, the UK supply chain will need to recruit additional staff in many areas. The ability of the UK supply chain to do so, from the diminishing pool of skilled and, particularly, experienced staff, may limit the UK supply chain's ability to create additional capacity and hence its involvement in a UK nuclear new build programme.

- Whilst the UK supply chain appears to have capacity in many areas, there is concern about the future level of competition from activities such as nuclear decommissioning and other infrastructure projects for a diminishing pool of skilled and experienced resources.

- The UK supply chain will only commit to investment in additional facilities and staff if it believes that it will be able to win work, and that the returns offered by the nuclear programme are at least as attractive as competing markets.

- The UK has the potential to be competitive in the typically labour intensive, construction site based activities identified above, and therefore, given sufficient notice and confidence in the programme, there is likely to be a case for the UK supply chain making the necessary investments.

- For other major items such as the primary circuit pressure vessels, the UK only retains a very limited capacity. Forging capacity exists in the UK, but not all of the forgings required for the construction of the major plant items can be produced.

- The availability of skilled staff, at all levels through the supply chain (eg, for site installation, design engineers, etc.) especially is a key issue, with many companies indicating that recruitment would be needed to allow them to fully support a new nuclear build programme.

- Currently, the UK has a full fuel cycle capability and global reserves of uranium are not expected to constrain a nuclear new build programme in the UK.

In very simple summary, the most significant constraints identified are the availabilities of large forgings and pressure vessels (eg, RPVs and steam generators), and skilled staff, although there are other constraints which should also be of some concern.

2.7.2. UK Capacity and Constraints

The following highlights some of the major issues in the UK-based supply chain for a nuclear new build programme which the reviews identified:

- UK constraints in the provision of some component parts to nuclear power stations could be overcome if there was confidence in the future of the sector.
    - A programme of new build, combined with growing international demand for nuclear power, may provide the incentives for UK companies to invest in the domestic supply chain.

- Industry has made it clear that for it to have the incentive to invest, both with regard to skills and infrastructure capacity, it will need an understanding of the level of business it is likely to win from any new build programme.
    - This information is, as yet, unknown, as it would depend on the extent of such a programme, the proposed reactor design, the structure of the construction consortia, and their procurement strategies.
    - By the time UK companies are fully aware of the potential opportunities, it may be too late to make such investments.
    - As a result, the Government would have an important role to play in clearly communicating its long-term position on nuclear power in order to provide the industry with a degree of confidence.

2.7.3. Global Capacity and Constraints

The following highlights some of the major issues in the global supply chain for a nuclear new build programme which the reviews identified:

- There are a number of areas in which the UK would be reliant on the global supply chain for a nuclear new build programme.
    - There is no UK-based reactor designer / vendor.
    - Potential 'pinch-points' exist with regard to reactor pressure vessels, steam generators, large turbines, and components from other large forgings.
    - There is no UK based capability for the fabrication of such components.
    - The global market will likely be able to provide the systems and sub-systems that the UK market is unable to supply, although the global capacity for some key items appears to be limited.

- There is a risk that if a number of countries place orders for nuclear reactors at the same time as the UK, the vendors may not have the capability to increase their operations.
    - Timing of any orders from the UK would be important if operators were to avoid the possibility of significant delays.

- Even a large programme of nuclear new build in the UK might be considered relatively small in the context of global expansion in this sector and, therefore, might not be a priority for potential suppliers, operators or investors.

2.7.4. Availability of Some Specific Nuclear Components and Materials

In this section, some of the issues associated with the supply of some specific components and materials, both nuclear island and non-nuclear island, are described. [See also reference 31].

Large and Ultra-Large Forgings

It is worth highlighting (again) the specific constraint of the availability of large or ultra-large forgings, which are used in various applications within the nuclear island, and similar sized forgings are also required for the non-nuclear island's large steam turbine and turbine generator rotors.

The supply of very (or ultra-) large forgings is critical to any new nuclear power plant build and such forgings are used for the manufacture of Reactor Pressure Vessels (RPVs), steam generator (SG) pressure vessels and tubeplates, pressurisers, and for the primary circuit pipework, as well as steam turbine and turbine generator rotors. Examples of such forgings and components are shown below in Figures 11-13 (see also Figure 8 above).

Figure 11 - Reactor Pressure Vessel (RPV) forging. (Courtesy of AREVA NP).

Some technical details for the major pressure vessels of the Nuclear Steam Supply Systems (NSSSs) undergoing the GDA are given in an Appendix to this report (see Appendix B).

Sheffield Forgemasters estimates that it is currently able to produce approximately 40% of the forgings required for a nuclear reactor and that Sfarsteel's Creusot Forge (France, and owned by AREVA) can produce approximately 70% of the required forgings, with Japan Steel Works (JSW) capable of producing 100% of the required forgings [32].

In addition to the capability to produce large and ultra-large forgings, technical quality assurance approvals, such as the American Society of Mechanical Engineers (ASME) certification is also required for supply into the nuclear industry, which can take many years to achieve. Sheffield Forgemasters has ASME approval and is thus approved for all large, critical nuclear forgings, regardless of reactor design.

Figure 12 - Large Reactor Pressure Vessel (RPV) forgings with nozzles. (Courtesy of AREVA NP).

Figure 13 – Steam Generator fabrication at Mitsui (now Doosan) Babcock, Renfrew, for Sizewell B. (Courtesy of Doosan Babcock Energy Ltd.).

Approximately 5,000-6,000 tonnes* of large forgings are required for each new reactor, depending on the design (see Figure 14 below). In addition, ultra-large forgings require ingots of 350-600 tonnes and large forgings require ingots of 180-250 tonnes [25]. In 2006, Japan Steel Works met 70% of total world demand for large and ultra-large forgings for nuclear reactor applications.

* Note: the finished weights of forgings, after machining, etc., for the AREVA EPR and Westinghouse AP1000 are approximately 2,000 tonnes and 1,500 tonnes per unit respectively (ie, per NSSS or reactor).

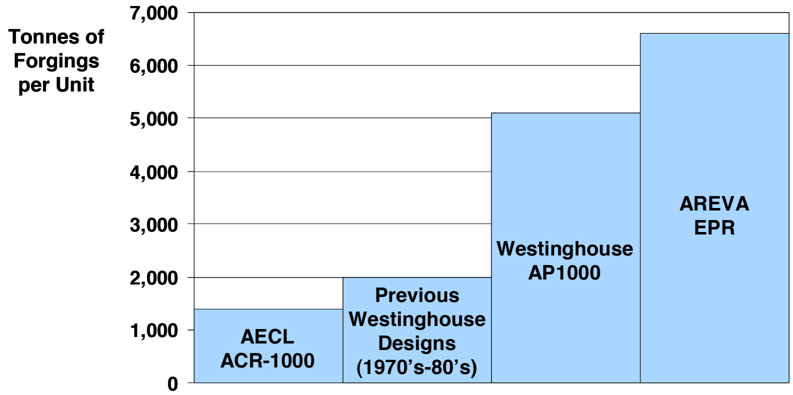

Figure 14 – Tonnes of forgings per unit for different nuclear reactors (modified from Ref. 32).

The companies which it is believed could supply ring forgings for RPVs and steam generators, and large head forgings, are [31]:

- Japan Steel Works (JSW) (Japan): all forgings for rings and heads.
- Doosan Heavy Industries and Construction, Ltd. (Korea): all forgings for rings and heads.
- OMZ (Russia): all forgings for rings and heads.
- AREVA Sfarsteel's Creusot Forge (Le Creusot, France): some forgings for rings and heads.
- China First Heavy Industries (China): some forgings for rings and heads.

In addition to these companies, there are a number of others which can produce large steam turbine rotor forgings and these include Saarschmiede (or Forge Saar, Germany) and Kobe Steel (Japan). There are also a number of global forgemasters which are planning to increase capacity for non-nuclear, ultra-large forgings.

For the Sizewell B PWR, most of the large forgings were supplied by Japan Steel Works (JSW) and from Creusot Forge in France, with UK-based companies supplying some of the smaller forgings.

Of significant concern is the limited global manufacturing capacity of some critical components which are reliant upon these large forgings. As mentioned above, the world capacity for RPVs is estimated at approximately 15 per annum and JSW, for example, have reported a full order book for forgings for RPVs out beyond 2012.

Within the UK, Sheffield Forgemasters International Ltd. (SFIL) currently have the capability to forge the smaller components for the nuclear marine sector (eg, ring and head forgings for RPVs and SGs) and have also supplied some forgings for civil reactors overseas. The company also has the capability to produce the large steel castings required. However, an investment in a large (15,000 tonne) forging press would be necessary to create a capability for the forging of all components for civil nuclear RPVs and Steam Generators.

Nuclear Steam Supply System Pipework and Tubing

The extensive pipework, both within the nuclear island and from the nuclear island to/from the turbine house is a critical element of a nuclear power plant. Although there are significant differences between the volume and dimensions of pipework needed in the Westinghouse AP1000 and AREVA EPR designs, which is linked to factors such as the number of steam generators in the two designs, both require tens of kilometres of pipework (see Appendix B).

Both the high integrity pipework and the more conventional pipework is similar to that found in fossil-fired power plants and chemical plant, for example, and is manufactured from drawn pipe and cast or forged components (elbows, tees, end caps, etc.). The volume/length of these pipes is large and it would not be conceivable that one or even a few companies could meet the total volume requirements.

Although there are many induction bending machines in the UK and the EC, there are not many for large diameter, thick pipes because the demand has not been present in recent years. Thus, there is currently no UK-based capability in induction bending of large diameter thick-walled pipes, which is a potential bottleneck for UK supply, and would have to be reinstated, or a new nuclear build could be supplied from mainland Europe, if necessary.

The UK also has no capability to supply seamless, thin walled stainless and alloy steel tubing and Ni-base alloy tubing, and supply of such tube is largely from mainland Europe, from Sandvik (Sweden), Valinox Nucléaire (France), DMV (Germany), Tubacex (Austrian facility of Spanish parent company), and Tenaris (Italy), but also from Simitomo in Japan. However, AREVA identify only Sandvik, Valinox and Sumitomo as serving the Western market for steam generator tubing [10].

AREVA also notes that the current capacities of these tube manufacturers are sufficient to meet requirements in the short to mid-term, but will rapidly become insufficient with the number of projected new nuclear power plant projects [10]. In addition, AREVA notes that limited capacity to meet rising demand from the petrochemical industry also puts these suppliers on a critical manufacturing path for nuclear island tubing components [10].

The Manufacture of Nuclear Steam Supply Systems (NSSS)

It is difficult to get a complete picture of the global capacity for nuclear island manufacture. However, AREVA's Saint-Marcel plant near Chalon sur Saone, France, which is dedicated to the manufacturing of heavy nuclear equipment for the Nuclear Steam Supply System (NSSS), is currently capable of manufacturing the equivalent of 1.6 nuclear islands per year [10]. This does not include reactor coolant pump sets, etc., but only the RPV and head, steam generators, pressuriser, large pipework, etc.

The Saint-Marcel plant has manufactured all of the heavy components for the 900-1450 MWe units in the French nuclear program and had delivered more than 500 of such components to global customers as of the end of 2007. AREVA are currently increasing the capacity of the plant, with a plan for a 50% reduction in the total component transit time by the end of 2009 – ie, to take the nuclear island manufacturing capacity to a little over 3 per year.

The increase in capacity of the Saint-Marcel plant is linked to an investment plan, over the period 2006-2009, to increase capacity at Creusot Forge (thermal treatment and machining processes), which will eventually generate a 90% increase in the number of forging sequences.

AREVA note [10] that supply slightly exceeds current demand for the manufacture of heavy nuclear components, where AREVA's global competition (Doosan and Mitsubishi Heavy Industries in Asia, Ensa and Camozzi (formerly Ansaldo) in Europe, and Babcock & Wilcox in North America) partner with Westinghouse or General Electric for engineering and project management. In addition, AREVA note that other potential competitors, particularly in China, are not yet active on international markets [10].

Pumps and Valves

The environment in which some pumps and valves operate within a NSSS is very demanding (high temperature and pressure). The main reactor coolant pumps circulate pressurized water within the Primary Circuit to the steam generator whilst the main reactor feed-water pumps supply hot water to the steam generators within the Secondary Circuit. Without the latter, heat could not be effectively removed from the reactor or steam produced.

Up to four reactor coolant pumps are used for each reactor and each unit may also have a number of other, large, safety-related pumps and a large number of smaller pumps, which operate on either a continuous or intermittent basis, but which must have exacting standards of integrity – ie, they must work when needed. The AP1000 and ESBWR designs have 'passive safety' features and do not require any safety-related pumps.

Although there has been no new UK build since Sizewell B, the UK has maintained a world-leading capability in the supply of all nuclear and turbine island pumps. However, although the UK has current capability, the number of pumps required within the UK and globally may highlight capacity issues.

As in the case of pumps, a nuclear reactor requires a wide variety of high integrity valves, etc. for the Primary and Secondary Cooling Circuits and elsewhere within the nuclear island. Up to 2,100 valves may be used within the reactor system, with up to an additional 16,000 valves used elsewhere in the plant [21].

High Quality Steel

AREVA also notes that there are very few steelmakers capable of meeting the quality standards of the nuclear industry [10], and that most of them are currently concentrated in Italy (Safas and Terni), the United States (Lehigh) and Asia (Doosan Heavy Industries in South Korea and JSW in Japan). AREVA also notes [10] that China also has considerable capacity, and that India is in the process of installing capacity, but that companies in these countries are not yet qualified to meet nuclear industry requirements. Within the UK, Sheffield Forgemasters and Corus can meet the high quality standards.

AREVA has recently announced the launch of an investment program in Le Creusot (Burgundy), France, to increase the group's production capacity of forged nuclear components. Linked to this investment is investment in steel ingot production at the Arcelor Mittal's Industeel steel works, which will enable Industeel to increase its annual ingot production from 35,000 to 50,000 tonnes.

Nuclear Accreditation and Qualification

One of the biggest challenges facing new entrants into the nuclear supply chain is the issue of nuclear accreditation and qualification. Companies seeking accreditation or, as will be the case in a considerable number of cases, seeking to re-establish lapsed accreditations will need to commit considerable resources, both in terms of time and money, to secure nuclear qualification.

3.0 Supply Chain Input from the Vendors

In this section of the report, information from first-hand discussions with the reactor vendors is given.

3.1. Vendor Supply Chain Strategies

AREVA

AREVA is the only vendor undergoing the Generic Design Assessment (GDA) which is both supplier and manufacturer throughout the whole nuclear supply chain (nuclear fuel cycle, plant & equipment).

The company has adopted a strategic approach to global new nuclear build programmes (Generation III+ EPR, ATMEA1 PWR and SWR1000 BWR), with ongoing investment over a period of three to four years of approx €6 billion, to date, across all aspects of nuclear supply chain and for the whole life supply cycle. This is in readiness for its ambition to construct approximately one third of the accessible global new build market.

AREVA has developed manufacturing capability and incremental capacity to support new nuclear build programmes, and has assessed market needs from people & skills, to key components and the supply chain, and is now executing a global strategy to bridge the resource, skills, manufacturing & supply gap on a global basis. Thus, although new build programmes tend to be on a regional basis (eg, Europe, USA, China, India, etc.). AREVA's approach to the supply chain is to seek global partners to meet both global & regional needs. This allows any changes to regional or local new build programmes to be balanced by the wider global new build market and, therefore, ensures greater industrial certainty for both suppliers and AREVA.

AREVA is developing greater global manufacturing capability for the NSSS with the capacity to support the global new build programme. This is being achieved by both: (a) increasing internal capacity and (b) forming strategic partnerships with external suppliers. Thus, AREVA is actively seeking supply chain companies able and willing to invest for both the global market and at the same time support local new build programmes.

AREVA has identified all critical components for the EPR and has developed a strategy to ensure security of supply which entails:

- Developing capacity with existing suppliers / partners;
- Developing capability/capacity through qualification and/or investment with new suppliers;
- Developing a number of global suppliers per component, if feasible; and
- Ensuring that clients (ie, the utilities) order the plant in such time as to ensure production capacity can be booked for those components currently in limited supply.

For the Finnish Olkiluoto 3 EPR, AREVA has approximately 2,000 suppliers, from 28 countries, of which over 40% are Finnish. This large number of suppliers reflects the need to re-start the nuclear supply chain; however, AREVA considers this number of suppliers to be unacceptably high for future new builds.

In China, AREVA has arranged long-term partnerships between the utility (CGNPC) and the vendor (AREVA), and between AREVA and local Chinese suppliers for the construction of two EPRs. These local suppliers are already contributing to the AREVA supply chain for heavy primary circuit components, and are supporting production of critical components such as reactor coolant pumps, control rod drives mechanisms, reactor vessels, steam generators, primary piping, etc. In addition, the local suppliers are supporting critical component sourcing such as gas-insulated switchgear solutions.

Note also that AREVA and EDF have worked with supply chain companies to develop the ‘Burgundy Nuclear Partnership’ (see Appendix C).

GE-Hitachi

GE-Hitachi is a global nuclear alliance created in 2007 by GE and Hitachi to serve the global nuclear industry, and is a world-leading provider of advanced reactors and nuclear services, with more than 40 years of experience.

GEH has evaluated the global supply chain for new nuclear build programmes, in terms of companies available and their capability. In addition, GEH states that it recognises the value in developing, enhancing and promoting local partnerships with local companies that employ local staff, and will continue to pursue this strategy through its nuclear build program.

Westinghouse

Westinghouse has a strong history and track record of localisation which has resulted in Westinghouse technology being the basis of almost half of the 440 nuclear reactors operating around the world today, including Sizewell B, currently the UK’s only PWR. Westinghouse’s latest generation of nuclear reactor design, the AP1000 PWR, which has already been licensed by the US Nuclear Regulatory Commission and is currently undergoing the UK’s GDA, has been optimised during its development to not only provide enhanced safety, but also to minimise risk during construction.

For example, a modular approach has been adopted as part of the reactor design, which provides the potential for a significant input from an in-country supply chain. This coupled with Westinghouse’s declared approach of “we buy where we build” means that the company is reliant upon a global supply chain as, unlike AREVA, for example, Westinghouse is no longer a vertically integrated nuclear supplier/vendor and makes only a small number of its own parts/components (eg, control rod drive mechanisms (CRDMs) in its facilities in Newington, New Hampshire, USA). This, in turn, provides the potential opportunity to ‘localise’ manufacture wherever possible.

This ‘localisation’ approach has worked successfully in S. Korea and is now being developed in China, where contracts are in place for four AP1000 reactors. In S. Korea, a series build of a fleet of similar plants was accompanied by a steady increase in the proportion of the work carried out by local companies and workers such that S. Korea has now developed its own nuclear manufacturing capability, but still maintains a good level of business with Westinghouse (eg, recent contracts with Westinghouse for engineering and some component supplies for Shin Kori 3 and 4 reactors).

A similar approach is taking place in China where localisation and technology transfer form the basis of Westinghouse's business model in China. Progress is being made quickly with the development of a manufacturing capability in China, in areas such as an AP1000 module fabrication facility already being established at Haiyang to build modules and the reactor containment vessels.

It is Westinghouse's intention to take the same approach in the UK and S. Africa. However, the full 'localisation' approach cannot be justified for a single reactor build and significant investment will only be worthwhile for situations where multiple reactors are likely to be built within the same country or region, and there is a benefit in economy of scale.

Westinghouse's current policy is not to invest directly in manufacturing capability and capacity in areas outside its core competence, but instead, the company guarantees some of the output of companies investing and it looks to partner companies within the supply chain, with the intention of building long-term relationships.

3.2. Opportunities for UK-Based Companies

AREVA

To date, AREVA has stated the following as regards its view of the UK's nuclear supply chain:

"AREVA maximises the use of both its global integrated manufacturing capability and local resources in all its new build projects. AREVA looks forward to working closely with the UK supply chain to develop the appropriate strategy to deliver UK, and wider global, new build projects. AREVA has a significant industrial footprint in UK, mainly through its Transmission and Distribution business, which will provide the foundation for new build opportunities."

As the UK is likely to be Europe's first major new build market, AREVA is in the process of identifying those UK companies which have current or future capability, and the capacity, to support a UK new build, and European and global new build programmes. Thus, UK companies will potentially benefit from being suppliers into the first European new build market and beyond.

Currently, AREVA do not know what percentage of a new build will, or would be, sourced from within the UK; its investigations into the UK supply chain have yet to be completed. However, the company's experience to date shows that each country or market is different, and there is no simple formula.

AREVA has announced a 'declaration of intent', which focuses on three areas:

- Regeneration of skills;
- Partnerships with UK companies to meet global & UK new build needs; and
- Development of industrial activity in the vicinity of new build stations.

AREVA has identified UK based companies able to support its new build programme, and is currently in discussion with those companies. These companies will gain nuclear sector advantage through involvement in a UK new build programme, which may then be exportable to the global market

AREVA is prepared to invest (training, quality processes, etc.) to develop suppliers, which would then serve both the UK and the wider global market ('partnership' investment).

The company's views of the UK's current capability and capacity for different elements of the supply chain for a new nuclear build may be summarised as follows:

- Regulatory & Safety:
    - o There is significant UK experience within UK companies. AREVA recognises this skill base and recently acquired RM Consultants, a UK Safety& Environmental Consultancy.

- Manufacturing to support the Nuclear Steam Supply System (NSSS):
    - o The UK capability to support a global manufacturing strategy is being actively explored, and integration could simplify transportation and associated logistics.

- Manufacturing of components for the balance of the nuclear island:
    - UK companies have the skills & capacity to support the design & manufacture of components for the balance of the nuclear island, in areas such as waste management & handling, fire protection, Heating, Ventilation, Air Conditioning (HVAC), etc, and AREVA is actively exploring options with UK companies.

- Construction ('civils'), Installation & Commissioning:
    - There are UK based companies with the skills & resource to act as civil contractor and to undertake the installation and commissioning; it is AREVA's view that these tasks would be best undertaken by UK-based companies.

- Post-Build Asset Management, Services & Maintenance (Operation):
    - There are UK-based companies which currently, and thus could in future, undertake these functions, which are best undertaken by local companies.
    - It is of note that AREVA is already in partnership with major UK companies to provide Outage & Maintenance Services to British Energy's Sizewell B PWR.

- Waste and Used Fuel Management/Recycling (a part of the whole nuclear fuel cycle):
    - UK companies are directly involved in this operation today, and it is of note that:
        - AREVA, in the Nuclear Management Partnership consortium with a UK & US company, has been selected as Preferred Bidder for the NDA contract for the management and operation of Sellafield Site Licence Company, which includes used fuel management.
        - AREVA, in partnership with US, Swedish and UK companies, is managing and operating the Drigg Low Level Waste (LLW) Repository contract for the NDA.
        - Both the above examples reflect how AREVA plans an integrated approach to UK nuclear issues, by working in partnership with UK companies.

Currently, AREVA regards the following as providing the best opportunities for UK-based companies and AREVA is actively exploring these opportunities within the UK Supply Chain (see also Table 1 below):

- Detailed understanding and development of Nuclear Safety Cases;
- Consultancy: technical and commercial feasibility studies and evaluation;
- Manufacturing and specialist equipment supply;
- Construction, Installation & Commissioning;
- Post-build operational support & maintenance; and
- Integrated fuel, used fuel and waste management services.

Service	UK Opportunity	Export Opportunity	Investment Needed
Detailed understanding and development of Nuclear Safety case	✓	Some	No
Consultancy: technical and commercial feasibility studies and evaluation	✓	✓	No
Manufacturing and specialist equipment supply	✓	✓	Most likely
Construction, Installation & Commissioning	✓	✓	Not necessarily
Post-build operational support	✓	Within Europe	Yes, in skills & training
Integrated fuel and waste management / services	✓	✓	Possibly

Table 1 – AREVA view of opportunities for UK-based companies in the nuclear new build supply chain.

In summary, AREVA already employs in excess of 2,000 people in the UK, mainly in transmission and distribution, but also in instrumentation and risk management. The UK will benefit by this number increasing significantly, not only during construction of nuclear power plants, but through the long-term, life cycle maintenance, operations and waste and used fuel management of these plants. For example, in the US, AREVA employs over 5,000 personnel in the nuclear sector alone, a number which is increasing significantly as the new build market moves into a new phase.

GE-Hitachi

To date, GE-Hitachi has stated the following as regards its view of the UK's nuclear supply chain:

"GEH's assessment of the UK Nuclear Industry is well underway and, so far, GEH is pleased with the investment, commitment and capability of the existing supply chain. The construction of a fleet of ESBWR's in the UK could provide a substantial opportunity for the supply chain. Throughout this process, GEH plans to integrate local industry capability with its proven global supply chain to deliver projects on time and on budget."

GEH believes that developing the UK supply chain for constructing the next generation of nuclear power plants is essential to realising the vision of a nuclear renaissance in the UK. In addition, GEH is in discussion with the UK Government and others regarding public and private sector capacity building initiatives designed to further expand the UK new nuclear build supply chain, and has stated that the company looks forward to working with the Government to develop programs directed at fostering the renewal and growth of local nuclear capabilities that will integrate into the supply chain for new nuclear plants in the UK for many years to come. Currently, GEH has engaged Atkins Ltd as consultant for the GDA process.

GEH has stated that one of the key criteria in the company's selection of suppliers will be based on their willingness to invest in the future of nuclear technology and, in particular, the UK marketplace.

Regarding specific opportunities for UK-based companies GE-Hitachi's views of the UK's current capability and capacity for different elements of the supply chain for a new nuclear build may be summarised as follows:

- In the EPC (Engineering, Procurement, Construction) contractor market, GEH considers three large UK-based contractors to have the labour, equipment and capability for a new build project, and a further three or so companies which have the engineering procurement, but not the labour capability for a new build project. Thus, the GE-Hitachi view is that there are approximately six UK-based companies which would have the capability to 'manage' one, or perhaps two, projects. In addition to evaluating EPC contractor 'technical' capability, GEH has evaluated the financial capability of the large contractors, as cash flow or company finances could be an issue for multiple, concurrent projects.

- In Project Management (Engineering/Architects, etc.), GE-Hitachi considers the UK's capability to be somewhat limited, and suggests that there are perhaps only two or three companies with the required capability, and also notes that this is a potential area for international companies to win business in a UK new build programme.

- For Plant and Equipment, the highest value component of a new build project, GEH consider three elements:
  - Steam turbine(s) and generator, where there are no UK-based OEM suppliers, although it should be noted that a couple of companies do provide a complete spares, repairs and maintenance service for steam turbines, from within the UK.

  - Reactor vessel, where the size of the GE-H ESBWR (European Simplified Boiling Water Reactor) vessel means that UK-based companies cannot supply currently. Japan Steel Works (JSW) has been contracted by GEH for new builds, and can satisfy needs within required timescales. GEH note that orders for large forgings now need to be placed seven years in advance of required delivery and believes that there is enough global capacity to supply.

- Balance of Plant (BoP), which includes pumps, valves, switchgear, electrical control & instrumentation systems, etc. GE-Hitachi's view is that the UK is relatively well positioned, with a number of suppliers. However, the company is also concerned about the capability of some BoP suppliers to meet the demands of multiple projects, because of potential cash flow and throughput capability issues.

- For the Nuclear Fuel Cycle, GE-Hitachi operates throughout the nuclear supply chain, including current service and nuclear fuel cycle capability within the US. It would be the company's intention to replicate its fuel handling capability within the UK, irrespective of whether or not engaged as a reactor vendor (ie, GEH will look to support all UK new build reactor types).

Westinghouse

To date, Westinghouse has stated the following as regards its view of the UK's nuclear supply chain:

"Our approach of "We Buy Where We Build" is based on a strong track record of localisation in countries like Korea, and we fully expect to repeat the approach in the UK. We have been most encouraged by the enthusiasm of UK suppliers to engage with us, and we are sure that the reactor coolant pump casings currently being made in the UK for the Chinese AP1000 plants will be the first of very many contributions to the AP1000 fleet to be produced here."

Westinghouse has identified several UK based companies across a range of disciplines which have the capability and capacity, either now or in the future, to support the building of AP1000 reactors in the UK, and is currently in discussion with those companies.

From discussion, Westinghouse would look to use UK companies to supply into some of the markets in Europe; in particular, those where it is likely that only one or two plants will be built in the medium term. Thus, UK companies will potentially benefit regionally from being suppliers into the first major new build market in Europe and possibly on a global basis. Indeed, some UK companies are already providing support to Westinghouse's programmes such as Sheffield Forgemasters which is providing reactor coolant pump casings for Westinghouse's AP1000 projects in China and Rolls Royce and Aker Solutions who are both working with Westinghouse on regulatory and safety case work for the UK GDA.

The Westinghouse design utilises approximately 300 nuclear island modules of varying size, and Westinghouse identifies several major UK companies with the capability to build modules.

In general, Westinghouse considers local supply capability in terms of:

- Competitive advantage;
- Logistics / schedule advantage;
- Quality; and
- Capacity & potential to be a global supplier.

Westinghouse can benchmark new build costs in UK with those in China and US, and believes that any additional costs of 'localisation' within the UK can be offset against: the reduced transportation costs vs. imports, the reduced risk and delays vs. imports, effected by more control and speed/timeliness of local supply, and the increased speed to start-up for the utility, which starts generating electricity faster.

Westinghouse believes that up to 70-80% of the value of the modular AP1000 construction (nuclear island) can be built in the UK; ie, that the UK has the capability to manufacture, construct and erect 70-80% (as a proportion of total value) of an AP1000 reactor. Furthermore, the company's view is that of the 20-30%, which cannot currently be provided from within the UK, investment would mean that some of this could be realised in the UK (eg, the RPV and safety significant pumps and valves).

The Westinghouse nuclear business consists of: New Plant, Fuel and Services. For the nuclear fuel cycle, subject to agreements and some investment, Westinghouse would intend to use the UK's nuclear fuel factory at Springfields to supply the fuel for a new build fleet of AP1000s in the UK, providing important security of supply.

This Light Water Reactor (LWR) fuel line sits within an existing facility at Springfields and has previously produced LWR fuel for Sizewell B, but will need some investment to be able to produce fuel for the

AP1000 reactor design. With the reactor numbers being projected (and discussed), the investment to reinstate the line could be justified. However, also an option is investment to increase capacity at the Westinghouse facility in Sweden, which currently supplies up to 30% of EDF's fuel, as well as reactors in Sweden, Finland, Germany, Spain, Belgium, Switzerland and the Ukraine.

Note: Further to (and supportive of) the above, the following announcement was made on the 4th September 2008:

"Westinghouse Electric Company has today signed pioneering agreements with BAE Systems, Rolls-Royce and Doosan Babcock to collaborate on work associated with bringing the AP1000 nuclear power plant to the UK.

The agreements are part of the Westinghouse strategy to "buy where we build" and are key milestones in the process which may lead to between 70 and 80% of the work and services required to construct the AP1000 being provided by the UK supply chain, securing valuable jobs in Britain.

The three separate Memoranda of Understanding (MoU) put in place arrangements for Westinghouse to work on an individual basis with BAE Systems, Rolls-Royce and Doosan Babcock. Areas of work in the three MoU's are different but cover areas such as:

- ***Design, production, fabrication and integration of modules***
- ***Development of a supply base in the UK***
- ***Onsite erection and assembly of components***
- ***Support for commissioning***
- ***Nuclear component manufacturing***
- ***Safety and technical support***

Westinghouse has a unique approach and demonstrated track record in localising the supply chain for new nuclear build. This approach is currently being implemented in China, where work is already underway on the first two of a series of four AP1000 plants ordered there."

3.3. The Nuclear New Build Value Chain

It is very difficult to get a good indication of where the value is in the construction of a new nuclear power plant, as this information is commercially sensitive. In addition, the different designs and modes of construction mean that there are likely to be significant differences in the value which may be apportioned to the different supply chain (eg, NSSS and construction) elements.

However, for reference, the total budgeted costs for the Sizewell B project were apportioned as shown in Table 2 below:

Section of Project	Total Value (£m) (at April 1987 Prices)	% of Total Project Value
Nuclear Steam Supply System (NSSS)	566	27.9
Civil Works	406	20.0
Turbines & Other Mechanical Plant	254	12.5
Control & Instrumentation	129	6.4
Electrical Plant	110	5.4
Fuel	65	3.2
Construction & Commissioning	43	2.1
Plant & Services Sub-Total	**1,573**	**77.5**
Software	449	22.1
Setting-up & launch Cost of Project	8	0.4
TOTAL VALUE AS AT APRIL 1987	2,030	100

Table 2 – Total budgeted costs for the Sizewell B PWR (from reference 16).

Note also, that some capital cost information for different reactor designs are given in a report by the University of Chicago for the US DOE [33], but this information has not yet been analysed as part of the present study.

In discussion, the reactor vendors have given the following, relatively limited, information as regards value in a nuclear new build.

AREVA

AREVA's view is that the new build value chain must be looked upon as part of, and not separate to, the whole nuclear life cycle value chain. Thus, UK companies will wish to participate in not only the (short) construction phase of a nuclear power plant, but also the (very long) operations, servicing and waste management phases of that plant, in all perhaps a 100 year + cycle, and the transmission & distribution of the electricity produced.

The new build value chain in UK will be driven by those companies able to meet the exacting standards of the nuclear sector and either add value across more than one part of the nuclear life cycle or provide key manufacturing. Currently, AREVA works in partnership with UK companies in PWR servicing & maintenance, fuel supply and waste management, and is seeking to expand the current partnerships and, as such, is actively seeking companies able to add value within the reactor construction part of the cycle, and beyond.

GE-Hitachi

GE-Hitachi did not provide any specific supply chain value information, only that Plant and Equipment, for the Nuclear and Non-Nuclear Islands, and the Balance of Plant (BoP), is the highest value component of a new build project.

Westinghouse

Westinghouse values the various parts of the AP1000, in round terms, as follows:

- Nuclear Island Plant & Equipment at approximately 55-60% of the total value, comprising:
    - Heavy components: around 20%
    - Mechanical: around 20%
    - Electrical: around 20%
- Construction: 30-35%
- Project Management: around 10%

3.4. Supply Chain 'Pinch-Points'

AREVA

AREVA has identified a number of 'pinch-points' in the new build supply chain, which it is overcoming by increasing capacity or working in partnership with other companies. As mentioned earlier, AREVA is actively exploring the ability of UK industry to support the major manufacturing required of the Nuclear Steam Supply System (NSSS) for the UK and globally.

GE-Hitachi

GE-Hitachi believes that potential 'pinch-points' such as large forgings and skilled labour (see below) will be exacerbated by multiple, concurrent builds, and sees an overriding issue as being the number of plants to be built in parallel, and within the UK. Thus, this may be the ability of UK-based resources to build up to say four plants on a staggered start, and ultimately concurrent, basis.

Westinghouse

From detailed analysis of the supply chain for the AP1000, Westinghouse has identified several 'pinch-points'; some of which are as follows:

- Ultra-large forgings for NSSS (eg, RPV & Steam Generators) and large steam turbine and generator rotors.
- Reactor coolant pumps, where there is currently a single global supplier (Curtiss-Wright EMD in the US), although Westinghouse is working to develop increased global capability/capacity, including within the UK.
- Stainless steel tubes and valves, which are available, but the demand is high from nuclear and from other process industries. In addition, these products are subject to significant price variability.

For ‘pinch-points’ such as ultra-large forgings, all customers committing to Westinghouse will have guaranteed supply, and reservation fees required by the forgers will be agreed as appropriate.

The Westinghouse view is that, with investment, capacity will be available for ultra-large forgings, as Japan Steel Works (JSW), IHI Corporation (Japan), Doosan Heavy Industries (Korea) and Sheffield Forgemasters look to develop either capacity or capability. In addition, China & India are expected to supply their own needs, with the scale of the new build programmes meaning that both countries will probably fully utilise their own capacity in future. Thus, although the view is that Chinese and Indian forgemasters will export eventually, initially these countries’ internal programmes are likely to keep them out of the global market.

Westinghouse believes that the UK has the manufacturing capability required, but not the current capacity (eg, facilities currently committed to existing work) to meet the needs of a UK nuclear new build programme. The company’s view is that significant investment in certain key facilities (eg, module fabrication facilities) is required.

3.5. The Availability of UK-Based Skilled Workers

AREVA

AREVA’s view is that the UK does have the skills required to deliver a sound nuclear new build construction programme, the question is overall capacity and priority for those skills. Thus, there are a number of factors which will drive the pace and rate of a nuclear new build programme, and AREVA believes it unlikely that skilled workers will be ***the*** critical issue in UK. A new fleet of UK reactors will be constructed over a period of time that will both allow training of new personnel, re-training of current personnel and the transfer of skilled personnel from one site to the other as new reactors are constructed and commissioned.

Once there is greater certainty in the new build market and contracts are let, then recruitment will start in earnest by both AREVA and its (contracted) partners, recruitment that will lead to training and major opportunities for UK personnel, and which will turn today’s opportunity recruitment market into a real market. AREVA’s view is that the sooner this starts, the greater the opportunity for UK personnel. AREVA is currently recruiting, globally, some 11,000 people a year; in the UK, the process started with the acquisition of RM Consultants.

Westinghouse

As in the case of manufacturing capability, Westinghouse believes that the UK has the skills required, but not the current capacity (eg, resources committed to existing work) to meet the needs of a UK nuclear new build programme. The company’s view is that significant investment in skilled workers to be allocated to a civil nuclear programme is required.

In particular, Westinghouse has identified a shortage of skills in project management and planning, and inadequate numbers of commissioning engineers and operators, where a year of full-time training is typically required. The requirement will be for approximately 300 to 400 operators per plant, depending on the utility requirements, regulations, etc., and whether or not multiple reactors are deployed. Thus, for a single reactor, it will likely be possible to meet the needs, but this will not be the case for a new fleet, without significant investment in skills. However, some operators will become available from the shut-down of retired plants. In addition, Westinghouse identifies a shortage of welding engineers, for the welding of high integrity pressure vessels, but not for the plant erection (eg, for structural steelwork).

Finally, Westinghouse notes a reliance upon companies with internal programmes for skills development, and Westinghouse itself has seen a significant increase in recruitment to 1,300 personnel in 2007/08, from 800 in 2006/07, and from 400-500 in previous years, and considerably smaller numbers in the 1990's.

That said, Westinghouse recognises that, with sensible planning, there is good time to develop the skills needed in sufficient quantities to deliver new build in the UK without the introduction of additional delay. Westinghouse is actively taking steps to make sure this happens - for instance, through active participation in the National Skills Academy for Nuclear (NSAN), where Westinghouse hold both a seat on the Board and the Chairmanship of the North West / North East Employer Steering Group. Springfields plays a central role in the NSAN programme and was one of the first recognised training providers in the field of engineering apprentice training. Westinghouse is also playing a positive role in skills development in other areas of the nuclear cycle and, as an example, has recently announced the establishment of a Westinghouse-funded Chair at Manchester University in the field nuclear fuel technology.

Overall, therefore, Westinghouse believes that the necessary skilled labour force will be in place for a UK nuclear new build programme.

GE-Hitachi

GE-Hitachi has expressed concerns about the availability of skilled workers; in particular, when into the construction phase of a new build programme and for multiple, concurrent builds. The company identifies a shortage of coded welders, capable of welding to nuclear standards, Control and Instrumentation technicians, and coded, skilled craftsmen, which it believes may see contractors importing skilled workers.

GE-Hitachi sees UK labour rates as being some of the highest in the world, such that the labour 'content' of a new build programme would be greater than for other regions of the world, which may cause some issues (eg, when tendering), the extent of which may be dependent upon the specific 'make-up' of any new build consortia.

GEH has established a UK-based centre of excellence for Europe-wide nuclear project management and technical expertise in Bracknell, and continues to ramp up the number of employees and the skills in line with anticipated development needs.

In addition, GEH is a board member of National Skill Academy for Nuclear (NSAN), and is developing links with several universities in the UK. Also, GEH aims to establish a sponsorship fund for nuclear related studies and is looking at a number of other ways of increasing the UK's nuclear engineering resource pool (eg, student sponsorship, the creation of a chair at an appropriate university and/or offering training opportunities in GEH's nuclear businesses).

4.0 Supply Chain Input from Selected Utility Companies

In this section of the report, information from first-hand discussions with personnel from EDF and British Energy is given. As mentioned previously, the intention is to seek very broad input from the utility companies to an assessment of the 'readiness' of the UK's supply chain, and this work will be carried out by the Office of Nuclear Development (OND) over the coming months.

EDF Energy

EDF and AREVA (nuclear operator and reactor vendor, respectively) are jointly managing the Generic Design Assessment (GDA) of the EPR. Upon completion of the GDA, EDF are not finally committed to using the EPR in any UK new build, and AREVA will have the rights to sell the EPR to any potential UK licensee.

EDF's role longer-term is focused on being architect/engineer for nuclear power plants, which is the company's current role for the Flamanville 3 EPR new build project in France, and which includes the design function outside of the nuclear island (ie, outside of the scope of the current relationship with AREVA).

For Flamanville 3 procurement, EDF has 130-150 contracts and planned costs are approximately €3.3 billion. The largest contracts are with AREVA (nuclear island equipment) and Alstom (turbine island equipment), with the remainder contracted through a tendering process. From the Alstom website, the company has been awarded a contract of €350 million for all engineering, procurement, construction and commissioning of the complete turbine island (steam turbine, generator, condenser, moisture separator reheaters and auxiliary equipment). From the Bouygues Construction website, the company has been awarded a contract of €300 million for all civil engineering.

EDF's procurement model for the UK is likely to be the same as that for Flamanville 3, although this is not yet defined. The intent would be to look for UK suppliers within the 130-150 contractors. Thus, based upon Flamanville 3, EDF estimates that in excess of €1 billion available for contracts beyond the nuclear and turbine islands - eg, for 'civils', which would be the largest contract, and other contracts (eg, erection, on-site structures/engineering). EDF are not yet in a position to cost a UK new build project; to some extent because of recent € / £ exchange rate variations. However, the company will have a better indication as Flamanville 3 proceeds.

EDF already has significant UK input to ongoing licensing & planning activities. EDF (and AREVA) has formed an alliance with AMEC, a licensed UK nuclear operator, for the EPR design licensing by UK regulators and for site studies, in which AMEC is working with EDF engineers with expertise related to the operation of nuclear plant. In addition, Rolls-Royce is involved in evaluating the nuclear safety case for the EPR.

As the nuclear island for an EDF power plant would be reactor vendor supplied, EDFs view on the 'pinch-points' in supply chain are the same as those of AREVA, although as mentioned above EDF is not finally committed to using the AREVA EPR in any UK new build.

EDF's view is that 'pinch-points' already identified are being addressed and that the real 'pinch-points' may not be as anticipated currently. However, EDF has great faith in the supply chain rising to the challenge.

British Energy

British Energy (BE) operates all of the UK's AGR reactors and the PWR reactor at Sizewell B, and has ongoing relationships with a number of companies for servicing existing nuclear power stations, and which would be capable of supplying into a new build programme – eg: for plant improvement projects, outage support, welding services and asset integrity assessment across the AGR fleet and Sizewell B.

BE notes that there are materials differences between the three reactor designs undergoing the GDA, and so it is not readily feasible to early order or stockpile for critical components. Thus, multiple suppliers for critical components are desirable/required.

For Sizewell B, there were approximately 150 major contracts, but it is now envisaged that for a new build, the reactor vendor and one or more of three or four capable (BE's view) Engineering, Procurement, Construction (EPC) contractors would manage lower tier suppliers.

BE notes that security of the supply chain for a new nuclear build is important, over the 60 year lifetime of a station. There will be a need for spares, repairs and service from the Original Equipment Manufacturers (OEMs) and a need to retain access to the supply chain involved in the original build. Thus, key suppliers need to remain in business and be able to provide service for the life of the stations and, in terms of responsiveness and logistics, 'local' suppliers are 'ideal'.

BE sees opportunities for UK based companies in supply for both niche and more generic applications. Thus, there may be global opportunities in niche markets (eg, nuclear grade pumps & valves), in which UK-based companies have previously generated export business as a result of developing capability for supply into Sizewell B, for example. In addition, there may be opportunities for the supply of more generic components, where supply is not tied to either US or French Standards (eg, high quality, 'low smoke zero halogen' cabling for harsh (elevated temperature, corrosive) environment applications).

BE believes that there are opportunities for suppliers who can do better than those currently within the supply chains for ongoing projects (eg, Olkiluoto 3 in Finland). However, new build nuclear island plant and equipment will be designed to standards not commonly in use currently within the UK, which international supply chains are often best suited to meet.

BE also notes that there will be opportunities for UK-based supply into existing fleet life extension, in the form of spares, replacement parts, etc. In this respect, the Nuclear Installations Inspectorate (NII) has no requirement for particular Codes and Standards, but prefers suppliers with a nuclear pedigree and those international standards that they are familiar with.

BE believes that the market may see transfer of knowledge, etc. to UK based subsidiaries of multi-national companies (eg, US-based parent companies), such that companies which have 'done it before' or are supplying elsewhere in the world may use this route to overcome some of issues associated with nuclear accreditation, for example, and accelerate the time required for technology/knowledge transfer.

BE identifies the following global supply chain 'pinch-points':

- Ultra-large forgings, for large steam turbine and generator rotors as well as forgings for RPVs and Steam Generators. Thus, although capacity is not an issue currently, dependent upon how quickly global new build programmes materialise, large forgings could become a significant 'pinch-point'.

- Primary loop coolant pumps, where Curtiss-Wright EMD (US) is the only current supplier. However, British Energy believes that Westinghouse is trying to qualify a supplier in Germany (which is consistent with Westinghouse input), via a different design, which may introduce some interchangeability issues.

- Steel grades for transformers (a capacity issue).

- Skilled construction capability and the availability of good project management, where large project management companies may have their pick of global construction projects, are also likely to be an issue. However, currently it is not clear how big an issue this will be.

5.0 Supply Chain Input from Selected Construction Companies

In this section of the report, information from first-hand discussions with personnel from Sir Robert McAlpine and Costain is given. As mentioned previously, the intention is to seek very broad input from the construction and EPC contractor sector to an assessment of the 'readiness' of the UK's supply chain, and this work will be carried out by the Office of Nuclear Development (OND) over the coming months.

Sir Robert McAlpine

Sir Robert McAlpine (SRM) was architect, designer and builder for six of the UK's nuclear power stations, and with the acquisition of Taylor Woodrow Construction's nuclear design consultancy business in March 2007, SRM 'gained' a company which was designer and builder of a further six of the UK's nuclear power stations. Thus, SRM was designer and builder of 12 of the UK's 17 nuclear power stations. In addition, SRM is involved in the Flamanville 3 project, as designer to a French company for the auxiliary building, which is increasing the company's nuclear experience.

Currently, SRM is in discussion with all reactor vendors, with no current commitments, which it believes is likely to be the same across the construction industry. The company anticipates that for series builds, the same contractors will be used for a given vendors' activities; the benefits of which are that the knowledge/experience gained in construction is retained for subsequent builds.

However, SRM's view is that it should not be assumed that Nuclear Power Plant (NPP) construction will default to UK-based companies, as it will be a competitive situation. Regardless, SRM's view is that the vast majority of the construction workforce will be British, even if overseas-based companies win construction contracts, as it is not cost-effective to bring an overseas workforce to the construction site.

SRM estimates that perhaps 25% of the value (cost) of a new build NPP is the civil engineering/construction and notes that very few construction companies take on contracts of £400-500 million or so, the anticipated value of the civil engineering/construction contract(s), alone. Construction companies will usually partner to spread the financial (and other) risk. Thus, with joint ventures, the consortia with new build capability are reduced to perhaps three or four.

However, it is not yet clear how the building of a NPP will be organised, which will depend on the client, and contracts will vary from client to client. SRM notes that the civil engineer/contractor usually has a logistics role for infrastructure projects, but again, it is not clear how this will work for NPP construction.

Most constructors have little or no experience of building a nuclear power station; thus the experience is that of 'first time'. In this respect, SRM notes that there is little difference between NPP construction and that of other major infrastructure projects, although the quality is higher and the paperwork is increased. However, companies can prepare for this, and SRM's view is that there will be time to prepare for NPP construction, following planning consent, etc. lasting perhaps two years.

SRM does not perceive there to be any real capacity 'pinch-points' in the construction supply chain, with the only potential issue foreseen to be that of workforce mobility to remote NPP sites. The view is that construction staff do not move around as much as previously and perhaps some incentive will be needed for them to do so. In general, the construction industry uses two resource 'models'; the first of which employs a large number of in-house or in-company operatives, and the second uses sub-contractors. Of these two 'models', SRM use the sub-contractor model.

In addition, SRM does not perceive that there are issues regarding concurrent NPP builds and concurrent NPP construction and other potential major infrastructure projects (eg, Severn Barrage, Crossrail, etc.). Thus, although the construction industry has been stretched in recent years, the pressure has now been relieved to some extent with the 'credit crunch' and slow-down in construction activity.

In addition, there are different elements of construction, which mean that different skills/resources are required for different phases of the build (eg, foundation/piling specialists are required for early construction phases, followed by above ground specialists for formwork, steel fixings, etc.). It should be noted also that the Severn Barrage could use a completely different form of construction; hence, different skills/resources would be required. However, some staggering of build projects would clearly alleviate any potential resource issues.

Costain

Costain has recently constructed the Diamond Synchrotron facility at Harwell, which involved equivalent, high levels of quality required in NPP construction. In addition, the company will look to use its experience/expertise gained in decommissioning projects, in a new build programme.

For nuclear new build, Costain's delivery model will be one of construction and project management (EPC), using specialist sub-contractors, and the company's working assumption is that civil engineering/construction will have a value of approximately £600 million for each Nuclear Power Plant (NPP), which is based on approx. 30% of the total of approximately £2 billion per NPP. For such a large contract, Costain would look to partner in civil construction to spread the financial risk, as in the case of other major infrastructure projects (eg, road, rail, etc.).

Costain notes that in addition to the basic NPP design, the civil engineer/constructor also needs to consider the geology, etc. of the site, as this may influence the nature of the temporary works, which have to be put in place to enable the construction itself.

Modular construction, as in the case of the Westinghouse AP1000, will influence the civil construction method of a NPP. Thus, the benefits of a modular approach are as applicable to site construction as to other aspects of a NPP new build programme, as follows:

- Enables some construction close to site rather than on-site;
- Reduces the numbers (workers) on site;
- Increases overall quality;
- Shortens the time required for the build; and
- Improves safety, as although the movement of larger pieces of equipment/modules takes place, but there are fewer of them.

As in the case of Sir Robert McAlpine, Costain does not perceive any issues regarding the availability of resources for concurrent NPP builds, or from other potential major infrastructure projects, and the company does not identify any real capacity 'pinch-points' in the construction supply chain, which includes the availability of materials (eg, re-bar, cement, etc.). However, Costain highlights grid connectivity of the new build NPPs as an issue which needs addressing.

As regards the availability of skilled workers, Costain anticipates that there may be an issue of workforce quality at some 'remote' NPP sites, if other major infrastructure projects are ongoing at the same time as a NPP build. Thus, the proximity of other infrastructure project(s) may influence the availability of 'highly skilled' workers at such sites. In addition, Costain notes that new build projects will (need to) employ some foreign labour, as is currently the case for major infrastructure projects such as 2012 Olympics site construction.

6.0 Additional Supply Chain Input

In this section of the report, information is given from first-hand discussions with personnel from a number of other companies with either aspirations to supply into, or provide services to, a nuclear new build programme, or with ongoing nuclear-based activities, both UK-based and global. As in the case of the utilities and construction sector, the intention is to build upon this relatively limited information, and to seek very broad input to an assessment of the 'readiness' of the UK's supply chain, and this work will be carried out by the Office of Nuclear Development (OND) over the coming months.

AMEC Nuclear

AMEC and its predecessor companies, has a long history in all phases of the Nuclear Power Plant (NPP) lifecycle, from design through construction and maintenance to decommissioning, both within the UK and overseas. AMEC has been at the forefront of the development and assessment of alternative designs of reactors for the UK market, and designed and built the UK fleet of Magnox, AGR and PWR civil nuclear reactors, as well as the Magnox reactors at Latina in Italy and Tokai-Mura in Japan. Most recently, AMEC were the designers of Sizewell B PWR, through a Joint Venture with Westinghouse (PWR Power Projects), which had responsibility for the major auxiliary systems in the nuclear island.

Since Sizewell B, AMEC has performed the role of reactor concept consultant/advisor to UK regulatory reviews, and currently AMEC is providing technical and project support to the UK EPR Project for the Generic Design Assessment (GDA) phase. AMEC has worked with BNFL/ Westinghouse previously, on the AP600 and AP1000 designs, and is currently supporting EDF for the UK EPR.

AMEC also has significant involvement supporting Bruce Power on design, construction and commercial management in the ongoing Bruce A, reactors 1 and 2 refurbishment and re-starts, in Ontario, Canada.

AMEC offers Continued Operations Support, Decommissioning and New Build services to the nuclear sector and would look to perform an architect engineer role with a utility in a new build project, where the company could deploy staff across the supply chain. In this respect, AMEC has a substantial pool of skills in nuclear and related industries, and so has some flexibility to move resources from different parts of the business. (eg, from broader power & process and oil & gas sectors).

AMEC identifies a number of issues which lie on the critical path to nuclear new build implementation – ie, represent risks to the deployment of new NPP. For example, the availability of large forgings, of sites and the availability, or numbers of, qualified engineers. Regarding the latter, within the UK, there has been little opportunity to exercise nuclear new build skills, other than through consultancy and AMEC's strategy has been to seek involvement in international reactor relevant projects including Generation IV reactor projects, such as the Pebble Bed Modular Reactor (PBMR), which helps provide opportunities for skills maintenance and development.

In addition, AMEC recognises a shortage of skilled mechanical and electrical installation engineers, which it believes could represent a significant challenge for the UK in a sustained nuclear new build programme.

AMEC notes that in isolation, the UK could provide significant content to a nuclear new build programme. However, the existing (vendor) supply chain has to be taken into consideration. Thus, the utilities will want a reliable and cost-effective build programme, which will exert pressure on the vendor to use its existing and qualified supply chain.

Rolls-Royce

As mentioned previously, Rolls-Royce has recently announced that it is establishing a new business unit to address the global market for civil nuclear power. The company estimates that this worldwide market could be worth £50 billion a year by 2023. Rolls-Royce has a significant nuclear supply chain, comprising approximately 260 companies, most of which are UK-based.

Rolls-Royce's believes that its experience in nuclear power, which originates from its involvement in the development and support of the nuclear steam raising plant for the Royal Navy's nuclear submarine programme, is directly applicable to all phases of a nuclear new build programme. In addition to the nuclear submarine programme, Rolls-Royce established Data Systems & Solutions (DS&S) in 1999, which provides safety critical instrumentation and control for civil nuclear reactors in Europe, including France's 58 reactors, the US and other markets such as China.

Rolls-Royce's civil nuclear unit will provide "a service that can support a number of the phases of a civil nuclear programme, including providing advice to governments and operators, technical engineering support and safety assessments, manufacturing, procurement and through life support."

Rolls-Royce has outlined an analysis of the UK based supply and value chain for a nuclear new build programme based on the following assumptions:

- To maintain the current balance of nuclear energy production, the UK will have an initial requirement for approximately 12 GWe of replacement capacity, equivalent to about 10 new power plants or reactors, at a cost of approximately £14-16 billion, with ongoing support of £80 million per annum per plant; and

- The construction of the first plant will take about 5 years, whilst succeeding similar plants will take 3-4 years.

The analysis values the new build market elements, or roles, in round terms, as follows:

- 'Client roles' – eg, contingencies fees, license and risk management: around 15-20%
- Nuclear plant constructor roles, including project and site management and commissioning: around 5-10%
- Turbo-Generator and High Voltage systems: around 20%
- Civil, Mechanical & Electrical, and Construction: around 20%
- Safety case, and detailed procurement construction management: around 10%
- Reactor Plant: around 30%, of which major reactor vessels, valves, pumps are 10-15%, Instrumentation and Control are around 10%, and Fuel Handling systems are around 5%.

In addition, Rolls-Royce values the ongoing support (post-build and commissioning), in round terms, as follows:

- Maintenance: around 15%
- Operating staff costs: around 15%
- Engineering and Safety: around 10%
- Fuel and Waste services: around 35%
- Reactor Spares and Outage Management: around 25%

The above assumes that a number of the above ‘roles’, in both new build and ongoing support, will default to the UK and be undertaken by UK labour pools (eg, site management, civil, mechanical, electrical and construction, operating staff and maintenance activities).

Of the remaining activities Rolls-Royce’s view is that the UK should focus its effort on developing and sustaining world-leading expertise in the following areas:

- Detailed understanding and development of the Nuclear Safety case;
- Reactor Plant sub-system module and product definition, and regional supply chain management;
- Reactor Plant manufacture, assembly and its engineering support; and
- Fuel and Waste services.

Furthermore, Rolls-Royce notes that as the nuclear plants to be built in the UK are likely to be the same plants as those which will be built in the Far East, USA and the rest of Europe, the skill sets developed, particularly those of a specialist engineering and nuclear safety nature, will be of high value in overseas markets due to the shortfall in such skill sets against the predicted worldwide ‘nuclear renaissance’.

Serco

As mentioned above, Serco is responsible for managing the day-to-day operations of the Atomic Weapons Establishment (AWE), Aldermaston (Berks.). Serco’s Technical and Assurance Services business provides specialist technical support to the UK nuclear industry, providing expert safety, environmental, risk and asset management advice and operational solutions to many of the UK’s civil nuclear sites.

Serco in not currently active in a new build programme, but would look primarily to fulfil two major roles which are both related to technical consultancy (safety case and technical assessment), for either the regulator (the NII) or vendors in regulatory processes such as the Generic Design Assessment (GDA).

Serco has a pool of approximately 300-400 nuclear engineers/scientists/technicians who are engaged in safety case assessments and the regulatory process, both new build and activities on the UK’s existing fleet of nuclear power plant, both civil and defence (British Energy AGRs and RN submarines).

Serco identifies the availability of skilled workers/engineers as an issue and the nuclear regulatory processes as major ‘pinch-points’.

Parsons Brinckerhoff

Parsons Brinckerhoff (PB) provides international consultancy services to the power and infrastructure sectors, offering services which include: Programme and Project Management, Quality Management and Inspection Services, Construction Management, Strategic Consulting and Environmental Advice on compliance with regulations during design, construction, operation and decommissioning of nuclear power plant and facilities.

PB is currently short-listed to be the Owner's Engineer for a number of potential purchasers of new nuclear power plants around the world, and is already engaged by British Energy, EDF and RWE in the UK. However, due to the slow development of nuclear new build in the UK much of their focus is now on opportunities elsewhere in the world.

PB believes that at present the UK has the capability to compete for a substantial proportion of the work on any nuclear new build programme, but is concerned that the UK has become one of the slowest markets to develop. Thus, PB resources and skills are focussing on more rapidly developing markets including the USA, South Africa and the Middle East.

Furthermore, PB believes that any significant developments in these other markets are likely to draw a significant proportion of the UK capability overseas. In addition, the reactor vendors will focus on these markets and make their investment in the supply chain in those areas, such that when the UK eventually looks to order new nuclear plants, they may struggle to find good resources and will have to buy from the developed supply chains elsewhere in the world.

As regards the manufacturing supply chain, PB undertakes the quality inspection on behalf of most of the UK nuclear utilities and believes that the UK has the capability in many of the required areas for a nuclear new build programme, but it will be their ability to compete economically which will determine the proportion of components that are supplied by UK companies.

PB identifies the GDA as a significant bottleneck in the UK's nuclear new build process, as without the process coming to fruition, no building can take place. In addition, the issue of sites is now critical and needs to be resolved before the UK industry can move forward.

In addition to skills (and PB is recruiting heavily), PB also identifies turbine generators as a significant 'pinch-point' in the nuclear supply chain, as there are very few (four) large turbine generator OEMs and so there is little competition and incentive to increase capacity to serve the large nuclear and fossil fuel power generation markets.

BAE Systems

As background (very recent only), BAE Systems (BAES) designed and is currently building (at Barrow-in-Furness, Cumbria) Astute Class submarines for the Ministry of Defence under a Prime Contract, which will also provide initial in-service support. The building of the submarines uses a modular build and sub-system integration strategy, which involves the integration of many sub-systems, in a similar manner to that of the construction of the Westinghouse AP1000 in particular.

BAES's current supply chain for the Astute consists of approximately 190 'significant' suppliers, many are UK-based as security issues, in particular, have a significant impact on procurement policy. Over time, the number of direct suppliers has been reduced significantly and BAES has established a 'key suppliers' group.

BAES has been actively thinking about involvement in the civil nuclear build for more than two years. However, it has only become clear within the company that it should be involved in the UK's new nuclear build programme within the last year or so, and since the Nuclear White Paper [18], in particular.

BAES has been in discussion with both Westinghouse and AREVA regarding the UK nuclear new build, and as mentioned above, Westinghouse's modular, 'factory based' construction approach is most compatible with BAES's strengths/skills, developed in submarine building. In this respect, BAES has details of the modules of the Westinghouse AP1000 and considers approximately one third of the modules to have sufficient equipment content and complexity to be of interest. Furthermore, BAES considers the remaining modules to be of general engineering/construction interest, some of which would be expected to be integrated into the more complex modules by BAES, whilst others would be integrated as part of the construction process at the Nuclear Power Plant (NPP) site.

Contrary to this is BAES's view that the UK content of the AREVA EPR will be comparatively small and has difficulty in identifying what it could contribute to building the 'site constructed' AREVA design.

As a result of the compatibility of submarine building and the modular construction of the Westinghouse design, BAES is seeking a significant scope of work for the AP1000 within the UK's nuclear new build programme, including supply of the more complex modules and some of the larger structures (eg, the reactor containment vessel), supply chain management, site integration and commissioning. In addition, BAES would also look to supply into the Westinghouse global nuclear new build with factory built modules and ‘super modules’ manufactured in Barrow, for the European market and potentially other territories where appropriate and competitive.

BAES has considered the impact of involvement in the civil nuclear build programme on its ‘core product’ (ie, marine defence at Barrow), and has been concerned that the comparatively high level of activity in civil nuclear could dominate the attention of the existing supply chain. Thus, part of BAE’s civil nuclear strategy is defensive, as involvement in a civil nuclear programme would enable maintenance and development of core skills and, wherever possible, BAE would seek to manage the level of interest of the (existing) supply chain in (both) the defence and civil nuclear supply chains.

BAES also believes that innovation in the submarine build supply chain could also be applied to a civil nuclear build. Thus, BAES has involved the supply chain in reducing cost, through, for example, re-examination of specifications (performance & capacity), Commercial Off the Shelf (COTS) solutions, management of warranties, and would look to replicate the approach in a civil nuclear programme.

7.0 Nuclear Industry Skills

In this section, issues associated with nuclear industry skills are discussed, but only very briefly. However, it is clear from the above, from information contained within the capability reviews and input from vendors, utilities, and potential suppliers and service providers to a nuclear new build programme that the availability of a skilled workforce, from operators to nuclear engineers (and engineers, in general), is of major concern.

The existing pool of skilled and experienced nuclear industry labour is diminishing in the UK, due to the combination of an aging engineering and construction workforce, the period of time since the last nuclear build programme in the UK, and a limited number of new skilled staff entering the engineering and construction industries.

Thus, although there will be a major long-term decline in overall employment at UK nuclear sites over the next 30 years, as they progressively move from operation to decommissioning and site remediation [14], there is likely to be strong competition for both the staff and facilities required to deliver a new build programme. This competition will primarily be between the existing demands of operational support to the existing nuclear fleet, decommissioning work by the Nuclear Decommissioning Authority and any new nuclear build programme, but also from other industries including the power, rail, and oil and gas industries, and major projects such as the London Olympics in 2012.

Concerns about the availability of skilled and experienced staff have recently been expressed by a number of bodies [eg, 34-36], in response to United Kingdom Parliament Innovation, Universities and Skills Committee Inquiry on the subject [37]. However, long before this inquiry, the issue of a skills shortage in the nuclear industry had been raised [eg, 19].

As a result of the period of time since the UK’s last new build programme, a large proportion of this workforce is now approaching retirement, which would not be a problem if the industry was not struggling to replace those who are leaving with suitable science graduates.

If private sector companies in the UK are to build new nuclear power stations, the industrial skills base will have to be strengthened, through education and training of an existing and a new workforce. Clearly, this will require companies to train their own workforce, with support from Government, universities, etc.

In this respect, Cogent, the Sector Skills Council, successfully applied for funding to create a National Skills Academy for Nuclear (NSAN) in October 2006, and the NSAN was launched in January 2008. From its headquarters in W. Cumbria, the Skills Academy operates via a network of Regional Training Clusters. The NSAN will be employer-led and will seek to deliver a coherent education, training and skills strategy, which will address the needs of the wider nuclear industry, including decommissioning and power generation [38, 39]. A key part of the NSAN will be a brand new facility, The Nuclear Academy, which is to be built on the Lillyhall Industrial Estate in W. Cumbria.

As part of the 'Towards a Sustainable Energy Economy' programme, the EPSRC has provided funding of about £1M to a 'Nuclear Technology Education Consortium' to provide masters-level and continuing professional development training for the nuclear industries.

As mentioned above, the EPSRC has also agreed a future collaboration on research and training activities in nuclear technology and engineering. The first action is a Centre in Nuclear Engineering under the Engineering Doctorate scheme with funding of £5 million from the EPSRC and contributions anticipated from private and public sector partners. As also mentioned previously, the University of Manchester has established the Dalton Institute which aims to be at the forefront of nuclear education and research.

Fortunately, the long-lead time for nuclear power stations provides an opportunity for the UK further and higher education sectors to respond to the skills needs that a nuclear new build programme would create.

It is also worth noting that the UK has leading nuclear engineering expertise across both the academic and industrial sectors, and with the world class facilities at the newly established Sellafield Technology Centre (see below), in particular, the North West has a very strong skills and R&D base. Some very brief information regarding UK-based nuclear engineering R&D activity is given in Appendix D.

Finally, it should be noted that the Technology Strategy Board (TSB) and the Regional Development Agencies (RDAs) are in discussion regarding a proposal to 'map' the nuclear R&D capability within the UK.

8.0 Summary of the Status of the UK's Nuclear New Build Supply Chain

The following gives a summary of the status of the UK's civil nuclear industry and its supply chain for a nuclear new build programme:

- The UK maintains a capability in the design, construction and operation of nuclear power plant, and in full fuel cycle facilities, nuclear plant decommissioning and nuclear waste management.

- As the UK does not have a 'proprietary' nuclear process or design, UK companies are well positioned to offer impartial advice (eg, Engineering & Design Consultancy) on process / reactor selection for new facilities (new build and waste management).

- The UK has full fuel cycle facilities for conversion, enrichment, fuel fabrication, reprocessing and waste treatment, which should be capable of supplying fuel(s) for a nuclear new build programme.

- With 50 years of experience in building and operating nuclear generation facilities, the UK has a mature and experienced skill base which is very well placed to support new build facilities asset management, and the extensive decommissioning programmes which will take place worldwide.

- The likelihood that the UK's new nuclear build programme will be amongst the first major build programmes in Europe, will give the UK and UK companies 'early mover' advantage for implementing services, products and skills overseas, providing that the skills, capability and capacity are available.

- The extent of UK company involvement in the supply chain will depend on the structure of new build consortia and the choice of reactor design. Thus, the design owners or vendors will have existing supply chain arrangements, which are likely to affect the scope for UK participation.

- The UK supply chain has capability in most of the areas required to support a new nuclear build programme, although some investment and training is required.

- This capability is currently being used to support existing nuclear power plants and new fuel cycle plant, and in decommissioning and waste management activities, and to non-nuclear projects which utilise similar skills.

- There are only a small number of UK companies which could undertake the Programme Management role on the scale required for a new nuclear build programme, and consortia of companies are likely to take on the Programme Management role.

- However, there is a significant number of UK-based companies which could provide Project Management Services for individual projects forming the overall new build programme.

- All elements of the civil construction (ie, Building & Construction of the nuclear and turbine islands, balance of plant and supporting infrastructure) and On-site Fabrication could be undertaken by UK companies.

- There are several UK-based companies with manufacturing facilities and experience capable of supplying a large number of the components (Plant & Equipment) required for a nuclear power plant. Some of these companies are world leaders in the supply of equipment to overseas nuclear industries and/or to non-nuclear energy and civil engineering projects.

- Although the UK's manufacturing base for nuclear power plant and equipment has been eroded quite considerably over the past 20 years or so, a consequence of the majority of UK's nuclear power 'fleet' now being between 20 and 50 year old, it is estimated that UK companies could supply approximately 50% of the required Plant and Equipment with current facilities and resources. In addition, with some investment, this UK-based 'content' could increase.

- With increasing world demand, it is possible that some UK companies would invest to increase their scope and capacity for a UK nuclear new build programme and for potential export. Companies which have redirected their efforts since the last nuclear build could reinstate facilities and skills if the business case justifies.

- Security of the supply chain for a new nuclear build is important, over the 60 year lifetime of a station, and there will be a need for spares, repairs and service from the Original Equipment Manufacturers (OEMs), and a need to retain access to the supply chain involved in the original build. Thus, key suppliers need to remain in business and be able to provide service for the life of the stations and, in terms of responsiveness and logistics, 'local' suppliers are 'ideal'.

- Limited world capacity to produce critical components such as forgings, for Reactor Pressure Vessels (RPVs), steam generator pressure vessels and for primary circuit pipework, as well as large steam turbine and turbine generator rotors, and the associated long lead times for such components, may affect the ability to deliver a UK new nuclear build programme, unless there is some investment in such capacity.

- Currently, no UK companies are set up to produce civil RPVs – forging and subsequent fabrication, and the largest forgings for nuclear Steam Generators, although a proposed investment in a 15,000 tonne press and ancillary equipment at Sheffield Forgemasters International Ltd. (Sheffield) would establish the forging capability (only).

- The global capacity for the fabrication of major Nuclear Steam Supply System equipment (eg, RPVs, Steam Generators and Pressurisers) is considered to be insufficient for projected nuclear new build rates, and some investment in capacity will be needed to meet future world demand.

- In addition to the demand for large forgings and Nuclear Steam Supply System equipment for nuclear new build programmes, there will be significant and increasing demand for the same from fleet lifetime extension programmes for existing reactors (eg, replacement RPV heads, Steam Generators, Pressurisers, etc.).

- Currently, there is no UK-based capability to supply seamless, thin walled stainless and alloy steel tubing and Ni-base alloy tubing for nuclear island applications (eg, for Steam Generator heat exchanger tubing), and there are also global capacity concerns regarding supply of the same.

- In addition, there is no UK-based capability in the induction bending of large diameter thick-walled pipes for nuclear island applications.

- It will take significant effort to build up the required resources (skills) within the timescale for licensing and contract awards; within a period which is likely to be no longer than 5 years.

- There is likely to be strong competition for both the staff and facilities required to deliver a new build programme. This competition will primarily be between the existing demands of operational support to the existing nuclear fleet, decommissioning work by the Nuclear Decommissioning Authority (NDA) and any new nuclear build programme, but also from other industries including the power, rail, and oil and gas industries, and major infrastructure projects such as the London Olympics in 2012.

- In addition, there will be strong competition from overseas new build programmes for nuclear skills (eg, in engineering/technical consultancy).

- Clear signals (and certainty) are needed by the supply chain before investment in capability and capacity, and skills development, will be made.

- Nuclear fission related R&D in the UK has declined steadily over the past 20 years or so, and since the 1980's, public investment in nuclear fission R&D has dropped by more than 95% and the industrial R&D skill base has decreased by more than 90%. However, any new build programme will utilise international standard designs which could minimise the level of R&D required to support such a programme; in particular for design and engineering associated with the Nuclear Steam Supply System (NSSS).

- However, the UK maintains leading nuclear materials expertise across both the academic and industrial sectors, with key initiatives concentrating UK efforts.

9.0 SWOT Analysis of the UK's Nuclear New Build Supply Chain

The Strengths, Weaknesses, Opportunities and Threats for the supply chain for a UK nuclear new build programme are given below. Note: the lists are certainly not exhaustive, but highlight some of the major findings from a review of the relevant literature and form discussions with representatives of companies from within the nuclear energy sector, or with aspirations to supply into, or provide service to, the sector.

Strengths

The UK's key strengths in the nuclear new build supply chain include:

- A highly skilled and experienced resource base, active across all aspects of the nuclear energy sector;
- Proven major project management and engineering capability;
- Expertise in operating nuclear assets (for power generation and nuclear processing) and in plant lifetime extension;
- Design, manufacture and installation of advanced equipment;
- World renowned academic institutions, leading-edge research and development; and
- A strong link between the energy sector and The City of London (financial and trading centre), which together with a full range of professional services, make the UK a key location for new energy development.

Weaknesses

Weaknesses in the UK's nuclear new build supply chain include:

- There are few UK-based Engineering, Procurement & Construction (EPC) contractors with recent new nuclear power plant experience;
- There is no UK-based capability for the production of the largest forgings required for the manufacture of Reactor Pressure Vessels (RPVs), steam generators and primary circuit pipework, as well as large steam turbine and turbine generator rotors;
- There is no UK-based civil Nuclear Steam Supply System (NSSS) manufacturing capability;
- There is no UK based supply of major equipment for the non-nuclear (turbine) island;
- The relatively high UK labour costs, noted by the vendors, which would make the labour content of a new build programme greater than for other regions of the world (including W. Europe); and
- There is currently a nuclear engineering skills gap.

Opportunities

Opportunities in UK and overseas markets for the UK's nuclear supply chain could include the following, some of which would require investment:

- Consultancy: technical and commercial feasibility studies and evaluation;
- Detailed understanding and development of the Nuclear Safety case.
- Project management of new plant construction (which can account for up to 15% of overall project value);
- Supply of raw materials (eg, steel, cement, etc.);
- Civil engineering and construction ('civils') (accounting for up to 25% of project value);
- On-site erection / installation ('mechanicals'):
- Reactor plant sub-system module and product definition;
- Supply chain management;
- Specialist equipment supply (instrumentation & control, and electrical);
- Electrical, on-site installation;
- Supply of large forgings for Nuclear Steam Supply Systems (NSSS);
- Supply of other forgings and castings for the nuclear island:
- Specialist component supply (valves, pumps, cables, etc.);
- Manufacture of nuclear island equipment, including steam generators, pressurisers and primary circuit pipework, and its engineering support (with some investment);
- Manufacture of reactor pressure vessel (RPV) internals (with some investment);
- Operational and asset management and plant life extensions;
- Integrated decommissioning project management and site management;
- Decommissioning specialist equipment; and
- Integrated fuel and waste management / services and disposal.

It should not be forgotten that UK companies can (and do) contribute significantly to non-nuclear island plant & equipment, not as Original Equipment Manufacturers (OEMs), but through component supply to steam turbines and generators, etc.

Threats

The threats (or risks) to development of the supply chain for deployment of a UK nuclear new build programme include the following:

- Perhaps the major threats to supply chain development, and UK-based companies developing both capability and capacity for a nuclear new build programme, are those related to the timeliness of the various Government facilitative actions (set out with indicative timelines in the Nuclear White Paper).
- In particular, the timely completion of the facilitative actions is threatened by a shortage of skilled inspectors and engineers engaged in the GDA process (within the NII), such that delays

in the completion of this process and the possible knock-on effects of delays in the planning and licensing processes would affect confidence throughout the supply chain.
- Significant and early activity in other markets which could result in resources and skills required for a UK nuclear new build programme being 'pulled' from the UK-based resource pool.
- The growing skills gap in the nuclear industry not being closed or narrowed within the required timescale (for new build start).

In addition to the above, it should be noted that any delays in the Strategic Siting Assessment and subsequent identification of suitable sites may also affect UK-based supply chain development, as utility companies and vendors may seek alternative markets.

Recommendations

From the work carried out to date, a number of recommendations can be made to develop the UK-based supply chain for UK nuclear new build and global new build programmes, as follows:

- Supply chain development activities should be initiated, which make potential supply chain companies aware of the opportunities of a nuclear new build programme, and help companies develop capability and capacity to relieve supply chain 'pinch-points'.

- Additional supply chain 'mapping' should be carried out, including to lower Tiers of the supply chain, to understand where the UK has expertise and/or the potential to compete for UK nuclear new build and in overseas nuclear builds.

- To provide certainty to the nuclear industry and development of the supply chain, the Government facilitative actions must remain on schedule to ensure that the indicative timelines presented in the Nuclear White Paper are met. Recruitment of the appropriate number of skilled inspectors will be important to ensure that the Generic Design Assessment (GDA) process runs to time.

- Targeted support should be provided to companies seeking nuclear accreditation and qualification. Thus, companies seeking accreditation or, as will be the case in a considerable number of cases, seeking to re-establish lapsed accreditations will need to commit considerable resources, both in terms of time and money, to secure nuclear qualification.

- Companies must have access to education and training programmes, and a supply of high quality graduates, which meet their needs in the development of a skilled workforce across all aspects of the nuclear supply chain, which will include the development of non-nuclear specific skills.

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Appendices

Appendix A
AREVA's Scenario of Nuclear Power Plant Construction to 2030

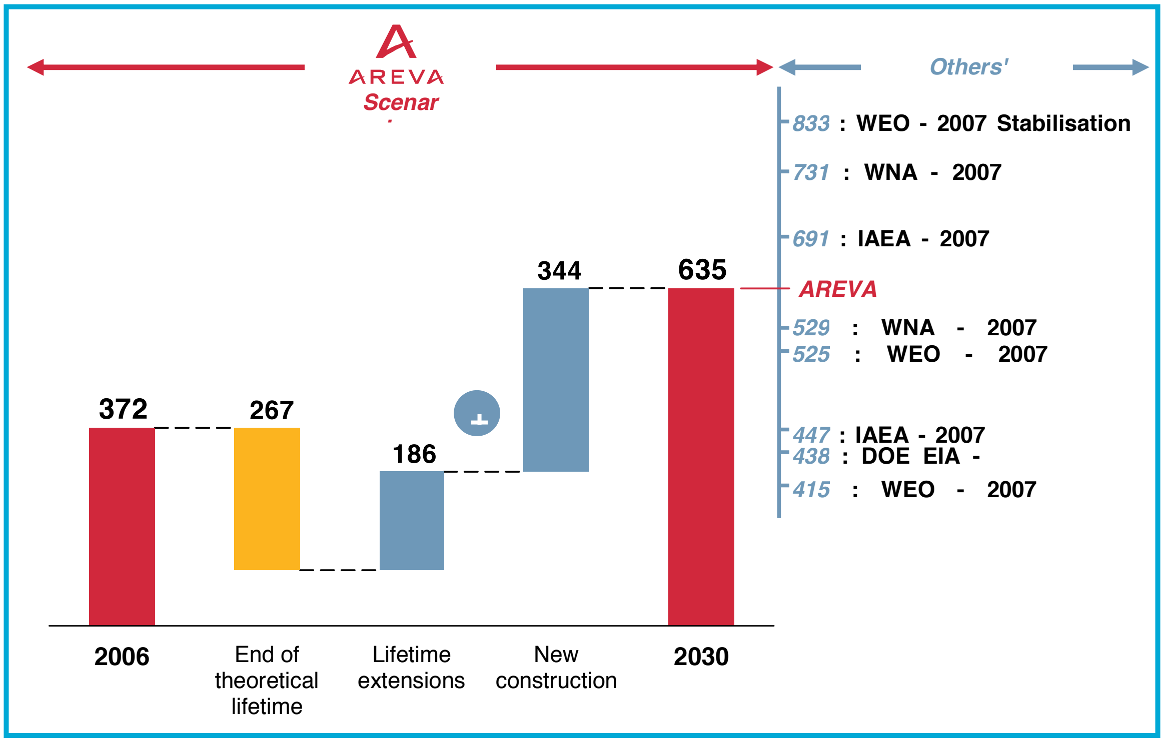


Figure A-1 - AREVA's 2030 scenario of nuclear capacity construction and lifetime extension GWe (net installed). (Courtesy of AREVA).

Appendix B
Major Nuclear Steam Supply System (NSSS)
Pressure Vessel Technical Data

Some technical data for the major NSSS pressure vessels, and taken from the vendors' GDA submissions are given below:

Westinghouse AP1000

Reactor Pressure Vessel
Cylindrical shell inner diameter: 3,988 mm
Wall thickness of cylindrical shell: 203 mm
Total height: 12,056 mm

Steam Generators
Number: 2
Number of heat exchanger tubes: 10,025
Tube dimensions: 17.5/15.4 mm
Maximum outer diameter: 5,575.3 mm
Total height: 22,460 mm
Transport weight 663.7 tonnes
Shell and tube sheet material: Carbon steel, and Tube material: Inconel 690-TT

Pressurizer
Total volume: 59.47 m^3
Inner diameter 2.28 m
Total height (surge nozzle safe end to 16.27 m spray nozzle safe end)

AREVA EPR

Reactor Pressure Vessel
Inner diameter of the cylindrical vessel: 4,870 mm
Outer diameter of the flange: 5,750 mm
Largest diameter (for transport): 7,470 mm
Total height of the lower section (from flange to bottom of dome): 10,532.5 mm
Total height, head, control rod adaptors and venting tube included: 13,722.5 mm
Vessel body weight: 410 tonnes
Vessel head weight: 116 tonnes

Steam Generators
Number: 4
Steam drum maximum outer diameter (nozzles excluded): 5.168 m
Total height (including safe ends): 24.621 m
Total mass when empty: 490 tonnes

Pressuriser
Total volume: 75 m^3
Inside diameter: 2,820 mm
Inner radius of spherical heads: 1,430 mm
Total height (overall): ≈ 14,400 mm
Total weight empty, as delivered: 150 tonnes

GE Hitachi ESBWR

Reactor Pressure Vessel
Nominal inner diameter: 7.112 m
Nominal wall thickness including clad: 182 mm
Minimum cladding thickness: 3.2 mm
Nominal height from the inside of the bottom head to the inside of the top head: 27.56 m

Appendix C
The Burgundy Nuclear Partnership (BNP)

In considering the global nuclear supply chain, it is worth noting the 'model' of the Burgundy Nuclear partnership (BNP) (see: http://www.polenucleairebourgogne.fr/). Thus, the French nuclear industry is centred on the Burgundy region, around the large (AREVA Sfarsteel) forge at Le Creusot and AREVA's Nuclear Steam Supply System (NSSS) manufacturing facility at Saint-Marcel near Chalon sur Saone, and in the form of the Burgundy Nuclear Partnership (BNP).

The BNP describes itself as; "the European reference for nuclear equipment; a global player in the nuclear renaissance", and as “a one-stop shop for the sourcing of key components in a nuclear power station.”

The BNP has more than 80 members, representing a workforce of 9,000 people, collaborating directly with world leaders in nuclear power, EDF and AREVA. The electricity supplier, EDF, in partnership with all the component manufacturers, has developed know-how with regard to both the construction of nuclear power stations and safety and waste management.

The BNP was founded to drive its members through three main challenges:

- To consolidate the industrial integration of this key segment of the nuclear energy industry to build faster, highly secured nuclear energy plants;

- To attract and train new generations of workforce, from engineers to specialists for the nuclear industry; and

- To promote worldwide the know-how of the Burgundy Nuclear Partnership.

The industrial knowledge of the BNP members covers the whole range of nuclear energy production needs (pressuriser, steam generator, primary coolant pumps, reactor pressure vessel and RPV head, piping and supporting systems, auxiliary equipment, etc.), and includes the following:

- Heavy forgings;
- Tubes and components;
- Precision engineering;
- Non destructive testing;
- Education and training;
- Engineering and services; and
- Electricity distribution.

Members of the BNP include: AREVA (large forge NSSS manufacturing plant), EDF, Cerec and Valinox Nucléaire (both subsidiaries of Vallourec Group, a world leader in the field of tubes for power stations), Valtimet (welded tube manufacturer), Aubert and Duval (forger), and Arcelor Mittal's Industeel steel plant. Further details of members can be found at the BNP website (see above).

Directly or through their industrial partners, the members of the BNP sell and manage specific nuclear related products in numerous countries worldwide, and with the renaissance of nuclear power on the energy market, one of the main challenges of the BNP is to represent its members in promising markets globally.

Appendix D
The UK's R&D Capability in Nuclear Engineering

In this Appendix, some of the major R&D institutions are mentioned, but it should be noted that there is a significant number of other activities ongoing within both UK-based universities, RTOs and industrial companies (ie, the information is by no means exhaustive).

Nuclear fission related R&D in the UK has declined steadily over the past 20 years or so, and since the 1980's, public investment in nuclear fission R&D has dropped by more than 95% and the industrial R&D skill base has decreased by more than 90%. The decline in UK personnel engaged in nuclear R&D is significant. On a global basis, whilst this trend is not uncommon, other countries are now investing significantly in nuclear R&D skills.

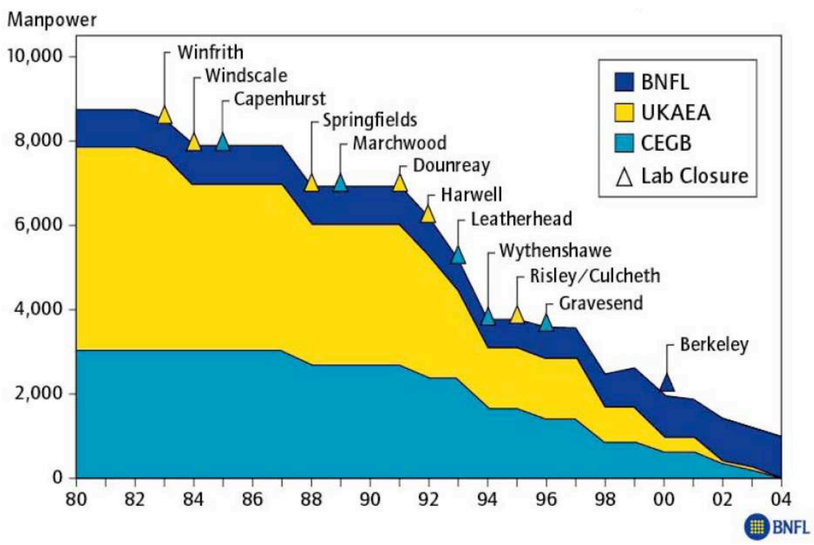


Figure D-1 - Best estimate of the decline in UK R&D personnel (from a presentation given by Prof. R. Clegg at the NIA 'Energy Choices' Conference, London, on 2 December 2004).

A reduction in the overall levels of fission research in the UK has created a number of areas of concern, as follows:

- Fragmentation and disappearance of expertise from industry;
- Capacity and capability and sustainability of the UK's skills pipeline, with a number of key research disciplines showing signs of a shortage developing;
- No authoritative independent source of nuclear skills, education & training advice for government to help inform policy, carry out departmental research and respond to questions;
- Reduced capacity for international influence in a technology which has global strategic importance;
- No overall UK roadmap for nuclear R&D, which links current reactor operations, clean-up and decommissioning, defence and fusion; and
- Uncoordinated UK public investment in nuclear R&D and related studies.

However, the UK still has leading expertise across both the academic and industrial sectors, and with the world class facilities at the newly established Sellafield Technology Centre, which is operated by Nexia Solutions Ltd. on behalf of the NDA (with other facilities at Springfields and Risley), the North West, in particular, has a very strong skills and R&D base.

This is supported by the academic community. For example, a Nuclear Engineering Doctorate (Nuclear EngD) degree is offered by a consortium of UK universities, led by the Dalton Nuclear Institute at the

University of Manchester in partnership with Imperial College London, and supported by the universities of Bristol, Leeds, Sheffield and Strathclyde.

The Dalton Nuclear Institute, an interdisciplinary nuclear research centre, was established at the University of Manchester in 2005, with aims which include: support for the development of expertise to underpin the UK's nuclear clean-up programme, and the maintenance and development of skills for any future new build programme.

Research alliances have been formed between Nexia Solutions and selected University departments at Manchester, Sheffield and Leeds. As of mid-2007, there were 120 researchers engaged on projects supported by these research alliances, about half of whom are based at Manchester's Dalton Nuclear Research Institute, which has been established to develop a programme of post-graduate level nuclear education and training.

In October 2006, the Secretary of State announced that subject to contractual terms being agreed, the Government expects that there will be a UK National Nuclear Laboratory (NNL). It will be based around the British Technology Centre and Nexia Solutions Ltd. in Sellafield, West Cumbria.

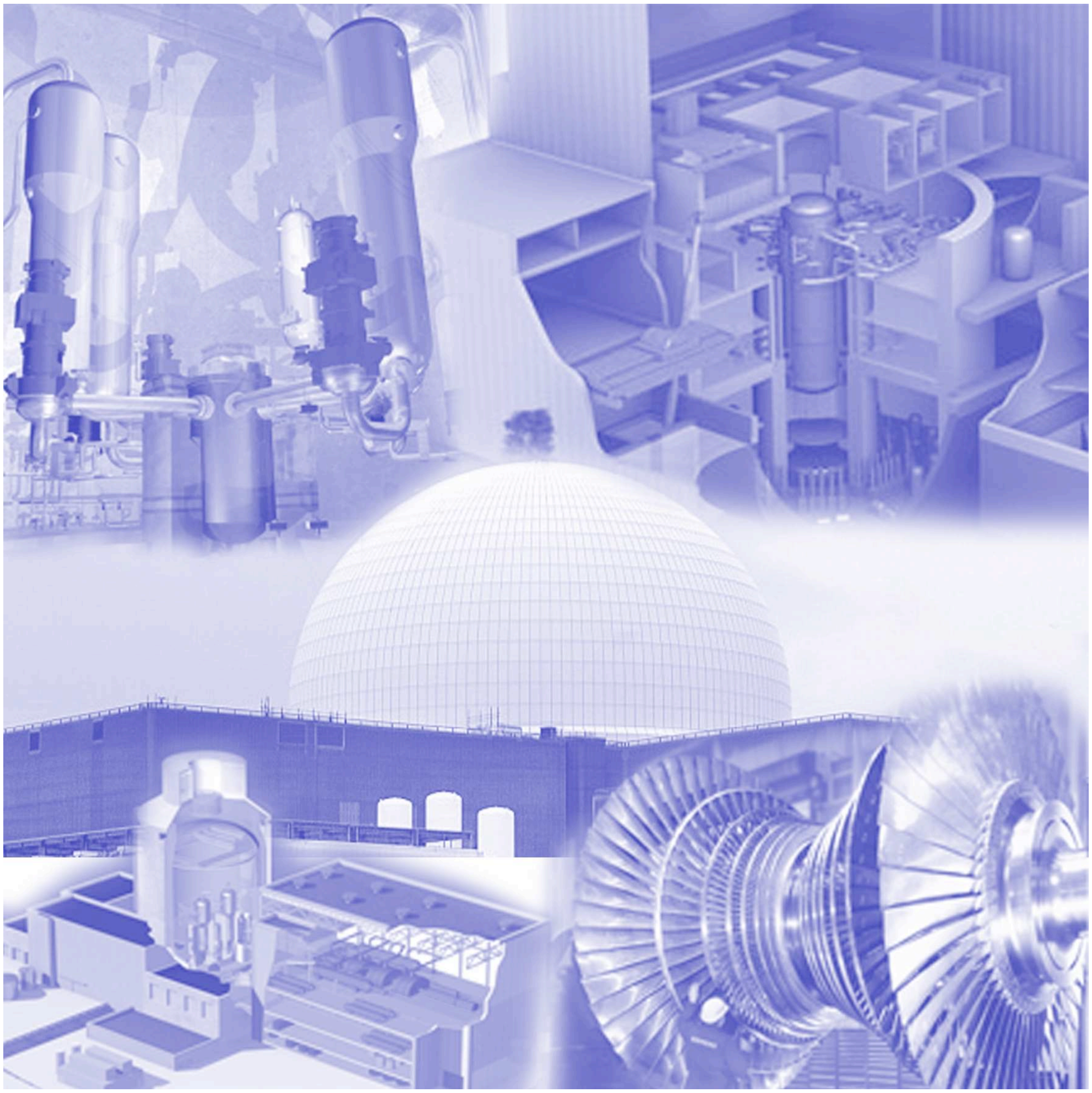
Subsequently, on 23 July 2008, it was confirmed that the Government will establish a National Nuclear Laboratory, and launch a competition to appoint a commercial operator to run the organisation. The NNL will provide a world-class nuclear research capability, with staff from Nexia Solutions and facilities owned by the Nuclear Decommissioning Authority (NDA), including the Sellafield Technology Centre. It will be owned by Government, but run by a commercial operator.

In addition, in January 2007, it was announced that a major new nuclear research facility, the Northwest Nuclear Research Centre (NNRC), is to be established in Cumbria with £20M of initial funding from The University of Manchester's Dalton Nuclear Institute and the Nuclear Decommissioning Authority (NDA), which will see each organisation invest £10M over a seven-year period.

The 'Keeping the Nuclear Options Open' (KNOO) programme is a four-year, £6.1M initiative (start date 1st October 2005), established to maintain and develop skills relevant to power generation through nuclear fission, and is funded through the 'Towards a Sustainable Energy Economy Programme' of Research Councils UK.

The KNOO grant has been awarded to a consortium of researchers from Imperial College London, the University of Manchester, Cardiff University, University of Sheffield, University of Bristol, University of Leeds and the Open University. The universities are working with a number of Government agencies and organisations, and UK-based nuclear sector companies.

As mentioned in Section 7 of this report, the Technology Strategy Board (TSB) and the Regional Development Agencies (RDAs) are in discussion regarding a proposal to 'map' the nuclear R&D capability within the UK.



namtec
national metals technology centre