Major Projects Association

A New Generation of UK Nuclear Power Plants – are we ready?

Seminar 123 held at the Institution of Civil Engineers, London
28th February 2006

Summary

Key Conclusions

- The economics of new build programmes are workable, but we will lose credibility in the UK if projects overrun on time or cost.
- There is a need for the government to underwrite some very low probability, but massive impact risk that no capitalised organisation in the world would take on.
- The new nuclear build market must be made attractive to generators and suppliers from the UK and overseas. If we are perceived as being a country where there is high risk the supply chain will go elsewhere.
- It is important that the UK limits reactor designs to one or two, rather than several, as it has in the past.
- We are an ‘infant’ nuclear country, so need to utilise experience from other parts of the world to influence both the government’s role and the supply side.
- We need to invest in white and blue collar training courses, in order to nurture sufficient appropriate skills to support the possibility of simultaneous construction of three or four £1.5 billion nuclear power plants.
- In Finland it took seven years from the commencement of the regulatory approval process to starting on site; if we are looking at a UK shortage of energy supply in 2015 we are already behind schedule.
- There has to be appropriate risk transfer.
- We need a macro solution in the UK for waste disposal, decommissioning and the overall regulatory process.
- All of this can be accomplished with the active leadership of the government and its creation of an enabling environment.

Introduction

Following the government's announcement in November 2005 of a review of the UK's energy policy, nuclear power is once again on the political agenda, and the issues of cost, financing, ownership, design, safety, construction, operation, waste disposal and decommissioning are being thought through afresh.

Given that a new generation of nuclear power plants will, most likely, have to be privately funded and owned, what lead will the government offer and what policies need to be put in place?

The seminar assessed the capability and capacity of UK industry to deliver a new generation of nuclear power plants and the Health & Safety Executive's (HSE) role in securing nuclear safety in the UK. Reactor options were discussed, as well as the ability of the supply chain to deliver the project.

The Energy Review

Since the 2003 Energy White Paper was published, evidence about the adverse impact of climate change has continued to grow. Fossil fuel prices have risen sharply and are projected to rise even higher. The UK has become a net gas importer sooner than expected and is also a net importer of oil. Progress in introducing truly open energy markets in the European Union (EU) has been slow and the dispute between Russia and the Ukraine over pipeline supply has affected the perception of security of supply.

The Energy Review builds on the 2003 White Paper, and the government remains committed to its four goals:

- To put the UK on a path to cut carbon dioxide (CO_2) emissions by some 60% by about 2050, with real progress by 2020
- To maintain the reliability of energy supplies
- To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and improve productivity
- To ensure that every home is adequately and affordably heated

Up to 30% of the total UK electricity generation may need to be replaced by 2020 and the ageing infrastructure requires new investment. Nuclear sources currently account for around 19% of UK electricity, but generators are ageing and plants are likely to be decommissioned over the next 15 years, so that by 2020 only around 7% of our electricity will come from nuclear sources.

The Review looks at the risks of increasing import dependence and recognises that new nuclear build might be necessary to meet carbon reduction targets. It considers the possible role nuclear power might continue to play alongside other technologies, and its policy proposals will be published in the latter part of 2006.

Global nuclear power generation

There are 440 nuclear power plants operating in the world, predominantly in the North East of North America and Canada, Western Europe and in East Asia, particularly Japan and Korea. There are not many in China and India, but it is early days in terms of their planned programmes. Nuclear electricity output has risen in the last ten years, but the number of nuclear reactors in operation has hardly altered as existing reactors are functioning more efficiently.

The percentage of electricity produced worldwide from nuclear power, against other sources, has been fairly constant at about 16% over the last 15 years, with significant differences between countries. For example, in the United States, Germany, Japan and the UK the share is around 20% – 30%, whilst in France it is nearly 80%, and in countries such as China and India only 1%.

Over the last decade there has been a revival of interest in generating electricity from nuclear plants, due to factors such as strong growth in world electricity demand, improvement in nuclear power economics, environmental advantages and the need for security of energy supply. There are very good deposits of uranium ore in the world in politically stable countries such as Canada and Australia and the price of the raw material is not considered to be a significant cost factor.

The International Energy Agency's (IEA) forecast that the world electricity demand will double between 2000 and 2030 implies a necessary increase in generating capacity of 4,700 gigawatts (GW). Some of this increase will be incremental, but in some countries, such as the UK, considerable replacement capacity will be required.

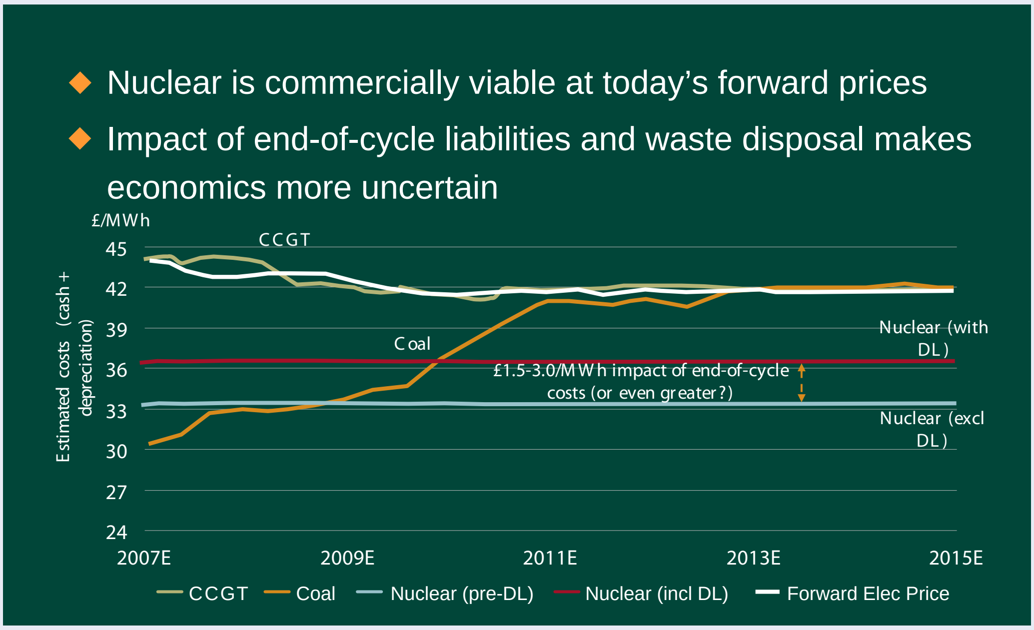
Nuclear power plants have high initial capital costs and take time to build, but providing they are well run they have low and stable operating costs. Gas generating plants have low capital cost and can be built quickly, but operating costs are relatively high and returns can be very variable, depending on the gas price.

The UK has a number of different nuclear reactor designs, many of which are due for closure by 2020. 90% of the reactors in the rest of the world are pressurised water reactors (PWR), but the UK has only one PWR, Sizewell B. Whilst the UK has a mature technology, new build nuclear power is an infant industry; other countries are now building reactors much more efficiently to standardised designs, and the UK will need to do the same.

Economic viability of new nuclear build in the UK

Nuclear generated power can be a viable energy source, but the key to success is standardising design, fixing the scope of the programme, having a predictable regulatory regime and good project management practice.

Is new nuclear an economically viable alternative?

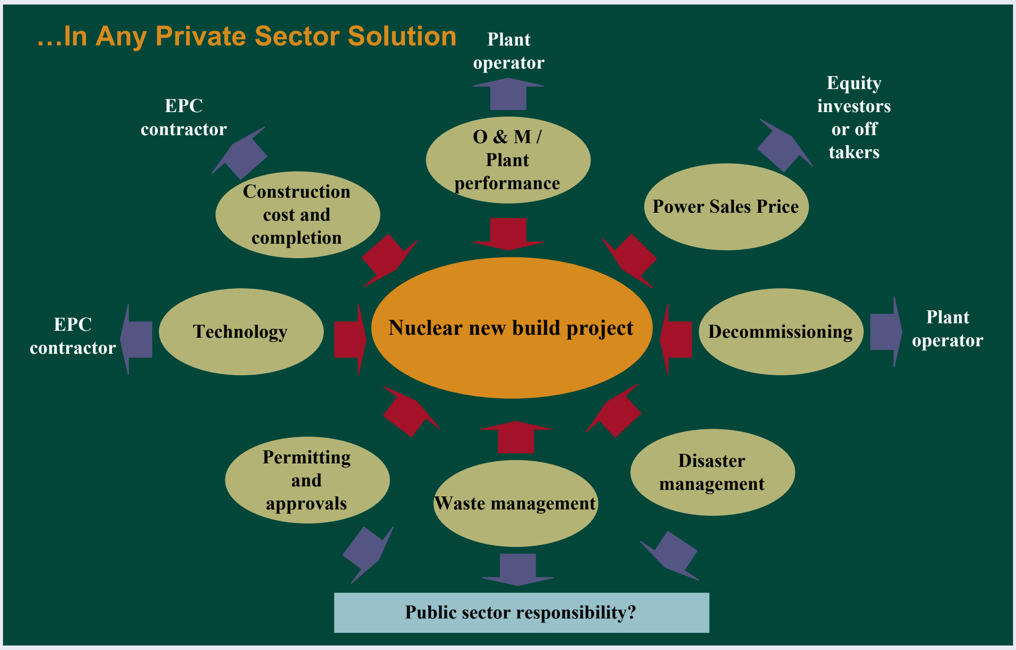


DL: decommissioning liabilities

The above diagram shows a projection of forward electricity prices in the UK and the projected costs for producing it from coal, gas and nuclear power, with and without the decommissioning costs. The current electricity price is predicted to remain at around £42 per megawatt hour (MWh) for the next ten years. Coal is set to rise from around £30 MWh to around £40 MWh over the next five years. Gas, currently at over £40 MWh, will remain more or less the same. The long-term forward electricity price is predicted to be high enough to justify the cost of investing in new nuclear plant, operating it for the foreseeable future and meeting the cost of back-end decommissioning liabilities.

Allocation of risk in the private sector model

Risks must be carefully allocated



Building new nuclear plant will involve the normal risks in technology and construction. The plant has to comply with building and operating specifications, be delivered on time and within budget and allowance has to be made for decommissioning. All these risks are effectively transferred to the contractors.

However the regulatory framework for permitting and approvals is at present unclear and it is unlikely that the private sector will spend money applying for permits without certainty of outcome. The government needs to create a clear policy for waste disposal and disaster management, possibly by sharing the risk or providing backstop funding. Catastrophic incidents can involve massive evacuation costs and third party action suits. The government perhaps needs to assist in the creation of ‘no fault’ public insurance and other third party liability.

Power prices in the UK and in Europe over the last five to ten years have been volatile, and an offtake investor in a new plant will not be prepared to take the risk that the price will go down substantially. Major electricity companies could be willing to enter into long-term offtake contracts, but will need predictable and stable costs of long-term power. The longer the term of a fixed price offtake contract, the greater the funding available through the markets; carbon credits or cash subsidies could be used as incentives in this respect.

Leadership of new nuclear build

Four possible leaders of new nuclear development in the UK are:

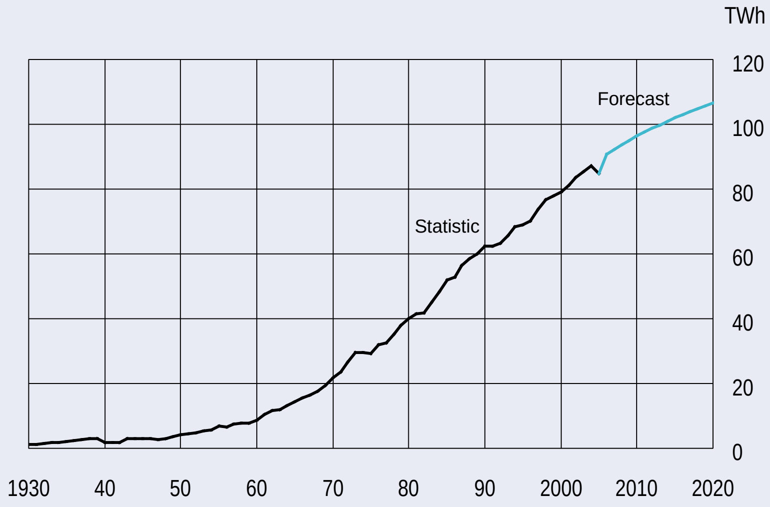
- The government, which would play a central role in managing the energy policy and control the assets. In our liberalised and developed market this is unlikely.
- British Energy, which has operational expertise and existing plant, but lacks financial strength and would have to raise the money.
- Major European players in the energy market, such as E.ON, RWE or EDF, who have access to nuclear expertise and strong balance sheets. Some financial commentators have suggested combining British Energy's existing expertise and sites with the operational and investment expertise of these large companies.
- A financial consortium, comprising a project company and various shareholders consisting of contractors, shareholders and operators who would raise third party financing. The complexity and size of a new nuclear project would require parties of resilience and financial stability.

Funding could come from three sources: the equity market, the 'mezzanine' high yield markets and the debt markets.

The Finnish case history

Finland has a very high per capita consumption of electricity because of the climate and large energy consuming industries such as pulp and paper manufacture. The share of nuclear power in 2005 was about 26% of the total energy sources, direct fossil fuel about 20% and net imports of electricity around 20%.

Energy consumption in Finland



…continued

Electricity consumption in terawatt hours (TWh) has been increasing by about 2% per year over the last few years. In the next 10–20 years Finland will have to replace ageing power plants and maintain the increment, so new capacity for generating electricity is necessary.

Why Finland is supporting the new build of nuclear power plants:

- Finland has 25 years of positive technical and economical experience of nuclear power
- According to cost estimates nuclear power is very competitive compared with other alternatives and has long-term price predictability
- The carbon dioxide free energy form is in line with national targets to protect the environment
- Nuclear power supports Finland's efforts to reduce dependence on imported electricity and increases security of supply
- The TVO model is well-suited for this kind of a long-term investment in Finland
- The system of nuclear waste management and funding has been accepted politically

The construction of a new nuclear power unit at Olkiluoto for the operating company TVO was started in 1998 and will be commissioned in 2009. The European pressurised water reactor (EPR) was the final choice and the supplier of the plant is a consortium formed by the Framatome ANP and Siemens companies.

The unit will have a net electrical output of 1600 megawatts (MW), an estimated annual production of about 13 TWh and a planned service life of 60 years. The investment is roughly €3 billion including hook-up to the infrastructure and waste management. It is a fixed-price turnkey contract including everything except excavation of the site by the TVO company.

Nuclear waste management was an important consideration in building the new unit. Finland has two existing underground repositories for low and intermediate level waste, which are built in crystalline granite bedrock excavated to a depth of about 100 metres. Facilities for deep disposal at a depth of 420 metres will be ready by 2020.

Money from the sale of nuclear electricity is collected for the future radioactive waste management. At the moment the total collected stands at €1.4 billion and is held by the Ministry of Trade and Industry in Finland. Even if the nuclear power plants were closed now, there would be enough money to take care of waste disposal and decommissioning.

Current nuclear options

Reactor Design	Type	Country of Origin	Lead Developer	Deployment Status
ABWR	BWR	US Japan	GE, Toshiba, Hitachi	Operating in Japan. Under construction in Japan & Taiwan
CANDU-6	PHWR	Canada	AECL	Operating in Korea, China,
VVER-91/99	PWR	Russia	Atomstroyexport	Under construction in China
AHWR	PHWR	India	Nuclear Power Corporation of India	Starting construction
APR-1400	PWR	Korea, US	Kepco	Planned for Shin-Kori
APWR	PWR	Japan	Westinghouse & Mitsubishi	Planned for Tsuruga
EPR	PWR	France, Germany	Framatome ANP	Under construction in Finland Planned in France
AP1000	PWR	US	Westinghouse	Licensed in USA
SWR	BWR	France, Germany	Framatome-ANP	Offered in Finland
ESBWR	BWR	US	GE	Under development
ACR	PHWR	Canada	AECL	Under development

ABWR	Advanced Boiling Water Reactor
ACR	Advanced Candu Reactor
AHWR	Advanced Heavy Water Reactor
AP1000	Advanced Passive PWR
APR	Advanced PWR (Korean)
APWR	Advanced PWR (Japanese)
BWR	Boiling Water Reactor
CANDU6	Canadian Deuterium Reactor
EPR	European PWR
ESBWR	Economic Simplified BWR
PHWR	Pressurised Heavy Water Reactor
PWR	Pressured Water Reactor
SWR	Simplified BWR
VVER	Russian PWR

The first six reactors on the list are already operating or under construction; the EPR and AP1000 are the front runners, in the near term, for any new nuclear programme in the UK, while the last three on the list will probably be strong contenders for new build in the future. They are all water cooled.

A number of incremental technological improvements have taken place and new features developed to give more protection in case of severe accidents and enhanced protection against aircraft impact and earthquakes. At present two EPR programmes are underway, one under construction in Finland and one planned for France.

...continued

The EPR has extremely strong containment features comprising exterior walls 1.5 metres thick and a robust internal containment. It has a novel feature in the molten core catcher, which in the event of a melt down would contain the core and prevent it from escaping into the environment. Four completely independent trains for supplying water in the event of a fault or loss of coolant have their own electrical supply.

In the AP1000, water is driven into the reactor core by gravity and then recirculated by natural convection. There is no AC electrical power needed to drive the safety system, hence the description ‘passive’. Because it does not require the four-train safety system its construction is simpler, with far fewer components.

The capital cost of a nuclear reactor plant is broadly proportionate to the building volume. The AP1000 has 45% less seismic building volume, which implies that the capital cost should be around half that associated with a conventional reactor. Compared with the Sizewell B installation, the footprint is vastly reduced. All of the major components within the reactor have been proven for performance by international experience.

Supply chain limitations

Globally, there are challenges in the supply chain capability, principally in the supply of large forgings for reactor pressure vessels and steam generators, and concurrent new build in the world will put a strain on the ability to supply a UK programme.

There is concern that skills in nuclear engineering are diminishing rapidly in the UK, and on the construction side there will be competition from project areas such as the 2012 Olympics. Suppliers need to be confident that the programme will proceed and that UK companies will be able to win work.

In an assessment of UK supply chain capability and component construction costs IBM found there is high capability in some areas such as main civil works and cabling, but no supplier in the UK for reactor pressure vessels and turbine generators.

HSE's role in securing nuclear safety in the UK

The amended Nuclear Installations Act of 1965 is now a relevant statutory provision of the Health and Safety Act of 1974, which describes a fundamental duty to reduce risks to workers and the public to a level 'as low as reasonably practicable' (ALARP).

A licence with safety conditions attached is required to build and operate a nuclear reactor, and the limits and conditions of safe operation must be adhered to. In the UK, nuclear operators must develop their own standards and criteria which the HSE will test to see whether they are adequate; any work carried out is charged to the licensee.

Licensing:

- No company may install or operate a nuclear reactor unless a licence has been granted by the HSE, and is in force.
- Site licences are only granted to corporate bodies, but they are granted for indefinite terms and may, in principle, cover the whole of the lifetime of the plant. There are no separate licences for construction, operation or decommission.
- A licence cannot be transferred by the company holding it to another company.
- A licence can be surrendered, providing there is no undertaking of activities on the site that require a licence.

Applicants for a licence will usually submit a series of safety reports during a large project, and the HSE has to be satisfied with the capability of the applicant's organisation on the chosen site, even when a licence has been granted.

The applicant must satisfy the HSE that the site organisation is compliant with safety standards and criteria, and the European Safety Standards Directive requires a 'justification of practice' for working with ionizing radiation.

Public enquiries may also consider safety issues and influence details of design. Regulatory approvals may have a 'shelf life' depending on a periodic safety review undertaken by the applicant. Generally speaking UK safety regulation is goal-seeking rather than prescriptive.

The HSE considers that the regulatory system is capable of accommodating new nuclear build within the UK, and is submitting a report on health and safety risks to the Energy Review. It is also reviewing its licensing strategy to ensure it remains effective.

A contractor’s view (Fluor)

The seminar heard about some of the problems faced by Fluor, a major international engineering company, in considering involvement in nuclear power plant new build.

Fluor hire people from all parts of the world, but globally are finding a shortage of skilled resources, particularly scaffolders, welders, pipe fitters and electricians. Nuclear engineering educational programmes have decreased both here and in the US. Only in Russia has there been an increase in the number of graduate nuclear engineers, to about 4,000 per year. The lack of qualified engineers is a key constraint in delivering large complex projects in the nuclear industry.

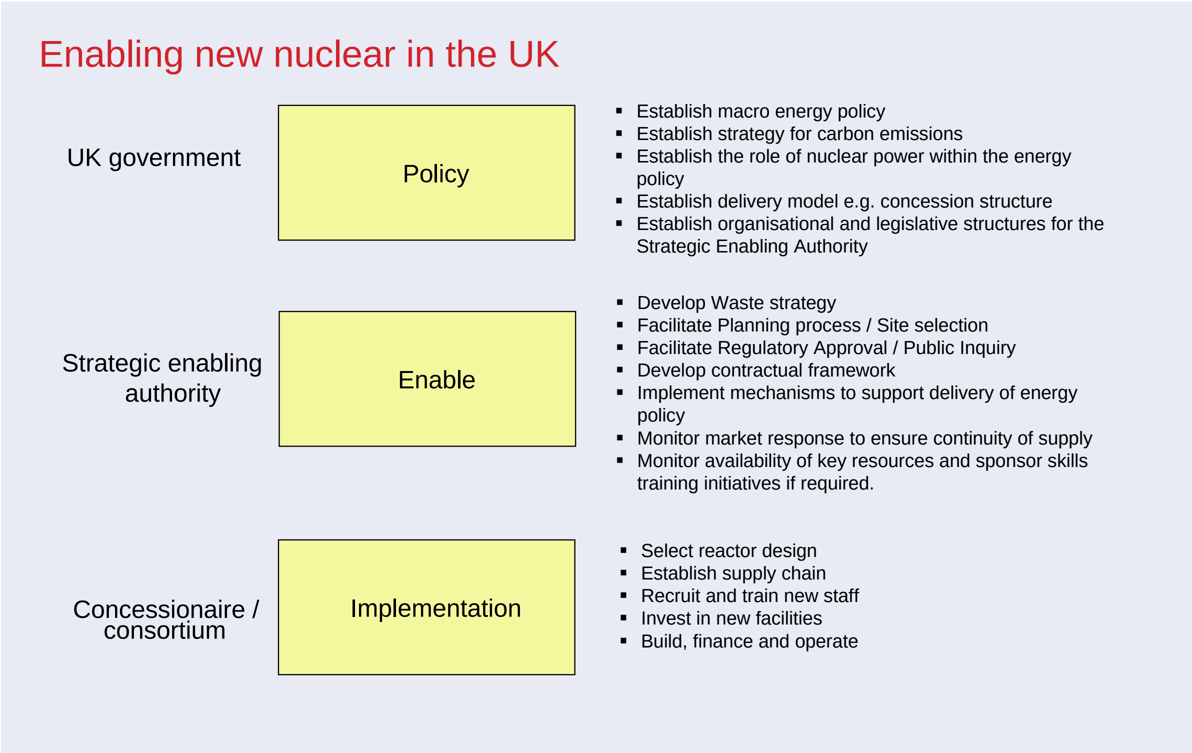
A problem for all developed countries is a lack of experienced regulators, construction staff and plant operators at a time of decline in nuclear technology education, an issue that is being looked at by the World Nuclear Association (WNO), which has co-operated with other bodies to form a World Nuclear University to address some of the issues.There is also talk of a nuclear skills academy, not just for nuclear engineers and other professionals, but also for skilled craftspeople. Imperial College, London, is a recognised centre for nuclear engineering skills, and Manchester University is now a very large research university developing expertise from basic nuclear physics and engineering to medical applications.

New procurement, contracting, manufacturing and design strategies will be required in the new build market, and to gain financing and make projects economically attractive, time frames must be compressed. For instance, a reduced manufacturing capability means that the UK will have to compete with other countries to purchase components, with widespread use of prefabrication, pre-assembly and modularisation for ‘just-in-time’ delivery and at specification.

An electronic computer aided design (CAD) drawing can be put out from a design centre and worked on 24 hours a day, seven days a week, in order to reduce design and construction time. 3-D modelling, high-deposition and robotic welding of key components are also used, together with techniques like global positioning systems (GPS), laser scanners and ‘open top’ construction to accelerate schedules and provide flexibility.

Analysis

Analysis of the day's proceedings offered food for thought, as outlined in the 'Key Conclusions'. Different ways forward for new nuclear build in the UK in terms of policy, enabling conditions and implementation were suggested, as proposed by IBM in a recently published paper entitled ''An evaluation of the capability and capacity of the UK and global supply chains to support a new nuclear build programme in the UK'' .



New nuclear plants are very complex, multi-disciplinary projects with large integration of risk between construction, operation and funding, but the issues facing the UK are resolvable. The financiers and the contractors need to be given the confidence to partake in the new nuclear build rather than in other energy sectors. But most of all, consultation between government and industry is needed, to avoid thinking in respective silos and ending up short of the energy we will require in the future.

Participating organisations

Arup
BAA plc
Balfour Beatty plc
Bechtel Ltd
BFNL plc
Bracchium Ltd
British Energy
CH2M Hill
CMS Cameron McKenna LLP
Costain Ltd
CRMP
Denton Wilde Sapte
Department of Trade & Industry
EC Harris LLP
EDF Energy
Emcor Rail Ltd
Ernst & Young LLP
Fluor
Freshfields Bruckhaus Deringer
Gardiner & Theobald LLP
Halcrow
Henley Management College
Herbert Smith
IBM Business Consulting Services
Jacobs Babtie Group
KBR
KPMG LLP
Laing Rail
Lehman Brothers Europe Ltd
Linklaters
Major Projects Association
Ministry of Defence (DPA)
Morgan Est Plc
Mott MacDonald Group Ltd
Mouchel Parkman
Nuclear Installations Inspectorate
Pell Frischmann
Risk Solutions
Rolls-Royce plc
Scott Wilson
Shadbolt & Co LLP
Simmons & Simmons
Sir Robert McAlpine
Taylor-DeJongh
Taylor Woodrow Construction
TVO - Finland
UKAEA
World Nuclear Association