Dr Robert Hawley, Chairman of Berkley Resources Ltd and Carron Energy Ltd, UK

Nuclear Power in the UK - Past, Present & Future

History

The technology stages in the life of the UK nuclear power programme fall into three phases:

1. Magnox
2. Advanced Gas Cooled Reactors
3. The Pressurized Water Reactor

Management has been in four stages, which, in my opinion, are:

1. Bureaucratic, coupled with technical understanding, under the existing Central Electricity Generating Board (CEGB), a state owned group.
2. Technically knowledgeable and dedicated management, after the split up of the CEGB leading to the formation of Nuclear Electric, and then in the early days of the newly privatized British Energy.
3. This was followed by a non-technical management, seeing only the opportunity for short-term profit, with no understanding of the need to technically maintain the assets and the skill base or the long-term needs of the business, which in turn led to the massive shareholder losses.

And today, a technically and financially competent management who have set out to rebuild British Energy from basically the same base position it was at after the split up of the CEGB in 1990.

Turning to history. On 30 January 1953 Duncan Sandys, Minister of Supply, announced Britain's first civil nuclear power programme. This was in two parts - one to build a full-scale nuclear power station and the second to carry out a long-term research programme into the possibility of developing a fast breeder reactor. So in March 1953 the first two 50 MW Magnox reactors were confirmed for Calder Hall A, to be followed by two more, announced in June 1955, at Calder Hall B, together with four similar reactors at Chapelcross.

Just prior to that, in February 1955, a White Paper "A Programme of Nuclear Power" took the engineering industry by surprise when it announced a major programme of another four stations, with the first two stations in operation by 1960-1961 and the other two to follow eighteen months later, with reactor sizes between 50 and 100 MW. A further four stations would come into operation in 1963-1964 with another four in operation by 1965, possibly with liquid-cooled reactors, as opposed to the Magnox gas cooled reactors. In other words, a programme of twelve nuclear power stations with a total capacity between 1400-1800 MW would be on line by 1965.

Such was the rush and size of the programme that no one company could be the lead agent, so four consortia were formed to bid for and build the stations; these were to be followed later by the formation of yet a fifth consortium. This was the first mistake - as the diversification led not only to scarcity of critical engineering design skills but also a multitude of design changes that were later to cause operating problems due to lack of interchangeability. The most significant departure from the Calder Hall design was the provision for on-load refuelling, in spite of the fact that Calder Hall and Chapelcross had no difficulty refuelling during normal maintenance outages. This was the second mistake, because the complicated refuelling equipment was less reliable than the reactor systems.

Nevertheless, in spite of design changes, technical problems during operation, much longer construction times than planned, a much greater cost of electricity than budgeted and the shock produced by the fire at Windscale Pile 1 in October 1957, the stations at Berkeley, Bradwell, Calder Hall, Chapelcross, Hunterston, Hinkley Point, Trawsfynydd, Dungeness A, Sizewell A, Oldbury and Wylfa, with a total output of about 4200 MW, have been faithful servants making a long and vital contribution to the diversity of the UK's energy supply.

The official opening of Calder Hall, by the Queen, which then saw its first production of commercial power, was on 17 October 1956. The building of Chapelcross was a significant achievement, 4 days ahead of the programme being completed, 3 years and 4 months after the letting of the civil engineering contract, with the first grid connection in 1959.

Currently there are 8 Magnox reactors in operation but all will be finally closed down by 2006-2010, a process started with the closure of Berkeley in 1989.

In April 1964 whilst the Magnox programme was under construction, the Government put forward plans for the next phase of nuclear power in the UK. These were to build 5000 MW of capacity in the years 1970-1975. A prototype Advanced Gas Cooled Reactor, an AGR, had been built by AEA and operated successfully for two years. Similar to the Magnox, it was a gas-graphite reactor with a higher rating and operated at greater temperatures. Tenders were called for AGR stations, although other reactors of proven design would also be considered. Three consortia submitted bids for AGR designs, in addition to three PWR and one BWR designs. The appraisal of the tenders, by AEA, lead to the choice in May 1965 of an AGR station, using a novel fuel element, to be built by Atomic Power Construction Ltd. at Dungeness B.

The technical appraisals of the designs, and the economic assessments, have been the subject of much controversy. Some critics thought that the wrong AGR tender had been chosen and the contract given to the wrong consortium. Some thought that the decision to adopt the British AGR at all, rather than the essentially American PWR or BWR systems, was a mistake, due to national prejudice rather than to real technical or economic advantages. Indeed, no AGR design was ever exported.

Be that as it may, the AGR programme had a troubled history. Severe technical problems at Dungeness B led to the collapse of Atomic Power Construction Ltd. The station was taken over by another consortium, but took many years to complete. Having been involved in the design of the turbine generators for Dungeness B, it was worrying to me that the station only reached full output years later when I was the CEO at Nuclear Electric. Later, other AGR stations were ordered from different consortia for Hinkley Point, Hunterston, Heysham and Hartlepool. These were commissioned between 1976 and 1988 giving a total AGR capacity of 8618 MW. To put the Dungeness fiasco in context, although it was the first station to be ordered, it was commissioned 8 years after the first unit at Hinkley Point.

So once again a major mistake was made by going to different designs from different consortia. For example, the turbine generators from the same manufacturer, for different stations, were not interchangeable, neither were the fuel rods. In parallel to this, by the end of the 1960s, international orders were being placed for PWR and BWR reactor units for outputs up to 1000 MW, whilst the French were clearly demonstrating the operational benefits, and the reduced building and construction costs, of having a standardized design.

But typical of the UK approach, by the late 1960s and early 1970s, the nuclear industry was beset by problems arising from changing circumstances and uncertainties about national energy policy, about forecasts of energy demand, about the nuclear share of generating capacity, about reactor choice and about the structure of the industry. Was Britain to go on building British designs, AGR or SGHWR, based on the 100 MW prototype at Winfirth Heath, or to adopt the LWR system favoured by the Americans and exported by them all over the world?

During 1968 and 1969, the two remaining consortia, TNGP and APP, were restructured. APP was re-formed as British Nuclear Design and Construction (BNDC). Both TNPG and BNDC had work for a few years ahead. BNDC had contracts for the Hartlepool and Heysham stations and the job of finishing Dungeness B. TNPG had Hinkley Point B and Hunterston B.

The new arrangement did not survive long. The third stage of the nuclear power programme was uncertain. What reactor system was to follow the AGRs? The question in 1971 as in 1963-64, was whether or not to switch to light water reactors, as the CEGB urged. A long delay ensued, during which an advisory committee deliberated without reaching a positive conclusion. A typical British approach. Then in 1972, the Secretary of State for Trade and Industry proposed the consolidation of the two design and construction units, TNPG and BNDC, into NNC because work was too slow in coming forward for two companies to share. There were no orders to follow the AGR programme, no order as yet for a prototype commercial fast reactor station and plans for new nuclear power stations in England and in the North of Scotland were dropped. Electricity demand was stagnant and Britain had surplus energy capacity. Yet another high-level committee was set up to study the problems of reorganising the industry.

The problem of reactor choice for the third nuclear power programme, which was to follow the Magnox and AGR programmes, remained. The main arguments advanced for the PWR were its cheapness, its export potential and its well-proven design. Arguments against the PWR were uncertainties about safety, especially the reliability of large welded steel pressure vessels and emergency core cooling systems. The main objections brought against the SGHWR were that it was an unproven design, since the Winfirth reactor was small, only 100 megawatts, and that it had no export potential.

In July 1974 the government announced its decision in favour of SGHWR, and in February 1975 consents were given for two SGHWR stations at Sizewell, in England, and Torness, in Scotland. However by the end of 1977 no firm order had been placed by the Electricity Boards. The SGHWR plans were abandoned on grounds of excessive costs and the choice once again, as in 1964, lay between AGR and LWR. Finally in January 1978, the Secretary of State for Energy announced that two more AGRs were to be ordered and the PWR option in the UK was to be kept alive by design and safety studies. There was still a surplus of generating capacity in Britain, but given the long lead times involved early orders were considered necessary, to avoid a shortage around the turn of the century and to keep the nuclear industry viable. We are faced with similar problems today.

An important study of nuclear power and the environment appeared in 1976 in the form of the sixth Report of the Royal Commission on Environmental Pollution, commonly known as the "Flowers Report". The report dealt in particular with problems of radioactive waste, and its recommendation led to the setting up of the Nuclear Industry Radioactive Waste Management Advisory Committee in 1978 and of the Nuclear Industry Radioactive Waste Executive (NIREX) in 1982.

In 1977, the proposal by BNFL to build a new plant (THORP) at Windscale to reprocess uranium oxide fuel was the subject of a lengthy public enquiry. A report was

published in March 1978 and in May the government accepted the recommendations and gave the go-ahead for construction of the plant. It has been the subject of much criticism from 1977 to today. Public anxiety about possible reactor accidents was aroused by the Three Mile Island accident in the USA, in 1979.

In December 1979 the newly elected Conservative government, led by Mrs Thatcher, confirmed the previous government's decision to order two new AGRs and said that the next nuclear power station would then be a PWR. In 1980, under the dynamic leadership of Walter Marshall, the CEGB announced plans for a PWR station at Sizewell, and in July 1981, a White Paper on the future nuclear power programme envisaged orders amounting to 15 GW by 1992.

What were the major nuclear preoccupations of the 1980s? Chernobyl occurred in April 1986. The AGR programme has still to be completed, for only two of the seven AGR stations had been commissioned in 1979. Three were commissioned in 1983 and the last two by the end of the decade. The long running of Sizewell B inquiry ended in March 1985. Two years later the Secretary of State gave approval and construction work at Sizewell began in July 1987.

Overall a story of infighting and political stop-go that was to continue to this day.

In 1989 the UK electricity supply industry was privatized. Privatization of the CEGB had a major effect on the UK civil nuclear industry. In December 1988 the government announced that the CEGB would be split into two generating companies, the larger National Power containing the nuclear stations, separated from the National Grid Company. However, by November 1989, due to the apparent large liabilities for waste disposal and decommissioning, the City would not accept investment in nuclear power stations. So the Secretary of State for Energy, John Wakeham, decided to create a new public sector company, hence the birth of Nuclear Electric on 31 March 1990. At the same time, plans for three new PWR stations, together with those for some large coal fired stations, were suspended. These were indeed dark days for the nuclear industry.

When Nuclear Electric was formed, the performance of the AGR stations was very poor and the overhead costs of running the Magnox and AGR stations were very high - mainly because of the requirements for specialized skills that existed only in the UK.

I had the pleasure of joining Nuclear Electric in 1992 when they were addressing the problems of the ageing Magnox reactors, the poor performance of the AGRs and the fact that the company was making an operating loss of almost £1billion/year. At that time the PWR at Sizewell B was under construction.

Over the period of the next four years, up to 1996, a number of the Magnox stations were granted life extensions, the load factors of the AGRs increased from 59% to 71%, many operating records were broken, the generating costs reduced from 5.2 p/KWh to 2.37 p/KWh, Sizewell B was completed on time and to budget, coming on steam in 1995, several of the Magnox stations started to be decommissioned and the safety records were exemplary.

These successes led to Nuclear Electric and Scottish Nuclear being privatized as British Energy in 1996. At the same time the control of the Magnox stations passed to BNFL. But there was a price to pay. The Nuclear Review "The Prospects for Nuclear Power in the UK" published by the government in May 1995 concluded that:

"*Providing public sector support for a new nuclear power station would constitute a significant intervention in the electricity market and current and foreseeable circumstances do not warrant such an intervention*".

Realising that private finance would not be available and the company did not have sufficient of its own funds, British Energy accepted that in the circumstances the government's conclusions were correct. In the light of the current and immediately foreseeable market conditions, further nuclear development was not economically viable and the company reluctantly decided, in December 1995, not to proceed with plans to build Hinkley Point C and to withdraw the planning application for Sizewell C.

The company stated that in the immediate future the issue was not whether nuclear power would survive, but whether the UK expertise in this field could be sustained long enough in the absence of a continuing UK programme, to take a role in future opportunities. Given the success in building Sizewell B to time and cost, British Energy would have liked to embark on new nuclear construction, but could not do so until prevailing market conditions allowed.

For several years, after 1996, the operation of its reactors was successful. By 1998 British Energy was the UK's largest generator, operating costs were down to 1.98 p/KWh and Sizewell B was operating at high load factors.

But after the good years the diversion of money into dividend and returning cash to shareholders led to lack of investment in the plant and this started to show. There were major unplanned outages at a number of stations, mainly due to the conventional equipment not the reactors, leading in turn to substantial financial losses. The AGR reactors became the worst performers in the world measured by WANO standards.

But worse was to happen. The collapse of the price of electricity, to a company that was a price taker, since its plants could not be switched on and off, resulted in a total

restructuring of the company, with shareholders losing most of their investment and the company basically reverting to being once again owned by the UK government. Under government control the company had to sell off to assets in North America and enter into long-term contracts for the sale of its electricity.

The UK 2003 Energy White Paper believed it was possible to meet CO_2 reduction targets by energy saving and a substantial increase in renewable energy and it also stated that:

"*Nuclear power is currently an important source of carbon-free electricity. However, its current economics make it an unattractive option for new, carbon-free generating capacity and there are also important issues of nuclear waste to be resolved. These issues include our legacy waste and continued waste arising from other sources. This white paper does not contain specific proposals for building new nuclear power stations. However, we do not rule out the possibility that at some point in the future new nuclear build might be necessary if we are to meet our carbon targets. Before any decision to proceed with the building of new nuclear power stations, there will need to be the fullest public consultation and the publication of a further white paper setting out our proposals.*"

But by 2005 it became clear that the UK would not meet its CO_2 emission targets and in addition the financial performance of British Energy had, helped by increasing electricity prices, improved dramatically.

The Present

To any nation the security of its energy supplies is of vital importance. The situation in the UK, which was becoming more and more dependent on imported gas, started to give cause for concern. This became acute when Russia started to cut off gas supplies to several countries, and in particular the Ukraine, last winter and used gas supplies as a potential weapon in the form of massive price increases.

On 16 May this year the UK Prime Minister, in advance of the production of yet another Energy Review in July, said:

"*Essentially the twin pressures of climate change and energy security are raising energy policy to the top of the agenda in the UK and around the world. The facts are stark. By 2025, if current policy is unchanged, there will be a dramatic gap on our targets to reduce CO_2 emissions, we will become heavily dependent on gas and at the same time move from being 80-90% self-reliant in gas to 80-90% dependent on foreign import, mostly from the Middle East, Africa and Russia.*

"*These facts put the replacement of nuclear power stations, a big push on renewables and a step-change on energy efficiency, engaging both business and consumers, back on the agenda with a vengeance. If we don't take these long-term decisions now we will be committing a serious dereliction of our duty to the future of this country*".

The publication of the UK government's 2006 Energy Review on 11 July 206 was a major step forward in the history of nuclear power in the UK. In great contrast to the 2003 Energy Review it recognised the need for future nuclear stations. It stated:

"*Nuclear power is currently an important source of low carbon electricity in the UK. The existing fleet of nuclear power stations will close in the years ahead. Our assessment is that higher projected fossil fuel prices and the introduction of a carbon price to place a value on CO_2 have improved the economics of nuclear as a source of low carbon generation.*

"*We have concluded that new nuclear power stations would make a significant contribution to meeting our energy policy goals. For illustrative purposes, if existing capacity were replaced, then by 2030 our carbon emissions would be around 8 MtC lower - equivalent to total emissions from twenty two 5000 MW (Mega Watt) gas-fired power stations - than otherwise, and our gas consumption some 13% lower.*

"*It will be for the private sector to initiate, fund, construct and operate new nuclear plants and to cover the full cost of decommissioning and their full share of long-term waste management costs. But in view of the potential benefits for our public policy goals, the Government proposes to address potential barriers to new nuclear build.*

"*By early next year, the Health and Safety Executive will develop guidance for potential promoters of new nuclear power stations. This will explain how they can obtain assessment of possible reactor designs before committing significant sums to planning and construction.*

"*On nuclear waste, the report of the Committee on Radioactive Waste Management, due later this month, following its interim report published in April, will provide the basis for a decision on the long-term management of waste by the Government and the Devolved Administrations.*

"*We are also setting out a proposed framework for considering the relevant issues and context in which planning inquiries should be held. This would be set out in the Energy White Paper to be published around the turn of the year.*"

The recognition of the need for nuclear and the desire to remove potential barriers to its construction has opened up the way for the private sector to give serious consideration to new nuclear build in the UK.

EdF have stated their very clear interest, whilst others, such as RWE and E.ON UK have the financial ability and expertise to be part of a future programme. British Energy, as owner of the sites on which new build will take place, is in a strong position to be part of the programme.

The reactor types are likely to be either the Framatome EPR

(1650 MW), already being built in Finland and on order from EdF, or the Westinghouse AP 1000 (1100 MW).

Whilst the EPR has the advantage of being under construction, the AP1000 with its modular construction and passive safety features, resulting in a much-reduced footprint, less components and quicker construction, could have significant advantage when being considered for existing space limited UK sites.

Other designs, such as the Mitsubishi Advanced PWR, the GE ABWR and the ACR (Advanced CANDU) are more remote possibilities.

The supply chain for the reactor construction will of necessity, due to shortage of UK capacity, be mainly international. This could lead to bottlenecks in the procurement programme depending on future orders from other countries, particularly China.

There is also now a major need to address the skills shortage associated with new nuclear construction and the operation of new reactors. This is particularly so against the long-term needs of the Nuclear Decommissioning Authority.

So, assuming there is no change in political direction what will we see happening in the next few years?

The Future

The main objective for the UK government is to ensure that a framework evolves that encourages private sector investment across the energy infrastructure and does so at an affordable price for the consumer.

A number of significant uncertainties in the planning process and regulatory framework need to be addressed.

The three key regulatory and planning processes are:

1. Section 36 Electricity Act 1989, Environmental Impact Assessment and planning consents;
2. Nuclear Licensing;
3. Compliance with the Euratom BSS Standards

New nuclear build should be based on standard international designs with a proven track record. Further, the regulatory scheme should maximise safety and reliability over the long-term by maintaining the design integrity in line with other similar certified designs worldwide.

Greater clarity for investors is needed on the processes to licence and consent new infrastructure, regulation throughout the life of the assets and the arrangements for handling longer-term liabilities.

Sizewell B took 15 years from conception to commissioning including a public inquiry that lasted over 2 years. It is necessary to reduce the time scale of the regulatory process for new nuclear build. Currently, the stages in the NII Licensing Process, the S.36 Consent and Land Acquisition Process and the Ionising Radiation Justification Process takes up to 11 years. Proposals from the legal experts at Hammond's have shown how this can be reduced to a more sensible 6 years.

Following the recent review of nuclear waste storage proposals, the government now needs to establish the policy framework and implementation plan to deliver the preferred solution to this issue.

New nuclear build can be progressed in parallel with the siting and building of the long-term repository.

The UK appears to be on the brink of a nuclear renaissance, brought about by the need to ensure secure and affordable supplies of electricity and to meet its targets to assist in the reduction of global warming.

There is still a long time period to go before the UK starts construction of new stations. In the meantime, closures of existing plant and annual increases in energy demand can only mean a second "dash for gas" in the UK. What a pity that this was not recognised in the 2003 Energy Review, rather than in the 2006 Energy Review.