GLOBAL PERSPECTIVES ON FUTURE NUCLEAR ENERGY UTILISATION

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ABSTRACT

This paper is presented as an overview of the nuclear sector from a global perspective.

The aim is to show that nuclear power does have a future but that this will only be fully realised when the industry is able to demonstrate that it is part of the solution to the world's energy and environmental difficulties rather than part of the problem.

The paper looks at the projected world energy demand as the population increases and countries develop, showing that nuclear power is required to meet this demand.

In presenting nuclear power as a solution, the paper addresses the challenges facing us such as public confidence, environmental opposition, political issues and finance. It addresses the debate over reprocessing and direct disposal of irradiated nuclear fuel and looks at the competition from other fuels.

The paper suggests how the industry might approach these issues such that nuclear power is indeed regarded globally as a solution to some of the worlds most pressing problems.

1. INTRODUCTION

What I want to present here are my personal thoughts on the future of the nuclear sector from a global perspective. These thoughts will be based on what I have learnt in BNFL since joining the Company six years ago.

The nuclear industry faces many challenges. However, I am convinced there are huge commercial opportunities within our grasp. Having seen first-hand the capabilities of the industry, and the tremendous potential of the people who comprise it, and having been heavily involved with a comprehensive strategic review within my own organisation, I am left in now doubt that those opportunities are ours for the taking.

There are two key messages I hope to leave you with:

- The first is that nuclear power has a future.
- Secondly, this future will only be fully realised when we in the industry are able to show that we are a solution to some of the most pressing of the world's problems, rather than another problem.

To do that we need to convince the general public, the environmental lobby, governments and financial institutions that prejudices against nuclear power are based upon our history rather than upon the industry as it is today. We need to continue to transform the industry to adapt to the new demands of a changing world. In particular, we need to move from the defensive, or from pleading special interests, and set out positively to show that nuclear power is competitive when investors consider their generating options.

2. NUCLEAR POWER HAS A FUTURE

So first of all why am I so confident that there is a future for nuclear power? Given the timescales inherent in the industry it is necessary to start with a somewhat visionary approach and look further ahead than the

next 15 years to see where nuclear power is really going. For that we have to look to the sort of global energy perspectives presented to the World Energy Congress (WEC) held in Tokyo in 1995, and to draw on some of its findings and conclusions. The WEC took the theme “Energy for our Common World - What Will the Future Expect of Us?’ It was a wide ranging but very detailed discussion on the issues facing a world seeing a continued expansion in its demand for energy.

The results of a joint WEC and IIASA (International Institute for Applied Systems Analysis) study, “Global Energy Perspectives to 2050 and Beyond,” were presented at the Tokyo meeting by Mr. Nakicenovic; he has also referred to them in his paper to the Uranium Institute Symposium in 1996. It is against those results, and the general themes from the WEC, that I will start to outline the place of nuclear power in this changing world.

2.1 Energy Demand

To put it in very simple terms, over the next 100 years the world population could double or triple and economic activity could increase by at least an order of magnitude. As a consequence, demand for energy would quadruple. In the developed countries it may well be possible to stabilise population and energy demands, but the majority of the world’s population does not yet have access to electricity. We cannot deny the developing world its right to strive for a quality of life that developed countries take for granted.

Other authoritative sources, not least the International Atomic Energy Agency, predict energy demand doubling over the next twenty to thirty years alone, with the rise in electricity consumption being perhaps twice as fast as that of primary energy requirements. We can do some simple projections of where the world could get this electricity from, up to the middle of the next century.

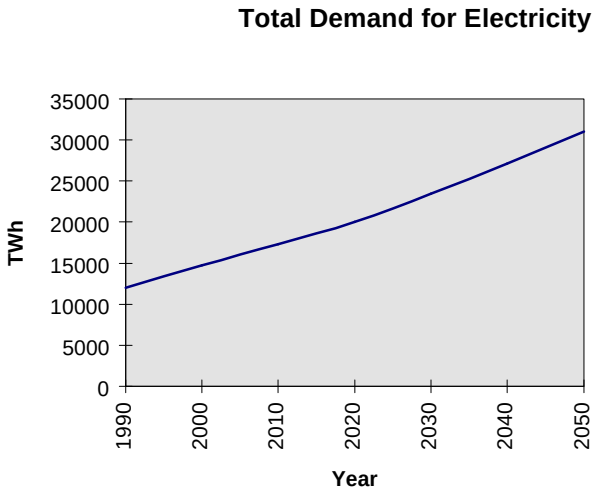

Figure 1 Projected total world electricity demand, 1990 to 2050.

This forecast (Figure 1) for total electricity demand is at the lower end of the range of the options covered in the WEC/IIASA study and makes full allowance for energy efficiency and conservation measures. As you can see, this still involves more than doubling demand over the next 50 years.

Because of the environmental impact of fossil fuels, let us assume that their use for electricity can be stabilised after 2000. There would, of course, still be growing use of fossil fuels for transport, so even this would not necessarily reduce greenhouse gas emissions, merely cutting the increase. Next, let us be very

generous and assume that renewable energy sources, currently almost entirely in the form of hydropower, can double their share of the electricity market from 19% to 38% by 2050. Finally, let us add on the known and planned nuclear capacity. This falls away sharply into the next century as I have only included current plans for new reactors, which stop in 2010.

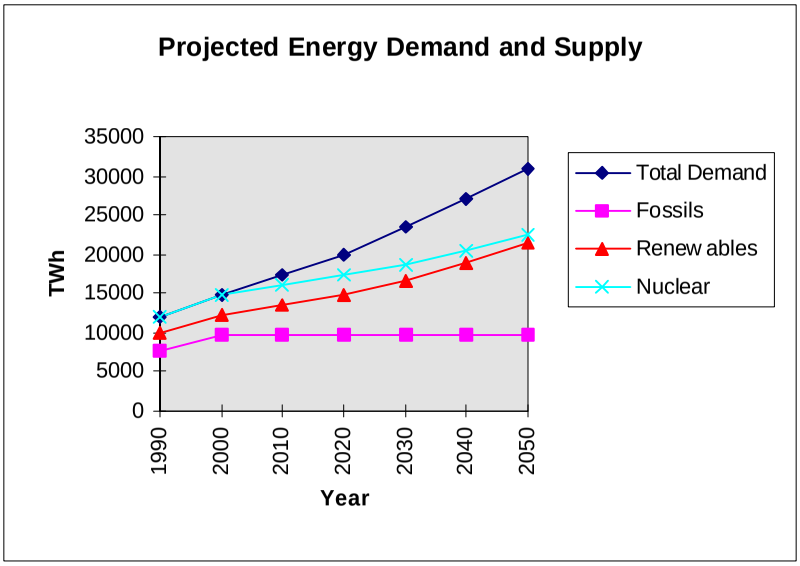

Figure 2 Projected total world electricity demand, and projected supply sources, 1990 to 2050.

As Figure 2 shows, this still leaves a large gap, rising to 8000 TWh by 2050, or some 1200 million tonnes of oil equivalent (mtoe). This significantly exceeds the current nuclear production of just over 2000 TWh (300 mtoe). I would argue that this gap can only be filled by either additional fossil-fired generation or by nuclear. The world has the luxury of being able to make a choice. The challenge for the nuclear industry is to ensure that the solution chosen is nuclear power.

2.2 The Current Position

So where do we stand in presenting ourselves as that solution? Commercial nuclear power started in the UK with the opening of Calder Hall over 40 years ago. Currently there are nearly 450 nuclear reactors operating world-wide in some 32 countries. This capacity of 340 GWe delivers 7% of the world's primary energy needs and 18% of its electricity.

There are some 40 reactors under construction and a further 60 in the planning stage. The total world capacity is expected to increase by 10-15% over the next 15 years. Virtually all the planned growth is in Asia, where nuclear capacity is expected to double by 2010. For example, South Korea expects to increase its current 11 units to 27. Indonesia could begin construction of its first plant in 1998. China, with three reactors now operating, has 13 more on the books.

Around 215 nuclear reactors, about half the world total, are in Europe. An additional 13 nuclear units are expected to be completed in Europe in the next three years, with a further six earmarked for completion soon afterwards.

In countries where currently there are no new nuclear orders being placed, including the USA, Germany and the UK, existing installed capacity will continue to supply a significant part of electricity needs well beyond the millennium. Even where there is a commitment to phase out nuclear power, such as in Sweden, there are practical problems in reducing their 50% dependency on nuclear power while retaining their

commitment to economic and environmental goals, particularly in respect of commitments to meet CO2 emission targets.

In summary, there is substantial installed nuclear capacity, some construction activity in Europe, and good medium term prospects for growth in South East Asia. However, world energy demand is increasing even more rapidly than the increase in nuclear capacity, so the world share of energy supplied by nuclear over the next 15 years is expected to decrease from the current 7% to around 6%. Because of the long lead times in the nuclear industry there is relatively little that we can do to influence this figure. But there is much that we need to do now for the longer term.

3. NUCLEAR POWER AS A SOLUTION

One of the major changes experienced by the nuclear industry over the past 40 years has been the shift in public perception from early enthusiasm to a generally much more sceptical or, for some, outright hostile position. This change has been brought about, to a large degree, by public reaction to the accidents that have occurred. The most notable, of course, have been the Windscale fire in 1957, Three Mile Island in 1977, and Chernobyl in 1986.

The causes and the physical scale and consequences of these accidents were very different. Indeed Three Mile Island could be seen as proof of the defence in depth of the LWR reactor systems. It was not perceived as such however; each accident however different, did result in a loss of public confidence. At the same time the demand for “safety” measures and a constant tightening of the regulatory position has raised nuclear generating costs. Indeed, the feeling that regulations may continue to become more restrictive has raised perceived risks about the long term costs of decommissioning and the treatment of wastes.

There has also been heightened awareness of environmental issues, and the impact that our consumption of energy is having on the world’s climate and ecology. We have seen two major crises in energy prices, caused by OPEC in the 1970s and the Gulf War in the 1980s. But in some parts of the world, at least, gas has emerged as the fuel of the moment, with its share of the world energy market expected to rise steadily over the next 20 years, with lower construction costs for new stations and faster pay back periods.

The ending of the Cold War has highlighted the legacy of the nuclear arms race, and nuclear power in many minds is being linked by word association with the pollution and clean up costs from the military legacy. All of these factors have combined to label nuclear as a problem rather than as a solution. However, I believe that the battle is now moving on to our ground.

3.1 The Environmental Debate

Over recent years the environmental debate on global warming has widened considerably. There is clearly fresh concern among politicians and environmental groups, which is leading them to see solutions in options that were previously ‘taboo’.

In July 1996, a United Nations conference on the Framework Convention on Climate Change endorsed the latest Intergovernmental Panel on Climate Change (IPCC) report. The work of over one thousand scientists, this report concluded for the first time that human activity is causing global warming, stating that “the balance of evidence suggests a discernible influence on global climate.” Of course, we have been here before. The prospects for the nuclear industry have not improved much since the Rio Earth Summit in 1992.

But one of the genuinely startling features of the recent UN conference was the astonishing conversion of the USA. Standing up to the might of their petrochemical and fossil fuel lobbies, the US government backed the Geneva Declaration, which committed the OECD group of nations to adopt legally binding limits and targets to reduce greenhouse gas emissions. This U-turn speaks volumes about how the actual or

perceived threat from global warming is beginning to influence global political developments. Global warming is now becoming the world's number one environmental issue, and that is an opportunity for the nuclear industry.

These concerns are also beginning to bring home the need to consider all the costs associated with power generation. The nuclear industry has been required for some time to make provision for the treatment of all of its waste streams and decommissioning. Now there are signs that people are beginning to recognise the need to internalise the environmental costs of all forms of electricity generation. The potential cost of global warming or acid rain is not added to the average household electricity bill of today's consumer. But, if global warming is a reality, it will most definitely appear on the bill of tomorrow's consumer who will effectively be paying the costs of 'decommissioning the worlds atmosphere'. The changing perception of the costs of nuclear's competition must also help us to be seen as a more viable solution.

But there is much that the nuclear industry itself needs to do to overcome the barriers to presenting itself as a solution to long term energy needs.

4. OUR CHALLENGES

4.1 Public Confidence

The first issue which the nuclear industry must tackle is public confidence, which is linked directly to safety. It is now some 12 years since the Chernobyl accident. It is this event, more than any other, which knocked our industry back, and it is still holding us back from realising our potential.

Despite the perceptions, and the accidents I have already referred to, nuclear power is actually a very safe form of generating electricity. According to Rémy Carle, when Chairman of the World Association of Nuclear Operators (WANO), US reactor safety has improved dramatically since Three Mile Island. The risk of an accident leading to core damage is estimated to have reduced by a factor of about 100 since that incident.

But Chernobyl has demonstrated that it is not enough to look just to Western safety standards. Although much improved, the safety standards of some Soviet designed reactors are still not good enough. We must be satisfied that standards across the world are up to the mark - and that they are enforced effectively. The formation of WANO provides a mechanism for the exchange of information, technical data and operating experience, and for improving training. The emergence of the IAEA-sponsored International Nuclear Safety Convention is another step in the right direction.

But much more needs to be done. We need to develop internationally acceptable ways of ensuring safety at every stage in the nuclear process: designing, building, commissioning, operating and decommissioning. As the industry becomes increasingly international, a common approach to safety and licensing will become more and more essential. The Chernobyl accident would certainly not have occurred if such a system had been in place 12 years ago. Safety and operating integrity must be our starting point throughout the world and an area for international co-operation.

4.2 Environmental Opposition

The nuclear industry is a favourite target of environmental pressure groups. This has been true despite the fact that the potential dangers of nuclear materials were recognised from the outset; as a result the industry has always been highly regulated and monitored. Controls were set to prevent unacceptable pollution, rather than to recover from it as in many other industries. The nuclear industry also advocated and practised recycling long before it was a popular "green" issue.

The overlapping of objectives should be even greater today. One only has to consider the environmental consequences of increased fossil fuel burning or the social consequences of restricted growth. The demand picture I have already painted of the future says clearly that nuclear generation will not disappear. The responsible management of nuclear wastes and responsible decommissioning are therefore necessities. There needs to be investment and international co-operation to improve safety in existing facilities, particularly in countries with older Soviet designed reactors.

Our common global objective therefore should be a well run, sensibly regulated, industry actively dealing with problems of waste and emissions. So much more could be achieved if the environmental lobby would work with us, rather than against us. I challenge them to put the past behind them and partner us in providing a future solution; to use their powerful lobby to persuade governments to put real money into dealing with necessary safety issues. Stop campaigning to have the nuclear industry shutdown, and join with us in keeping it safe.

4.3 Political Will

A saying I have heard more than once since I joined BNFL is that "There are no votes in nuclear." An industry which has a cycle of some ten years from investment decision to operation of a reactor, and a further twenty for payback, is always likely to be at odds with a system where the participants have a much shorter term of office, where they are looking for re-election typically every four to six years. However, in many countries the approach to nuclear power, and indeed the operation of nuclear plants, is directly controlled by the government. Even where there is private commercial involvement the influence of governments is strong, for example through the regulatory framework and constraints on international trade.

This influence can be beneficial when there is a clear national energy policy which survives successive governments. The development of the nuclear industry in France and Japan are good examples. But political support can be fragile. I note the concerns of our Japanese colleagues following the Monju incident. We can do much within the industry to lessen this volatility on a national level if we can overcome the first two barriers I have referred to, public confidence and environmental opposition.

The industry must also seek to ensure a stable regulatory and commercial framework. The scale of our projects, in both money and time, does require confidence that the conditions on which investment decisions were made will not be arbitrarily changed. Acceptance of international standards and mutual recognition of assessments and safety cases can only assist in this process. A common international licensing system would help cut through the log-jam of constraints that bedevil nuclear planning and construction in many countries. The airline industry would not be able to operate as it does today if each country that was overflown demanded the right to initiate its own safety assessments starting from scratch and based on criteria of its choosing.

However, any move towards international standards would need to be carefully managed. All countries recognise the benefits of air travel and hence the value in co-operating with international regulations. The same is not true of the nuclear industry (at least not yet!). We are well aware of the tactic of ratcheting regulations beyond the point of prudence as a way of resisting nuclear investment. We must ensure that there is sufficient dialogue within the industry to arrive at standards based on best practice and appropriate safety criteria.

Perhaps because of the degree of government involvement, either resulting from historical military connections or through funding requirements, the nuclear industry does not have the same presence of international companies as, say, the oil or chemical industries. The degree of international dialogue which the presence of such companies ensures needs to be provided in other ways.

4.4 Reprocessing and Waste Management

We must consider the debate within the industry between the proponents of recycling and those who favour direct disposal. It is right that there should be discussion, but the debate at times seems to be directed at establishing an absolute right answer to influence national policies. In practice I feel it should be a business discussion between customers and suppliers who have alternative solutions for customer problems (even if some of those customers are government owned).

As Commercial Director of a firm with strong interests in reprocessing you would naturally expect me to argue that the ability to recycle and re-use nuclear fuel must now be one of our strongest environmental cards and should increasingly become an integral part of our work. By providing a supply of recycled uranium for new fuel, which is under the control of the customer and not the supplier, recycling provides reactor owners with at least a partial cushion against the whims of the international commodity markets and the damaging effects of political uncertainty. The nuclear industry is, of course, founded upon uranium, and you are all aware of how uranium itself has begun to increase in price again. Recycling has the advantage of cushioning these price rises for our industry - this is an advantage no other energy source enjoys.

Regardless of whether you are convinced by these arguments, clearly a significant part of the international industry has chosen to accept recycling. Whilst the timing of the introduction of fast reactors still remains uncertain, the use of mixed oxide (MOX) fuel is an established practice. There is MOX fuel in reactors in France, Switzerland, Germany and Belgium, and its use is planned in Japan. There is MOX fuel manufacturing capacity with our colleagues in France and Belgium, and in the UK we are adding to our existing capacity with a 120 t/year plant next to our THORP recycling plant at Sellafield. The Sellafield MOX Plant (SMP), is currently being commissioned.

The marketing position is clear. One tonne of plutonium when recycled in MOX fuel can generate the same energy as more than 2 million tonnes of coal. Given the energy scenarios I have portrayed I would argue that the world cannot afford to ignore this resource. Nor, given the size of the gap between supply and demand, does recycling threaten the use of fresh uranium. It is not an either/or situation.

Those involved are convinced that a well safeguarded plutonium fuel cycle does not represent a proliferation threat, transportation has been shown to be both safe and secure. We naturally would hope to convince as many users as possible of the economic and resources advantages of recycling. However, if some utilities or governments take a different view we would hope that our position will be respected. All involved in the nuclear industry should welcome the successful exploitation of nuclear resources, and there needs to be co-operation in ensuring the world-wide transportation of both irradiated fuel for recycling and of plutonium - based fuel.

Before leaving MOX fuel, I would also note the role which it can play in helping to solve the problem presented by military plutonium. Burning that plutonium as MOX fuel in reactors offers a technically proven, immediately available route to making those stockpiles inaccessible for weapons use. It is a clear opportunity for the nuclear industry to show that it its expertise does hold the solution to at least one of the world’s pressing problems. We should not allow competitive differences to deflect us from he industry goal of ensuring that this route is chosen as the best option for disposition.

4.5 Financial Demands

The WEC in Tokyo included a report which suggested that the capital required for energy production, conversion, delivery and environmental compliance between 1990 and 2020 would be US$13-20 trillion. The WEC also heard that “investments of this magnitude cannot be financed from the public sector.” This

is in the context of total energy requirements and so is not just a nuclear issue. What it does highlight though is that nuclear power will be competing for scarce capital resources.

A detailed study undertaken for submission to the British government's nuclear review in 1995 showed that the unit cost of nuclear power, as provided by a modern PWR such as Sizewell B, is comparable with other forms of generation. The latest estimates for the European Pressurised Reactor design certainly make it competitive with coal. So why, apart from in Asia, is there little investment in new nuclear industry? I think there are three economically related reasons for this: the relative scale of the initial investment, the sourcing of finds, and perceptions of waste and decommissioning costs.

Firstly, alternative fuels are seen as demanding lower capital investment and providing quicker pay back periods. This is a very short term view. We do need to move the debate to a proper comparison of the overall economics of the alternative sources of generation; I will say more about nuclear's competitive position below. I think we can show that, not only are nuclear generating costs competitive, but they are also known and stable.

But we do also need to work as an industry to reduce capital costs. Work is going on within the industry in this area, but I would suggest that we should also look to see where costs could be saved through joint industry funding where appropriate, for example, generic development work or safety case preparation. Internationally recognised regulation and safety procedures, as I have previously mentioned, could also reduce both costs and uncertainty.

Secondly, the scale of nuclear investment costs appears too great and the period of cost recovery too long for the short term financial markets, given the associated uncertainties, such as those seen in the UK with the licensing delays that plagued both Sizewell B and THORP. Only in countries where governments provide the strategic framework can long term investment be supported alongside market-driven short term investment. For example, the London financial markets provide a significant amount of the funding for the expanding nuclear programme in Japan, where the long term commitment of the government is much dearer than in the UK.

But what about the developing economics where new generating capacity will be most desperately needed? Viable world-wide demand for nuclear power can only be created if it is funded by financial arrangements on a global scale. We need new international arrangements that can ride the peaks and troughs of individual economies and governmental policies. Along with international financing would go an international vested interest in ensuring that the plants are built to world standards, operated responsibly and safely, not abused for military purposes, and that they bring real benefit to the communities that they serve. International institutional finance can be the key to a proper world order in nuclear power.

Surprisingly enough, I think global warming can help even here. The insurance industry has issued warnings that it could face financial ruin because of the havoc wreaked by climate change. This is an industry controlling a major slice of the world's capital, with influence reaching into every corporate boardroom and on to every stock market floor. Our challenge is to convince these insurers that we provide part of the solution to global warming; that it is safe nuclear power that they should be investing in, not only as a secure investment in its own right, but also as a way of promoting the security of their other investments by reducing the threat of global warming.

The final factor which is currently inhibiting investment is the perceived uncertainty over the cost of decommissioning and waste management. Here I stress the word "perceived". Liability estimates for many facilities did rise dramatically in past years. However, increasing experience of decommissioning is proving that it can be done cost effectively. At Sellafield for example, over 20 decommissioning projects have been completed in the past 14 years, at 86% of the initial cost estimates. Waste streams associated with recycling are known, contained and being treated. We know the costs of managing these wastes. There is

also increasing knowledge about deep disposal, and even if these concepts are not physically demonstrated, we know the costs of long term interim retrievable storage.

The nuclear industry can also improve on the way it provides financially for these liabilities so they are not seen to be left as a public burden. When properly discounted the liabilities represent a small proportion of the generating costs; and as technology and demonstration improve we should be able to justify further reductions in the provisions that we have to set aside. The nuclear industry can also improve on the way it provides financially for these liabilities so they are not seen to be left as a public burden. When properly discounted the liabilities represent a small proportion of the generating costs; and as technology and demonstration improve we should be able to justify further reductions in the provisions that we have to set aside. We need to use these developments to convince financial institutions and the general public alike that nuclear costs are known and bounded.

4.6 Competition from Other Fuels

If nuclear power is to win its appropriate share of the capacity needed to fill the gap between electricity demand and projected supply, then we need to demonstrate that nuclear provides the lowest cost generating option both in economic and environmental terms; and the most stable.

The Gulf War saw oil prices more than double overnight. And yet Iraq and Kuwait's combined crude oil production was less than 5% of the global output. The trigger for the price increases was merely uncertainty. In Europe at present gas is the fuel of the moment, with North Sea and Siberian reserves. But the price of gas- produced electricity in 2020 is anyone's guess. There will also be the uncertainty introduced by the pressures to internalise the environmental costs of fossil fuel generation, as I have already discussed.

By contrast nuclear investment costs are known (within a set regulatory framework), and once the investment is made it is clear that there will be generating costs for the life of the plant. Furthermore, these known costs cover the full cost from cradle to grave; all waste streams are managed, and the costs are covered either directly or through provisions.

As we look out into the future though, I would suggest that there are two factors where we still need to concentrate: these are excellence in the management of existing facilities, and advances in technology.

The industry cannot afford fresh accidents or incidents. That is obvious, but it requires very close attention to detail, and attention to the skills and competencies of the people in the nuclear industry. We also need to be looking carefully at costs and imaginatively at modes of operation and ways of extending lifetimes. In the UK, vast strides have been made in improving the performance of the AGR reactors, for so long the under- performing members of the nuclear family. Elsewhere in the world, plant is also setting new records on availability and output. We certainly need to "sweat the assets."

In looking to 2020 and beyond, however, we need to be considering what advances can be made. We need to address the factors which are seen as competitive weaknesses, and enhance the strengths. We need to address, therefore, licensing and construction times, and capital costs. We may need to consider novel fuel cycles, and enhanced safeguards. We need to use existing decommissioning and clean up projects, including military ones, to demonstrate and develop techniques which will further reduce estimates of back end costs. Although the application may appear some time off, such development is urgent as many of the decisions will be made much sooner.

In my capacity as Chairman of a US company, BNFL Inc., I visited some of the US sites connected with the Manhattan project, and absorbed some of the history. I could not help but be impressed by how much was achieved in such a short period of time. I know that much of that reflects priorities and resources, but if we are to see a resurgence, a second nuclear age to help the world achieve the development it needs, then

we do need to recapture some of the boldness, innovation and drive which characterised the early steps. I would pledge myself and my company to set an example in this area.

5. CONCLUSIONS

As I have already said, I believe that the nuclear industry can only move forward if it is not seen as part of the problem, but is accepted as part of the solution. We will have to convince the public, interest groups, governments, generators and financial institutions.

This is quite a challenge, but for our industry the building blocks are all in place:

- To generators, we must show that nuclear is the lowest cost economic and environmental option.
- To financiers, we must convince them that ours is the investment of the future.
- To the public, we must be able to tell the truth behind our work; to remove the distortions and the misconceptions based upon our past which dog us to this day.
- To governments, we must present ourselves as the solution to the problems of industrialisation and a growing population; the only answer to growing demand. ·
- To environmentalists, we must show that our alternative is the only one which does not contribute to what is becoming the greatest perceived environmental problem we have faced; and the only one which preserves rare minerals and is able to recycle its raw materials.

Let me conclude by reiterating my key messages, and encouraging all those at this Conference and all in our industry to take up the call.

Firstly, our industry has a future, we have unique opportunities and every reason for confidence.

Secondly, by working together to proclaim our virtues as the problem-solver for some of the greatest threats and issues facing mankind, we can convince others to allow us the opportunity to show our potential.