BNFL SUBMISSION TO THE PERFORMANCE & INNOVATION UNIT'S REVIEW OF UK ENERGY POLICY

INTRODUCTION

The purpose of this paper is to present British Nuclear Fuels plc's (BNFL's) contribution to the achievement of the objectives set out by the Performance and Innovation Unit (PIU) of the Prime Minister's Cabinet Office, namely:

- to establish the objectives of UK Energy Policy, including the UK contribution to global policy initiatives, to 2050;
- to have a clear framework for reconciling the trade-offs between the different objectives of energy policy; and
- to develop a vision and strategy for achieving these objectives and identify the practical steps that need to be taken in the short and medium, as well as the longer term.

BNFL fully supports the promotion of sustainable development where safe, reliable, affordable energy underpins UK economic competitiveness while minimising the impact on the environment and contributing to global policy initiatives. We believe the current Energy Review is a timely and welcome commitment to ensure that an effective long term vision and strategy is evolved to address one of the nation's most important issues.

The paper, together with BNFL's responses to specific questions and propositions posed by the PIU in their Nuclear Scoping Note, will put forward BNFL's view on a balanced energy policy. This will highlight the role of nuclear power within the policy and also BNFL's role within the nuclear industry. It will conclude with a series of practical action steps that can be addressed now to ensure a balanced energy policy in the medium and longer term.

CONTENTS

1. EXECUTIVE SUMMARY

1.1 BNFL welcomes the opportunity to contribute to the UK Government's Energy Policy review.

1.2 The UK Government should use the opportunity of the Energy Review to set policies which ensure a balanced, long term energy mix which focuses on safe, secure, cost effective energy with minimal environmental impact. To achieve this, BNFL recommends that the Government actively encourages substantial development and deployment of both nuclear and renewable energy supplies.

1.3 BNFL believes that there is a powerful case for nuclear power to be supported. However if current market mechanisms are maintained over the next two decades and nuclear reactors are decommissioned as planned, no replacement capacity will be built. The UK will then be reliant on imported gas (up to 80% of supply) to meet the growing demand for electricity.

1.4 Over-dependence on imported gas for electricity would result in serious long term consequences: i) supply will be far less secure as over 60% of proven gas reserves lie in the Middle East and Russia, ii) prices would be volatile, and potentially rising, reflecting the need for gas infrastructure enhancements, as UK reserves dwindle; iii) greenhouse gas emission reduction targets would almost certainly not be met.

1.5 No baseload electricity generation plant has been built in the UK in a truly competitive marketplace. This is due to a combination of market prices and the need for long-term purchase and supply contracts. The electricity regulator and the Government must determine how future baseload plants of any fuel type can be built in the UK.

1.6 Nuclear electricity generation currently makes a major contribution to the Government's key energy policy goals. This capacity should be actively replaced so that nuclear power will continue to represent a significant proportion of the UK energy portfolio for the following reasons:

- <u>Safety</u>: the nuclear industry's safety record is impressive and has steadily improved across the world because of firm regulation, improved designs and greater operational experience. The UK's nuclear reactors have operated safely for the length of their existence, over four decades.
- <u>Security of Supply</u>: nuclear contributes significantly to security of supply: (i) nuclear adds to the diversity of energy sources; (ii) the uranium feedstock is plentiful and comes from stable countries such as Australia and Canada; (iii) nuclear provides reliable baseload generating capacity; and (iv) fuel availability can be assured through retention of strategic stocks either of finished fuel or of raw uranium feedstock.
- <u>Cost Effective</u>: nuclear generation costs for a new reactor in the UK are expected to be in the range of 2.2p to 3.0p/kWh for an advanced passive (AP) design, i.e. competitive with any other source. Costs, however, would be substantially less volatile due to low exposure to fuel cost movements. To ensure cost-effectiveness, it is vital to standardise on a world class reactor for the future, such as BNFL's AP design.
- <u>Minimal Emissions</u>: the presence of a significant component of nuclear power in the generation mix ensures that large quantities of high density base load electricity are provided with virtually no CO_2, SO_2 or nitrogen oxides (NO_X) emissions.

1.7 A strong domestic nuclear generation programme would maintain the UK's global market position in the nuclear fuel cycle. By helping the UK keep at the leading edge of the science and technology base, it would contribute directly to regional employment, as well as contributing indirectly through overseas earnings.

1.8 BNFL recommends that the Government takes the following actions to provide a level playing field, which will help to keep open the option for nuclear power:

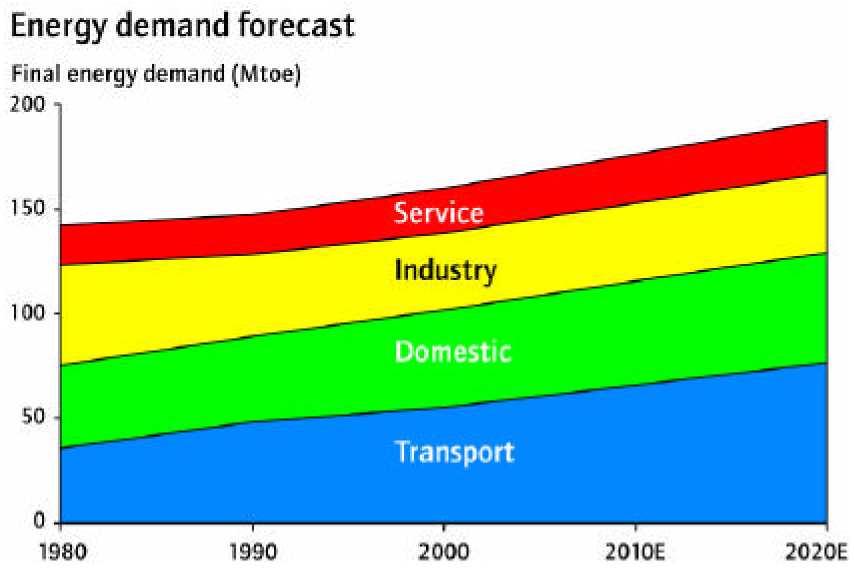
- **Modify current climate change mechanisms, such as the Climate Change Levy, recognising that nuclear generation should benefit from the fact that it makes virtually no contribution to greenhouse gas emissions.**
- **Improve planning and regulatory approval processes to ensure that major nationally important infrastructure projects, such as new nuclear power stations, can be delivered effectively and efficiently.**
- **Review how long-term electricity supply contracts - which are required for any baseload station, not just nuclear - can be put in place.**
- **Decide on an overall policy for radioactive waste management which recognises:**
  - **that nuclear wastes are currently managed safely;**
  - **that prolonged safe storage is a viable approach to the management of intermediate and high level wastes, whether fuel is reprocessed or not;**
  - **the need to manage legacy waste on a commercial footing;**
  - **the need for clarity for future nuclear generators in respect of their obligations for spent fuel management costs.**
- **Encourage the provision of nuclear education, training and R&D.**

There is an immediate need for Government action to recognise the true contribution nuclear power is making and can continue to make to the achievement of UK energy policy objectives.

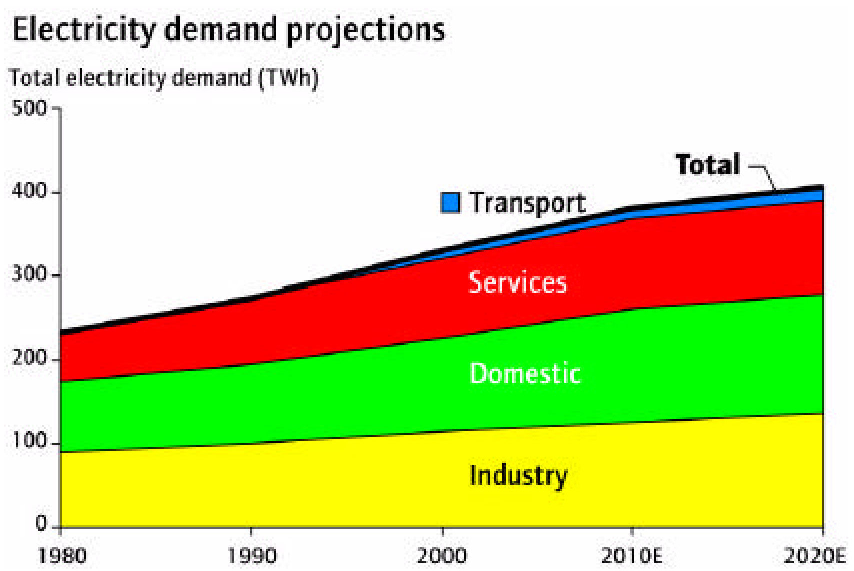
2. UK Energy Requirements and Supply

UK Primary Energy Requirements

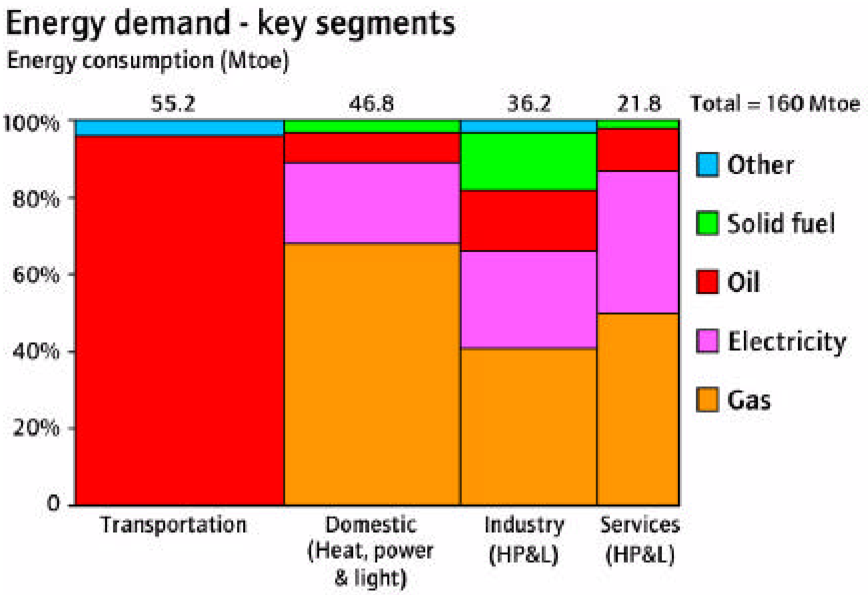
2.1 Over the next five decades demand for energy will continue to increase as the economy grows and end-user needs proliferate faster than demand-side measures are implemented. Overall energy demand is expected to grow by 0.7% to 1.1% per year through to 2020 and is likely to continue through to 2050, driven by continued growth in the transportation and service sectors. More gradual growth is expected in the domestic and industrial sectors.



2.2 Electricity generation will play an increasingly important role in the overall market as demand for electricity outpaces overall energy demand, with expected growth through 2020 of 0.7% to 1.6% per year



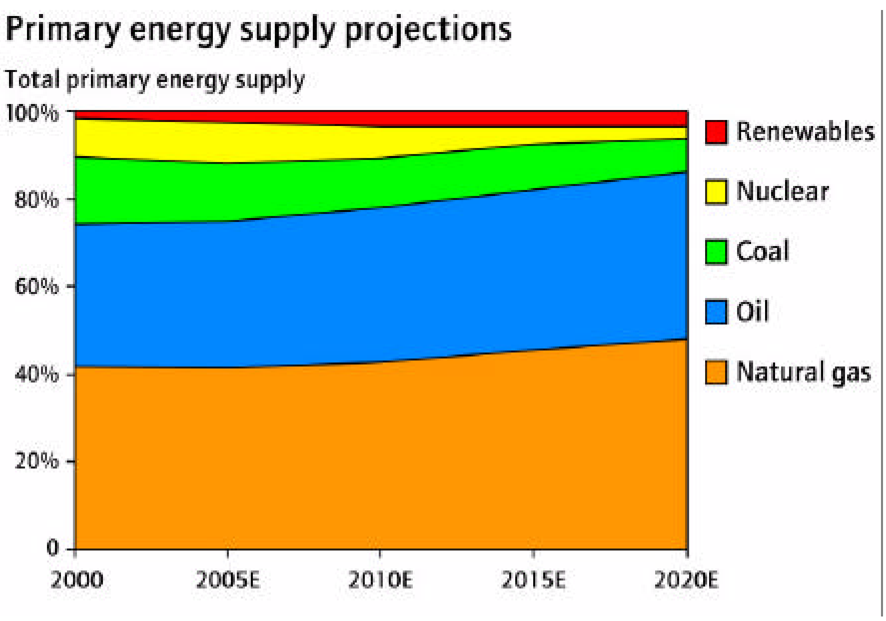
2.3 The growing service sector will require ever more electricity, and the growing number of domestic and industrial applications add to the demand. Substitution of fossil fuels with emission-free electricity is required to protect the environment – particularly in transportation, where oil currently meets 97% of demand.

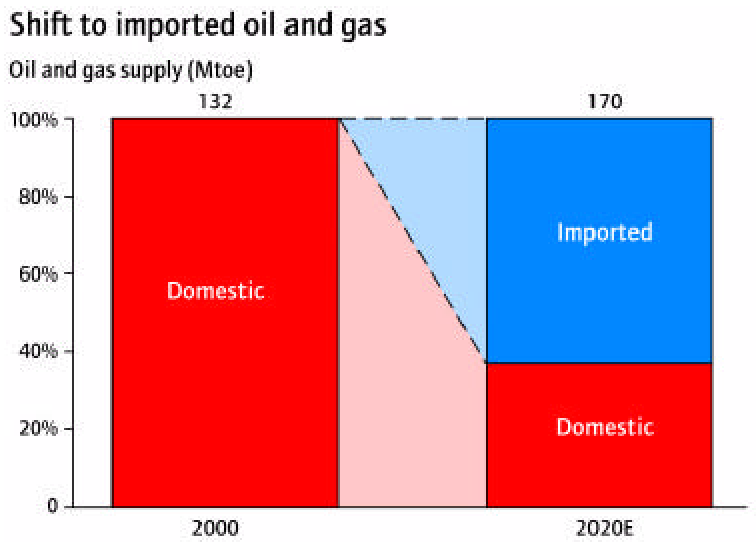


If fuel cell technology development occurs rapidly, demand for electricity could accelerate substantially

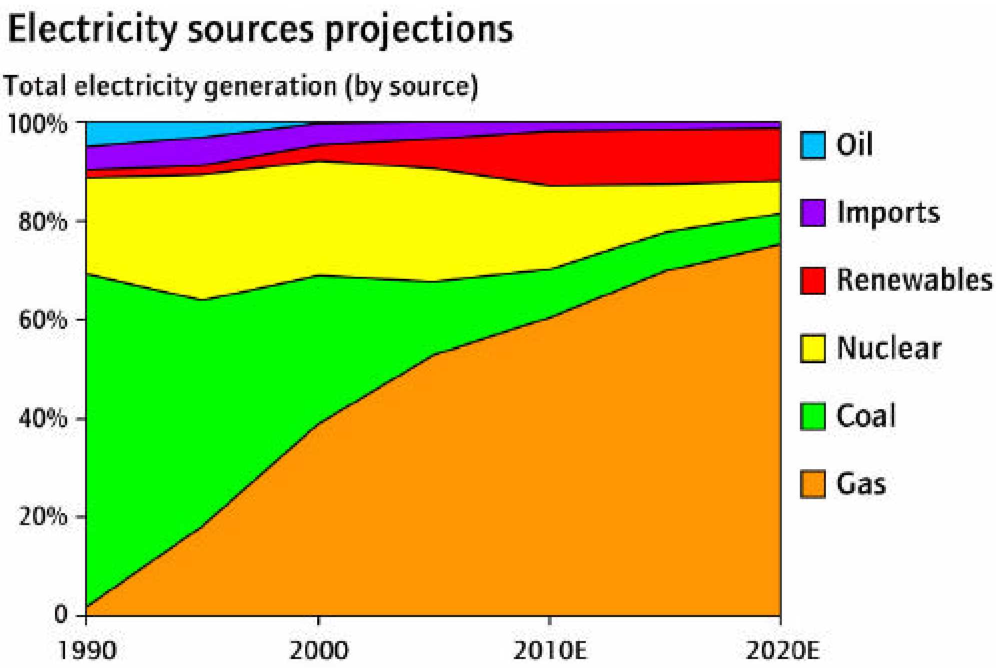
UK Energy Supply

2.4 In the context of rising demand, the UK Energy Policy has to determine a mix of energy sources which safely strikes an appropriate balance between the objectives of long term security of supply, economics and environmental impact. However, over the next two decades and through to 2050, with current market mechanisms in place, the UK will almost certainly become highly dependent on oil and gas to fulfil overall demand, much of which





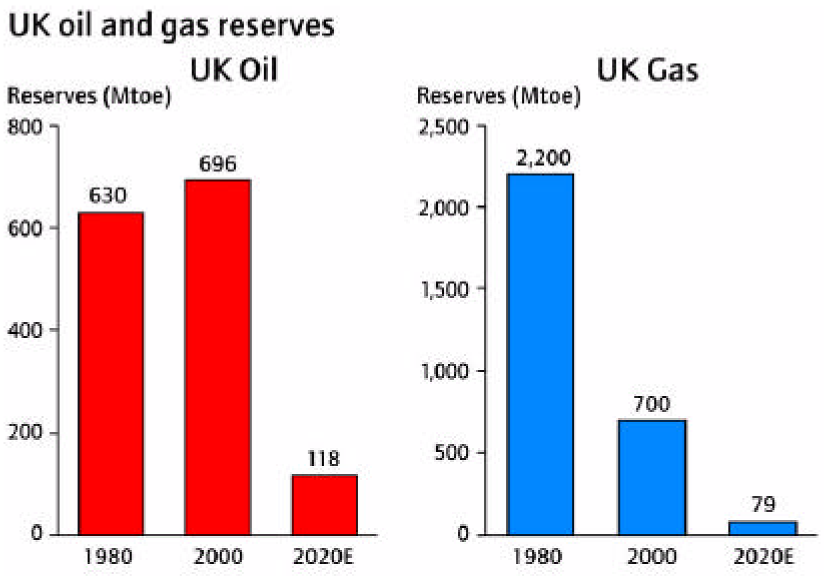
will need to be imported.



2.5 Similarly, the "dash for gas" will continue in the electricity sector. Today's balanced range of domestic electricity sources will shift towards a mix where imported gas will comprise up to 80% of supply.

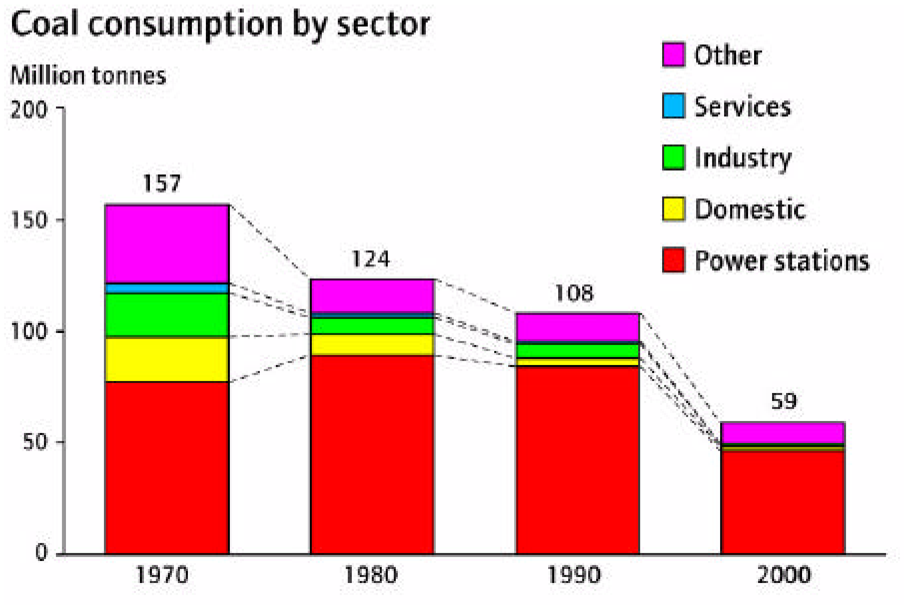
This shift will be driven by the following factors:

– <u>Depletion of domestic oil and gas reserves</u>: The current proven reserves of 700 million tonnes of oil and 26.8 trillion cubic feet of gas should be close to depletion by 2020



Although this time frame could change with exploration and drilling technology improvements, there is a finite amount of fuel present. New domestic reserves will be increasingly expensive to find and develop.

– Expectations for coal: Coal is expected to continue its decline due to its relatively high carbon emissions and high costs (despite recent favourable price movements relative to gas)



Technology does exist to burn coal through clean coal plants, but the economics of this are currently unattractive relative to existing alternatives.

– Decommissioning of nuclear power stations: Nuclear's share of electricity generation will decline sharply in the next 20 years (from ~23% share of electricity generation to ~5%) given plans for power station decommissioning and no plans for replacement build.

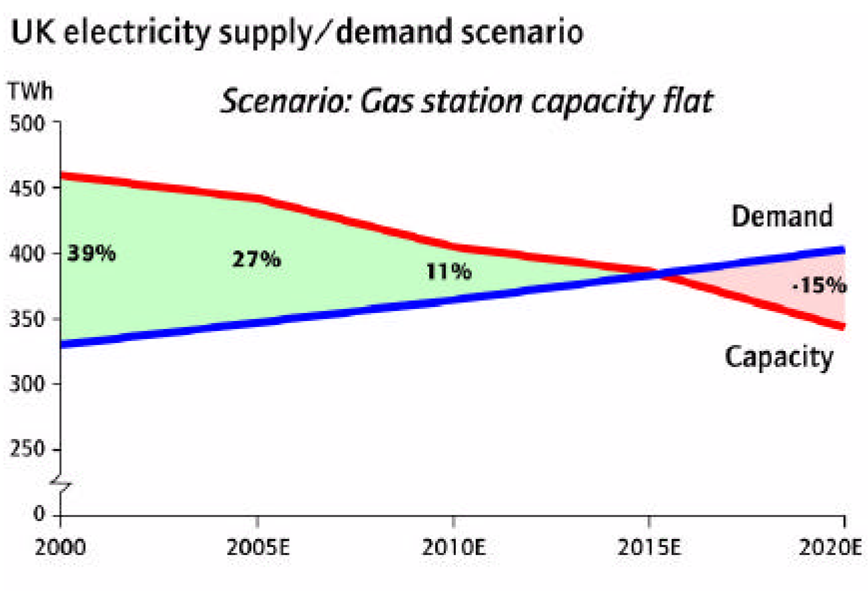
Almost 9000 MW of capacity is coming offline through the decommissioning of 12 nuclear plants before 2020 and a further 3700 MW through 3 plants before 2040.

– Development of renewables: Renewables increased rapidly over the last decade at around 10% annually and show some encouraging signs for further development due to highly advantageous incentives (high price guarantees and long-term contracts). They currently provide around 5% of electricity consumed. There are, however, limitations to the level of their development (including availability of suitable sites and variability of supply), and it is unlikely they will account for much more than 10% of electricity consumption in the UK over the next decade or so.

Over-Dependence on Gas

2.6 Over-dependence on imported gas for electricity (and imported oil and gas in the broader context of primary energy demand) would not meet the UK Energy Policy objectives: i) Supply would be significantly less secure as gas is imported from a concentration of less stable countries (over 60% of proven reserves of gas come from the Middle East and Russia); ii) Prices would be volatile, and potentially rising, as domestic reserves are depleted and the necessary substantial strengthening of the gas infrastructure is undertaken; iii) UK greenhouse gas emission reduction targets would not be met, assuming no significant developments are made in emission-reducing technology.

2.7 Current electricity prices are low, and act as a deterrent to investment – not just of nuclear capacity, but of **any** form of new capacity. If no new coal, gas or nuclear generating capacity is built, supply margins are predicted to fall from approximately 39% today to become negative in 2020.



2.8 There has been very little new build of baseload electricity generating capacity in the current deregulated market. Most "new" gas stations were built under the regulated market regime, with long-term electricity supply contracts underpinning the investment. The bulk of the recently added capacity has been in areas of the market where some regulation (in the form of additional incentive) still remains.

2.9 The UK is not alone in reviewing its energy policy to help guarantee long-term socio-economic sustainability. The USA and the EU have both recently concluded that in order to achieve sustainable development, government must be proactive in setting a policy framework within which a balanced energy portfolio of all key fuel sources can be delivered.

2.10 The UK Government Energy Policy should likewise establish a policy framework within which the market can be expected to deliver both short and long term policy objectives, namely safe, reliable, and affordable energy which has the minimum impact on the environment. Without such a framework, the electricity market can be expected to deliver only short-term solutions to market drivers.

3. ROLE OF NUCLEAR POWER IN ELECTRICITY GENERATION

3.1 Nuclear power represents an attractive and viable part of the future UK electricity supply mix, given; i) its impressive safety record, ii) its contribution to the security of energy supply, iii) its competitive and robust economics, iv) its positive impact on the UK's environmental commitments, and v) the fact that the technology exists to deal safely and effectively with waste arisings. These aspects will be considered in more detail after a discussion of nuclear systems development worldwide and specific UK considerations.

Nuclear Power around the World

3.2 Nuclear power has been providing clean, affordable electricity in various parts of the world since the 1950's. By the end of 2000, there were 438 nuclear reactors operating worldwide, contributing a total of 2,448 billion kilowatt-hours of power annually, or around 16% of global electricity demand. Most of these reactors are located in Europe (168), North America (120), Asia (94), and the Former Soviet Union (45). The percentage of nuclear generating capacity varies from country to country, with some countries such as France and Belgium producing more than half of their electricity from nuclear.

UK Nuclear Industry

3.3 The UK nuclear industry has been engaged in the development of civil nuclear power for around half a century (at least as long as any other nation). Recent figures show that, in terms of accumulated reactor years, the UK is the second most experienced reactor operator in the world behind the US. Britain's figure of over 1,200 accumulated reactor years represents around 12% of global operating power reactor experience. In terms of the production of nuclear generated electricity, the UK is currently the world's seventh largest, and around a quarter of the UK's electricity is generated by nuclear power. Through years of experience and the strength of its nuclear businesses, the UK has amassed one of the world's best track records for operational expertise and safety which has been leveraged into substantial skills and technology exports.

- <u>BNFL</u>: BNFL is at the forefront of the UK nuclear industry and is a truly international nuclear energy business BNFL is the second biggest nuclear fuel cycle and reactor service company in the world, with activities in 16 countries. Since the acquisition of Westinghouse, around 50% of reactors worldwide are designed or based on BNFL technology.

- <u>UK Nuclear Capabilities</u>: Whilst the nuclear industry itself is global – with BNFL as one of the major global reactor vendors – there remains a need for local skills in individual nations to underpin their national programmes. The UK industry (in BNFL and other key companies) has the complete nuclear fuel cycle capability for all types of gas-cooled reactors and Light Water Reactors (LWRs), from the receipt of uranium ore through enrichment; fuel manufacture; construction and operational support capabilities for reactors and fuel cycle facilities. The nuclear industry in the UK is leading the world in nuclear facility decommissioning, including research reactors and some early commercial stations.

- In the absence of a proactive programme of replacement nuclear build, many of these skills will decline. In particular, the regulatory experience in licensing new nuclear reactors has all but disappeared and needs to be refreshed urgently.

- Nuclear economics are enhanced in countries with a clear, stable nuclear programme which enables a series of similar reactors to be built and economies of scale obtained. The most common systems in the world are Pressurised Water Reactors (PWRs) -of which there are over 250 - and Boiling Water Reactors (BWRs) - almost 100. Together these two types make up ~80% of all commercial reactors, including all of the commercial nuclear generation in the USA, mainland Europe and Japan.

3.4 Historically, the UK has made different choices from other nations, initially selecting the Magnox and Advanced Gas-Cooled Reactor (AGR) systems. This led to the UK nuclear industry having many different reactor designs, which meant it did not benefit from the standardisation and increased reliability of operating units elsewhere in the world. The UK switched to the PWR system with the start of operation of Sizewell 'B' in 1995.

3.5 Modern standardised designs can expect to achieve 90% load factors, and operating lifetimes of up to 60 years. Lifetime extensions are being sought by many utilities, particularly in the USA.

3.6 The lesson to be learned from UK experience is to acknowledge that the capital intensive plant inherent in nuclear generation should be constructed as a "series build", ie several reactors of the same design should be deployed to capture the benefits of economies of scale.

3.7 Recognition should be given to the global nature of the industry and the technology. Greater recognition in the UK of licensing approvals granted in other countries would offer the prospects of reduced regulatory costs and the prospects of international consortia building a series of "standard" reactors in several countries. Closer links between UK Nuclear Installations Inspectorate (NII) and USA Nuclear Regulatory Commission (NRC) would be a useful first step in this respect.

Prospects for the UK Magnox Reactors

3.8 At present BNFL's Magnox power stations contribute around 7% of the UK's electricity. However, these stations are due to close progressively within the decade.

- Many nuclear utilities worldwide are successfully pursuing life extension of their existing assets (with favourable incentives to do so in the USA). For the UK, whilst it may be possible for BE to pursue life extensions of its AGRs and in the longer term Sizewell 'B', the closure programme for the Magnox reactors is already clearly defined, based on analysis of the issues carried out by BNFL.

- BNFL's detailed studies indicated that:

Significant investment would be required at the stations in order to sustain the necessary safety and environmental operating regimes beyond the announced closure dates;

Significant investment would also be needed in the rest of the Magnox fuel cycle, given the age and status of existing facilities at Sellafield;

There were significant commercial risks associated with further extensions to reactor lifetimes, as unforeseen operational issues could potentially lead to shutdowns (as evidenced by the recent shutdown at Wylfa).

- Following detailed consideration of these factors alongside the potential benefits, BNFL concluded that it was not commercially sustainable to extend the reactor lifetimes, and therefore announced that all the Magnox stations would close before 2010.

Choices of System for the UK for Replacement Capacity

3.9 A prerequisite for discussing the suitability of nuclear, is forecasting what type of reactor is most likely to prevail in the UK given the significant cost differences between reactor types. Consideration of choices being made in the global marketplace indicates the following points:

- In regions where sites are limited and specific geographic criteria apply (e.g. Japan), the tendency is to continue with large proven evolutionary LWR systems like the APWR 1000 (a Mitsubishi Heavy Industries product based on BNFL technology) or the ABWR 1400 MW (Toshiba Hitachi product based on GE technology).

- In Korea, the approach has shifted from a parallel programme of Candu reactors in tandem with BNFL System 80 units, to plants derived from the System 80+ concept (developed by BNFL in collaboration with the Koreans as their next generation plant).

- In the USA, where there is a successful track record in development of both PWR and BWR large (greater than 1,000MW) units, utilities have challenged vendors to develop systems with significantly improved economics but smaller size (600MW being the target size and 1000 to 1200 $/kW installed being the target capital cost). This led to the development of the BNFL AP600, the most up-to-date design licensed in the United States. Other vendors, AECL of Canada and GE, continue to pursue development of smaller systems.

- The drive for further improved economics - whilst maintaining the passive safety features within the design - has led BNFL to develop, with a view to licensing, the AP1000 (the larger ‘cousin’ of the AP600), with the global market in mind.

- Eskom (the South African utility) is leading the drive, now joined by Exelon (the major U.S. utility) and BNFL, to develop and commercialise the Pebble Bed Modular Reactor (PBMR) – a high temperature gas-cooled system. This system is expected to offer for longer-term application inherent safety features and the capability to be economically competitive in units of ~110 to 130 MW. This latter feature is important in areas where grid access is poor or restricted. Also, in deregulated markets, capacity addition in small increments is desirable because it significantly reduces the amount of capital outlay prior to operation.

3.10 In the UK, BNFL believes that the AP600 / AP1000 are most likely to prevail, with the choice of which one driven by the following:

- The importance of maximising output from a single unit and minimising cost at point of transmission;
- The importance of reduced capital outlay;
- Consideration of whether 600 MW units would be more compatible with UK experience with 660 MW turbines, and with existing UK grid infrastructure;
- Consideration of whether the product is likely to form part of a global programme of new build – giving rise to the benefits of series build;
- Consideration of whether the product is available for deployment now or in the near future.

3.11 The AP600 and AP1000 are both capable of burning Mixed Oxide (MOX) fuel, and so would represent an option – if so desired – for helping to reduce the UK's stockpile of plutonium. The projected UK stockpile could be consumed by two AP1000 stations over a 20 year period. In this context, it is important to stress that, once the reactor is built, the choice of fuelling on UO_2 or MOX fuel has only a marginal impact on fuel cycle economics.

Nuclear Systems for the Longer Term

3.12 Large system LWR technology will reach the end of its development evolution, although it will remain the product of choice over the next decade or more in the majority of existing markets, where its proven status and large plant designs will be perceived as the optimum solution. Western markets will move to adopt advanced passive LWR designs.

3.13 For the longer term, increasing attention is being directed towards the next generation technologies (the so-called "Generation IV" systems) such as the small LWR IRIS (International Reactor, Innovative, Secure) concept, but particularly gas-cooled reactor systems such as the PBMR, with the emphasis on:

overall economic competitiveness;

inherent safety;

proliferation resistance;

modularity and flexibility.

3.14 These systems, if successfully pursued through to commercial realisation, could be realistic prospects within the second (in the case of PBMR) or third (in the case of IRIS) decades of the century. It should be noted, however, that both PBMR and IRIS still require to be demonstrated in full-scale operation, whereas the AP system is based on proven technology and is available for selection today.

3.15 BNFL believes that fast reactors, other advanced systems and fusion are all beyond the scope of this study.

Nuclear Safety

3.16 The nuclear safety record in the UK and the rest of the world is impressive and has steadily improved through firm regulation, improved designs and greater operational experience.

3.17 UK Safety Record: The UK's nuclear reactors have been developed and operated safely for over four decades, and the industry's safety record is very good. The Government's own independent inspectors in HM NII exist to ensure that this record is maintained and to intervene if there is ever any doubt. Independent studies show that, considering all aspects of electricity generation and assessing long-term risks due to disease as well as acute risks due to accidents, nuclear is amongst the safest means of generation.

3.18 World Safety Record: The safety record of the world's nuclear power industry is impressive generally and continues to improve. There has only been one accident with significant off-site consequences, that in 1986 at Chernobyl, a reactor which could not have been licensed in the West. The accident at Three Mile Island in the U.S. in 1979 has been widely referenced and is often perceived as having significant consequences. The event, in fact, led to core damage, but did not lead to significant off-site consequences. Its after-effect was twofold: i) the utility suffered a major economic penalty for loss of power and subsequent remediation over many years, ii) the industry as a whole suffered due to the massive loss in public and institutional confidence as a result of mis-perceptions about the risks associated with nuclear power generally and the true impact of the event itself. Reactors built since the Three Mile Island accident benefited from substantial engineering improvements which have further enhanced safety and operational performance. The Sizewell B reactor is a case in point with extensive safety provisions.

3.19 Passive Safety Systems: Having passively safe or inherently safe designs available is not necessarily a prerequisite for new nuclear build. Many countries world-wide, especially in the Far East, are content to continue to develop and deploy the existing PWR and BWR technology base. Similarly in Europe, France has continued development of evolutionary enhanced PWR technology. However, the trend towards increased numbers of safety systems has also had the effect of increasing the capital cost of stations. As a result, in the early 1990s, the industry began to work on passively safe designs to give further improvements in safety performance. This had the additional benefit of reduced costs due to reduced complexity. The best example of a well-developed and secure passive safety system is the AP600.

3.20 Generation IV Systems: Looking to the future, the so-called Generation IV systems offer further advances in safety philosophy in pursuing designs which can be described as inherently safe. The Pebble Bed Modular Reactor (PBMR) would fall into this category.

3.21 Role of Government: The Government has a significant role to play in ensuring firstly that the risks and safety of the nuclear industry are put into perspective. Secondly that their decision-making is based on sound objective assessment. This applies both to power generation and to waste management.

3.22 Without such clarity, there is a danger of a mismatch between the perception and reality of public concern. For instance, a poll of UK MP's indicated that they underestimated public support for nuclear power by a factor of 14 and, likewise, significantly overestimated public opposition. Public opinion can also be greatly affected by real or threatened disruption to electricity supplies. Following recent breakdowns in electricity supply in parts of the USA, 66% of the USA population now agree with the statement: "We should definitely build more nuclear energy plants in the future".

Security of Supply

3.23 For consumers of electricity, security of supply is perhaps the single most important factor which an energy policy needs to address.

3.24 Nuclear contributes significantly to security of supply: (i) nuclear adds to the diversity of energy sources; (ii) the uranium feedstock is plentiful and comes from stable countries such as Australia and Canada; (iii) nuclear provides reliable baseload generating capacity; and (iv) fuel availability can be assured through retention of strategic stocks either of finished fuel or of raw uranium feedstock.

3.25 Stability of Current Sources: A key consideration is the balance between relying on imported gas and imported uranium. Due to the economics of transportation, gas can be imported from two different sources – members of European OECD countries such as Norway and Netherlands or less stable countries. Current proven reserves in the UK, Norway and Netherlands are lower than the UK gas requirements for the next 50 years. Countries such as Germany have already imported substantial amounts of gas from Russia which, along with the Middle East, holds over 60% of world gas reserves. In the long-term, the UK would have to import from the same sources – suffering the insecurity of being geographically located at the end of a trans-European pipeline.

3.26 Uranium Supplies: In comparison to gas, uranium supply is more secure, coming from countries with stable political and economic situations. Today, over half of global uranium mining is done in Australia and Canada.

3.27 Fuel volume requirements: The quantities of fuel required to support nuclear power are very small in comparison to fossil fuels. One year's strategic stocks of fuel for the nation's current nuclear capacity of around 10GW would only be around 250t, if this capacity was all provided through modern LWRs.

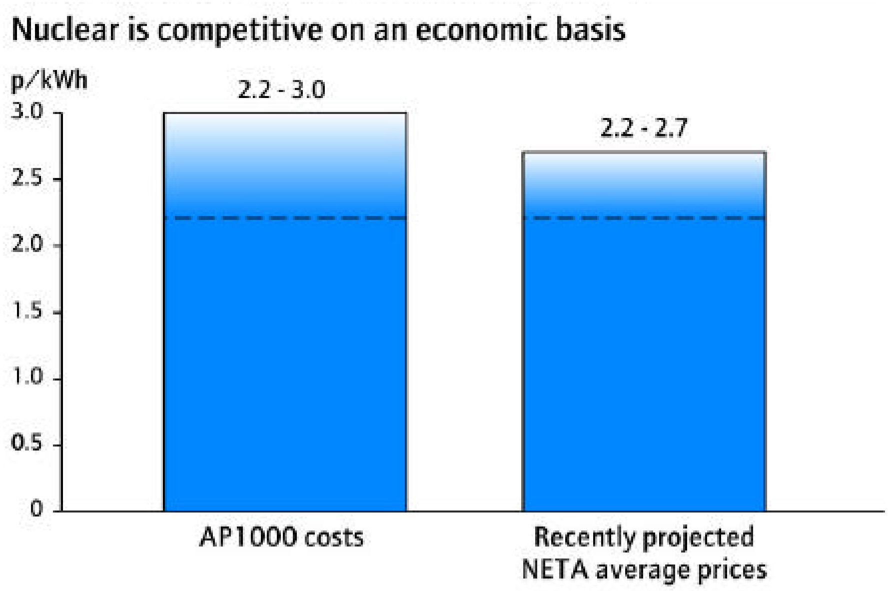
3.28 Nuclear supply is highly reliable: Nuclear and fossil fuel power stations provide consistent, reliable levels of baseload generation. This is not the case for many renewable technologies. For example, the output of wind turbines and solar cells is dependent on the level of wind or sunlight at any instant. Consequently, renewables have a low load factor. In the UK, wind farms have an average load factor of around 30%; in other words, around 3GW capacity of wind turbines would be required to replace 1GW of nuclear or fossil fuel capacity. Renewable generation does have a role in contributing to a diverse electricity supply system but will not, on its own, be sufficient to generate a large proportion of baseload electricity supply at high levels of reliability. Other generation technologies will have to be used in order to ensure both quantity and availability.

3.29 Excellent baseload capability: Nuclear stations deliver very high energy density, when generating capacity and land requirements are compared. Coupled with the high reliability noted above, this underpins why nuclear units provide the grid with baseload generation.

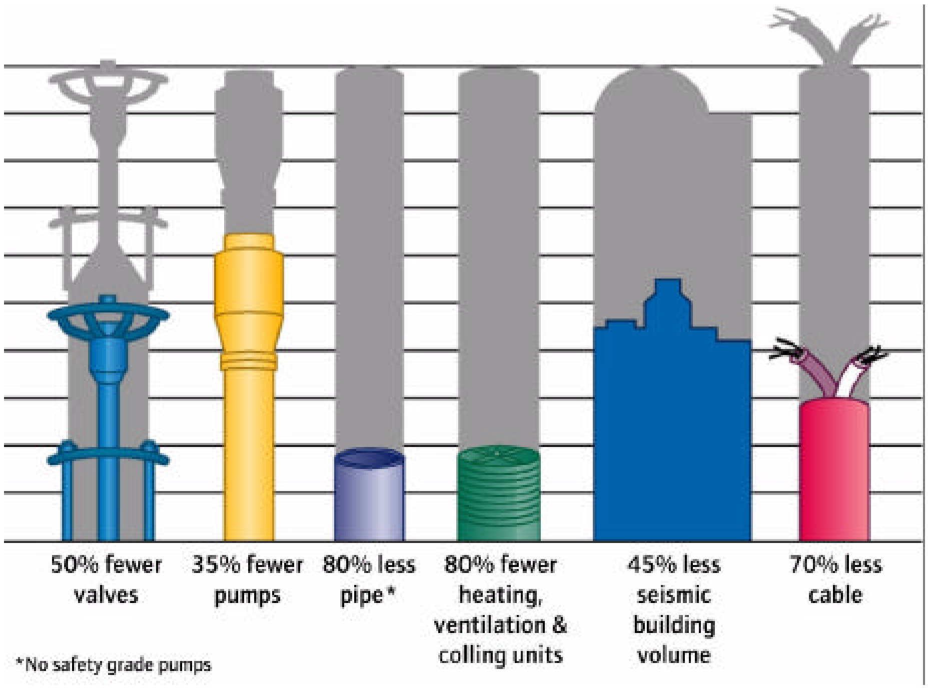
Nuclear Economics

3.30 Prevailing Reactors in the UK: From BNFL's perspective the Company believes that the AP600 and AP1000 are the most logical choices for replacement capacity in the immediate future.

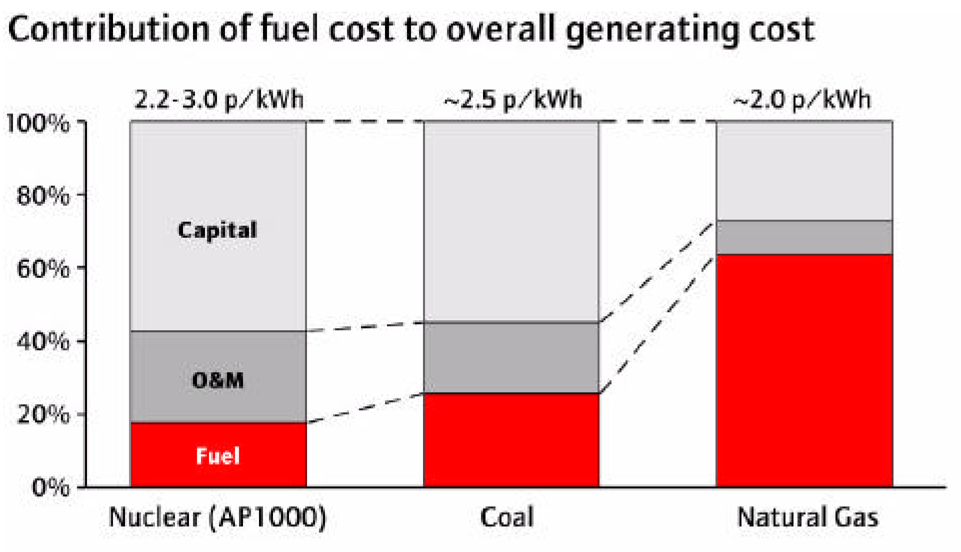
3.31 Nuclear Generating Costs: Generating costs for a newly built LWR (AP1000) nuclear plant will typically be in the range of 2.2p to 3.0p/kWh. The low end of these costs assumes a series of identical reactors built in the UK, on existing nuclear sites with current infrastructure retained and improved regulatory and planning approval processes. At this level of cost, nuclear generation is competitive with current average bulk electricity costs and comparable to other energy sources for baseload electricity. Operating costs, excluding depreciation, are also comparable to gas and much lower than coal.



One key factor which has led to AP600 / AP1000 generating costs being lower than historic experience of nuclear costs is the reduced capital requirements of the reactor systems, which in turn is a consequence of the simpler design based on passive safety features.



3.32 Volatility in Energy Source Prices: Nuclear is much less exposed to volatility in fuel costs given the relatively low contribution that underlying fuel costs make to total unit generating costs. Further, with the prospect of the depletion of domestic gas reserves, gas-fired station costs are likely to rise.



3.33 Nuclear generating cost sensitivities: Nuclear generating costs are most sensitive to cost components which can be significantly influenced through changed policies, particularly upfront costs and project financing:

- Duration and complexity of planning and approvals processes, eg the scope and duration of a public inquiry.

– The rate of interest charged on the funds required to construct the reactor

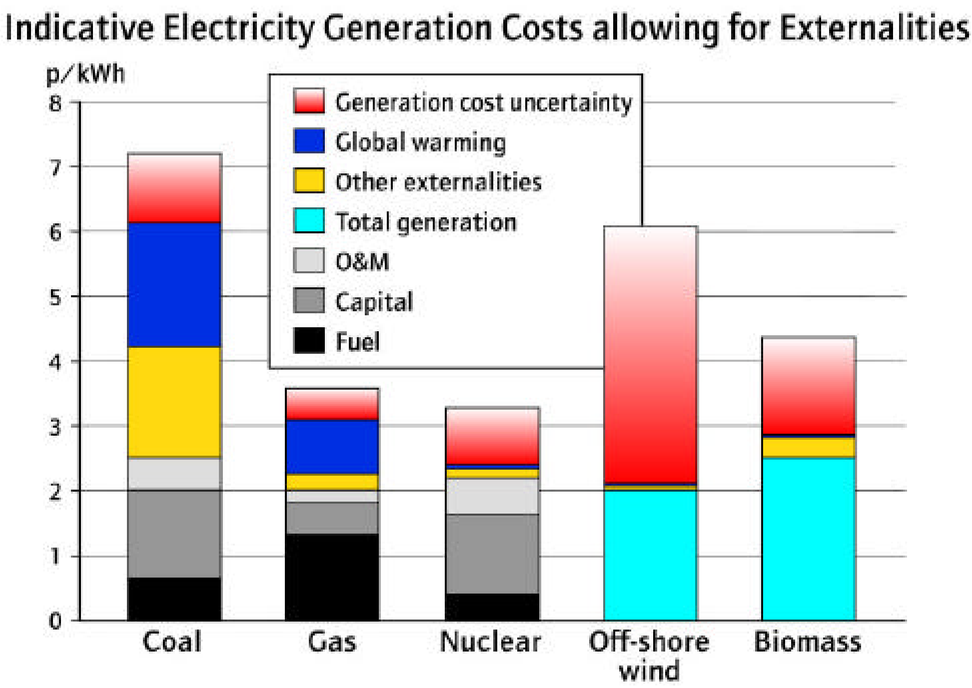
Other generating cost sensitivities include:

– Number of identical stations already constructed: there is significantly more detailed design and licensing work required for the "first of a kind" in a series of identical units.

– Requirements of the site: the extent to which site-specific design and engineering work is required to deal with issues such as seismic protection, coolant towers or seawater pipes, road and rail access for construction, etc.

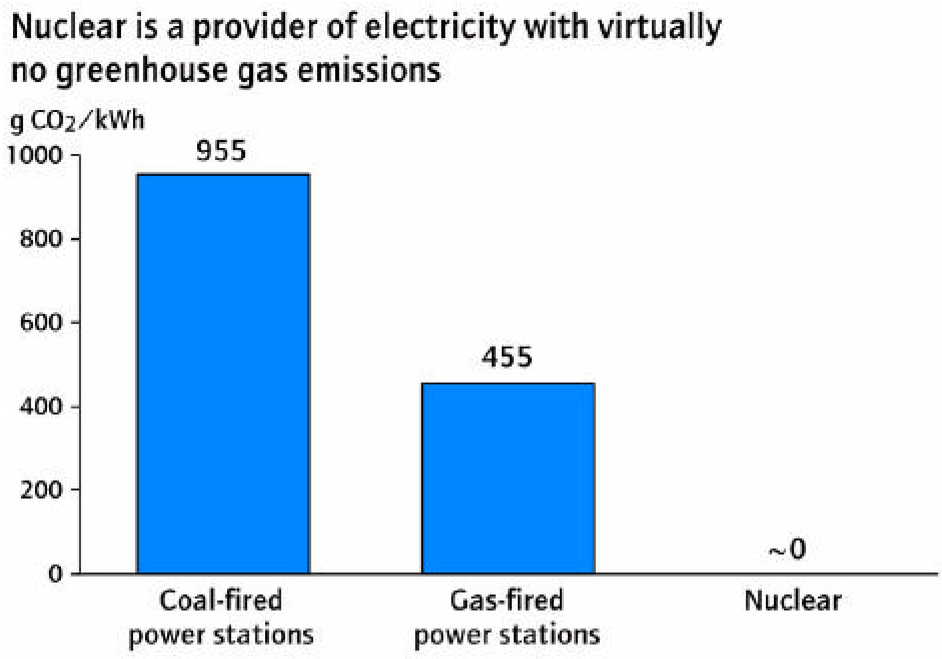
– Network infrastructure: Grid connection charges and potential requirements to install or upgrade grid connections

3.34 Impact of Externalities: When costs of externalities (external environmental costs) are considered nuclear becomes more favourable.



Impact on the Environment

3.35 Nuclear power compares favourably with other sources on a wide range of gaseous emissions and, despite common misconceptions, future nuclear generation would generate wastes with relatively little environmental impact when compared objectively with other sources of generation.



3.36 Emissions: Climate change has been recognised by the UK Government as the most serious environmental issue of the 21st Century. Over the long-term, emissions need to be reduced by 60% from 1990 levels by 2050 and perhaps 80% by 2100 in order to stabilise atmospheric greenhouse gas emissions at an environmentally sustainable level. Currently around 26% of UK greenhouse gas emissions are produced by the electricity generation sector. These emissions emerge almost exclusively from fossil fuel power stations. An energy supply strategy looking towards 2050 needs to consider how emissions can be cut in the electricity generation sector as part of an overall long term climate change strategy. It should be borne in mind that most types of electricity generation plant have operating lifetimes of many decades. New and replacement plant built in this current decade may well form part of the generation mix of 2050. Therefore, the choice of what plant should be built in the short term will influence the UK's greenhouse gas emissions levels for the long term.

3.37 Nuclear generation produces virtually no greenhouse gases, sulphur dioxide and nitrogen oxides and therefore makes a major contribution to UK progress on meeting environmental commitments to reduce emissions of these substances.

3.38 If the electricity generated today by nuclear power stations were, instead, generated from coal-fired power stations there would be an additional 71 $MtCO_2$ released annually. This is more than the annual greenhouse gas emissions from all cars in the UK. The deployment of additional coal-fired power stations would lead to a significant rise in greenhouse gas emissions.

3.39 Although a gas-fired power station emits only around half the greenhouse gas emissions of a coal-fired power station, the emissions are still significant. Switching from coal to gas did result in a significant reduction in emissions from the UK electricity generation sector in the 1990s. However, the predicted growth in the use of gas-fired generation and increased demand would result in an overall increase in emissions from the electricity generation sector.

3.40 The full life cycle greenhouse gas emissions of nuclear power and most renewables are very much lower than those resulting from electricity generation by burning fossil fuels. To achieve further greenhouse gas emissions reductions, the amount of electricity supplied from fossil fuel sources needs to be reduced. Simply replacing existing nuclear capacity with renewables or newly-built nuclear capacity would not make any impact on emissions.

3.41 The UK Government has already introduced its first measures to meet its emissions reduction targets for the first Kyoto Protocol commitment period. However, both the Climate Change Levy and the UK Emissions Trading Scheme fail to recognise the benefits that nuclear generation offers.

- The Climate Change Levy is a charge on the consumption of energy by industry. There is no distinction between electricity generated from fossil fuels and electricity generated from nuclear power. The exemptions for renewables and good quality Combined Heat and Power (CHP) are welcome from a climate change perspective, but this further highlights how this policy discriminates against nuclear generation.

- The UK Emissions Trading Scheme will not initially include electricity generators and, therefore, makes no distinction between them. Proposals for project participation only allow for efficiency improvements, limiting the potential for new and replacement nuclear build to benefit from carbon credits. However, the short-term nature of the UK Emissions Trading Scheme is such that it is unlikely that it could offer significant support for new build.

3.42 Of deeper concern is that proposals for emissions trading in the EU (and more broadly) may be affected by the agreement reached in Bonn (at the COP 6 meeting) to discriminate against nuclear power in the Kyoto Mechanisms. The EU proposal for an emissions trading scheme states that eligibility criteria for projects may be greater than those agreed for the Joint Implementation and Clean Development Mechanism in Bonn. This could lead to projects involving nuclear power being excluded from the scheme.

3.43 The ambivalent position taken by the EU in the COP suggests that the climate change benefits of nuclear power may not be recognised in EU policy. Recently, the European Commission published the ExternE report which confirmed that the externalities associated with nuclear power were similar to those of renewables, whereas those of fossil fuel power stations were higher. However, the Commission has proposed that only renewables should benefit from economic incentives to address this, with the inequitable treatment of nuclear generation again being ignored.

3.44 The failure of these financial mechanisms to give nuclear generation due recognition for emissions avoidance is regrettable and effectively penalises the industry without justification.

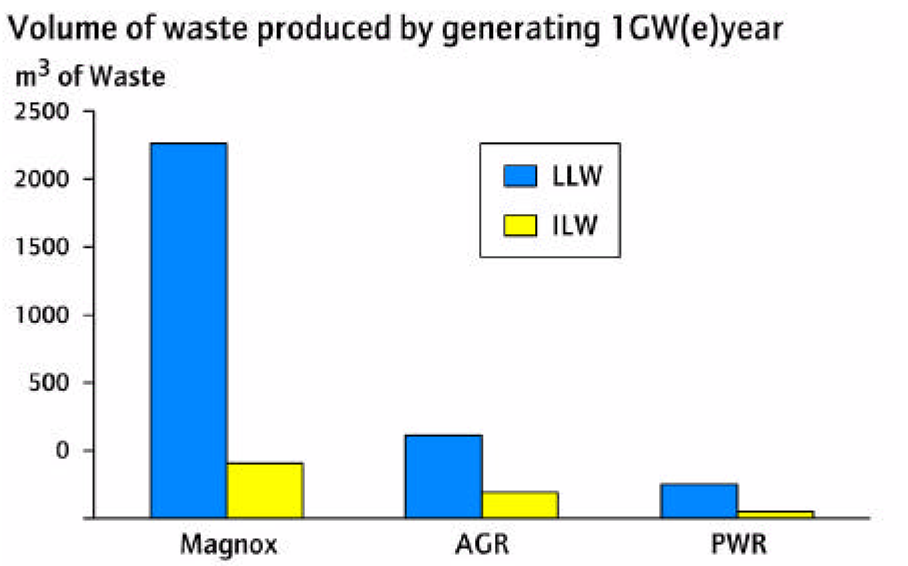
3.45 Since emissions avoidance from nuclear generation makes a significant contribution to combating the effects of climate change, it needs to be recognised and encouraged, not taken for granted as is currently the case.

3.46 Nuclear waste: Nuclear waste is cited by many as a major issue and potential "show-stopper". There is a serious gap between perception and reality which Industry and Government has hitherto failed to address.

- The nuclear industry has already proved that it can store spent fuel, or else recycle it, and condition the waste arisings into safe forms for storage over many decades (and arguably over centuries). Interim safe stores already exist and are demonstrable evidence that wastes associated with nuclear power can be cost-effectively and safely managed whilst the disposal issues are resolved - even though this may be many decades into the future. Hence, nuclear waste should not be a "show-stopping" issue as far as the Energy Policy Review is concerned.

- It is vital that during the course of the UK Energy Review, and in subsequent decision making, there is clear distinction made between historic nuclear waste issues and those associated with new and replacement nuclear generation.

- It is also important to recognise the significant differences between the quantities of waste generated per GW-year by a modern LWR, compared to Magnox or AGR reactors.



- Historic (legacy) wastes have arisen because of decisions taken for the UK to have an independent nuclear deterrent and, subsequently, that it would have a power programme using Magnox reactors and implementation of a fuel cycle that demanded reprocessing. Reprocessing was also adopted for the next generation of reactors built in the UK, the AGRs.

- The decision as to which management option - storage or reprocessing or both - should be adopted for the spent fuel arising from new or replacement reactors, will depend on future economic, policy and strategic factors. However, this decision can be safely deferred without detriment to the economics because both the fuel and its cladding are chemically stable and can be stored safely for many decades. Quantities of used fuel per GW of electricity are very small and can be stored at the reactor site. (An AP1000 would use approx. 750t over a 40 year life).

- Decommissioning of new reactors would be a much simpler issue. The technology and experience of decommissioning reactors and other facilities safely and to the satisfaction of commercial customers have already been demonstrated. The money required to decommission current reactors is already set aside as part of the operating costs.

- Geological disposal is advocated internationally as the most appropriate ‘final’ solution. Barriers tend to be socio-political and socio-economic; they are not technological.

- It is vital that future owner/operators of nuclear facilities have certainty regarding their obligations in waste management matters. Given the expected life of modern systems (at least 40 years), a system similar to that in the USA could be used whereby a small sum per kilowatt-hour is levied for the US Department of Energy (DOE) to take and deal with the long-term management and disposal of the spent fuel arising from USA power stations.

Other Direct/indirect Impact of Nuclear on the UK

3.47 The nuclear industry has had a significant direct/indirect impact on the UK economy.

3.48 Contribution to UK Economy: The UK nuclear industry directly provides 30,000 skilled jobs, and twice as many again indirectly. The UK industry has an annual turnover of about £4.7 billion and contributes about £3.3 billion to UK GDP.

3.49 Magnox Station Employment: Each of BNFL’s operating Magnox stations puts £13-£16 million into the local economy each year (2001 prices) in wages alone. Each one employs between 350-430 permanent staff as well as anything between 100-600 contractors on site each day.

3.50 Local Impact: Each station sources its needs from local suppliers and employs local contractors where possible. In turn, contractors agree to do the same in terms of sub-contractors, suppliers and employees. Typically, each station provides sponsorship or other direct support to around 50 local organisations every year. The types of companies that will benefit include architect engineering companies, construction companies, manufacturing companies and transport companies.

3.51 Impact on Rural UK: All of BNFL’s stations are in rural locations – areas from where, traditionally, there has been a ‘brain drain’ as well-educated young people leave in search of better paid work in urban areas. By offering well-paid, highly-skilled, high quality jobs, BNFL has enabled graduates to stay in their local areas.

3.52 Impact of Reactor Construction: The building of new and replacement nuclear reactors also has a major economic impact during the construction phase. Sizewell B, for example, involved:

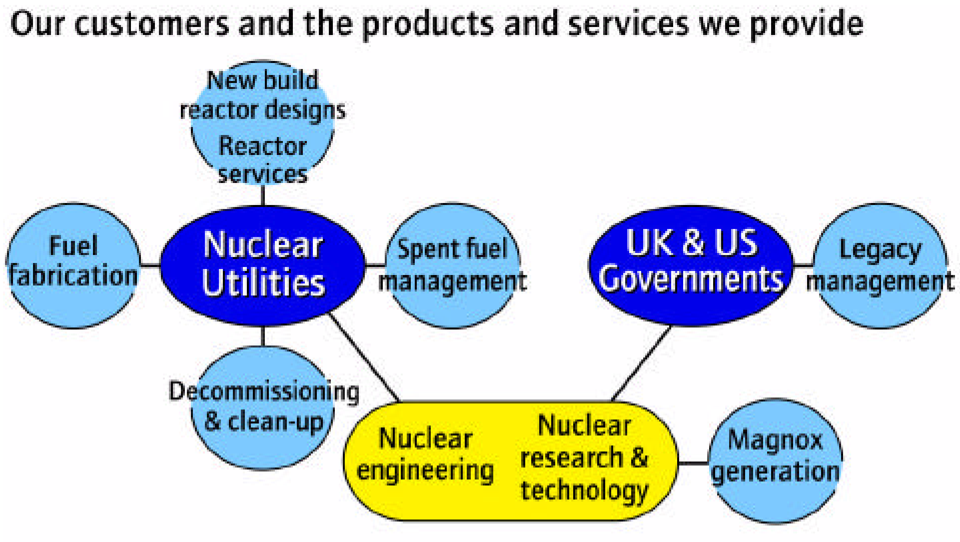
- 3,000 firms (including sub-contractors), the vast majority of which were UK-based;

- countless other firms that benefited from supplying the main contractors and sub-contractors;
- The creation of 20,000 jobs in the UK during the construction phase.

3.53 Skills and Capabilities: Previous UK experience in delivery of major technology projects (eg Sizewell ‘B’) is that in addition to the tangible financial benefits to such organisations, there is a great deal of intangible benefit though additional skills and experience when technology, which is new to the UK, is brought in and delivered. The same effect has been seen in other countries such as South Korea, where a significant increase in skill level in that country’s nuclear industry has come about through deployment of nuclear technology imported from the USA and Canada.

4. BNFL – ROLE AND IMPLICATIONS

4.1 At a time when talk of a resurgence in nuclear power – accompanied by an increased programme of nuclear reactor construction – is taking place across the world, the UK is fortunate to have, in BNFL, a company ideally placed to respond to such a development, if the right framework and enabling mechanisms are in place. BNFL combines a full fuel cycle capability, the design of the most advanced LWR licensed in the USA and a workforce with proven skills and experience of major nuclear projects in a wide range of countries.



4.2 BNFL provides products and services to two key groups of customers – nuclear utilities and governments (particularly those of the UK and USA). BNFL is strongly positioned internationally to provide a full range of fuel cycle services to utilities, from new fuel and reactor services, through spent fuel management to waste management and decommissioning. For government customers, BNFL provides technologies and experience for dealing with historic nuclear wastes and associated facilities.

4.3 Key attributes of BNFL include:

- BNFL owns one third of Urenco with its world class centrifuge enrichment technology and a growing 14% of the global enrichment market;
- The acquisition of Westinghouse and ABB fuel businesses, added to BNFL's existing UK fuel business, gives BNFL a leadership position in fuel production with over 30% of global fuel sales, 60% of USA and 20% of European sales;
- Nearly 50% of all reactors currently in operation use BNFL technology and the AP600/1000 design continues BNFL's leadership in reactor design;
- BNFL operates the UK's Magnox reactors, generating around 7% of UK electricity;
- BNFL has a long established Spent Fuel Management business, handling all UK spent fuel from the UK's Magnox and AGR reactors, and a significant share of international

reprocessing from Germany, Switzerland, other European countries and Japan, where its business has made it Britain's single biggest exporter of services for several years;

- BNFL has a successful track record in safely and effectively decommissioning a range of facilities, such as the Capenhurst gaseous diffusion plant. It is currently managing major decommissioning projects at both Sellafield in the UK and at Oak Ridge in the USA.

4.4 A replacement programme for UK reactors would enable BNFL to compete as a reactor designer and to be the provider of existing licensed sites and grid connections at the location of its Magnox stations. BNFL can also supply fuel, enrichment (via Urenco) and reactor services to the new and replacement reactors. Finally, BNFL has the capability to manage the spent fuel from these reactors and ultimately to decommission the reactors at the end of their lives.

4.5 Continued commitment to nuclear as part of a balanced UK Energy Policy also provides a range of knock-on benefits to the UK. For instance:

- A renewed programme of nuclear reactor construction in the UK will help to promote investment in the associated UK science and technology base. At present, BNFL employs over 1000 people in Research & Technology and invests £5 million per year externally in science research.

- A renewed programme of nuclear reactor construction in the UK will boost the skillbase of the nation's workforce and will provide significant direct and indirect employment in more remote regions of the UK. BNFL employs 23,000 people worldwide. Over half of these are in the UK, and a significant proportion are qualified engineers and scientists.

- A UK reactor replacement programme based on BNFL designs would help BNFL and other UK suppliers to capture a leadership share in reactor-build programmes in the USA and other worldwide markets. This, in turn, would drive continued investment in developing safer, more affordable and even more reliable reactor designs.

- Utilities will typically select BNFL fuel for BNFL reactors. Capturing a significant share of the construction of new overseas reactors will, therefore, provide continued opportunities for the BNFL fuel production, enrichment and reactor services businesses both in the UK and overseas.

- BNFL maintains strategic investments in research & development (R&D) of next generation nuclear fuel cycle technologies in fuel, fission reactor design and spent fuel management / recycling. Although outside the timeframes of this review, a continued nuclear programme until 2050 would enable these strategic investments to be maintained.

5. IMPLEMENTATION CONSIDERATIONS

5.1 Section 3 illustrates the true contribution nuclear power is making, and can continue to make, to the achievement of UK Energy Policy objectives.

5.2 However, the current structure and regulation of the energy market favours investment in certain types of generating capacity. Inconsistency in the treatment of external environmental costs favours fossil fuels, such as natural gas and coal. Risks in the planning process, regulatory structure and the long-run electricity price favour the adoption of short, quick pay-back projects. These factors have combined to create the "dash for gas" and a future which could be increasingly dependent on a single fossil fuel.

5.3 Government action is required now; a postponement will impair, if not preclude, nuclear from delivering its potential benefits for the foreseeable future.

5.4 Such action must be based on a sound and objective understanding of the relative safety and environmental impact of nuclear power, when compared with alternatives. Whilst it is appropriate to include in this consideration the perception of the public, care must be taken to ensure that a true picture is obtained, rather than a view skewed by vociferous single-interest groups.

5.5 BNFL has a role to play globally in new nuclear generation and the associated value to the UK economy. Countries such as France have shown that a planned nuclear programme can deliver safe, reliable and affordable electricity with minimal emissions. The key is to standardise on a world class reactor design; BNFL have such a design in its Advanced Passive series.

5.6 BNFL also safely manages, on behalf of the UK, a sizeable proportion of the legacy waste from the civil and military nuclear programmes. The incremental wastes created by replacing the UK's nuclear generation capacity into the future would only add marginally to that inventory. Thus, a distinction can be drawn between historic nuclear wastes and those from new or replacement generating capacity.

5.7 The current availability of private finance for large infrastructure projects in the UK (eg £650m for Birmingham northern relief road, £1.4bn for National Air Traffic Service) suggests that the market would consider the private financing of new nuclear plant positively, provided that the project is sufficiently attractive (in terms of its returns and risk profile) and that the key issues can be addressed. Furthermore, recent sales of existing nuclear plant in the USA demonstrate that the equity markets are not 'prejudiced' against nuclear plant.

To allow nuclear to play its legitimate role into the future, a number of enabling mechanisms need to be put in place:-

– **<u>More equitable climate change abatement mechanisms</u>**

The current electricity pricing framework discriminates against nuclear power by failing to recognise the environmental contribution which nuclear generation makes. More equitable climate change abatement mechanisms, such as a modified form of the Climate

Change Levy which treats nuclear plants in the same way as other carbon-free technologies, would provide the opportunity for a ‘level playing field’ to be established between nuclear and other sources of electricity.

– **Streamlining the regulatory and planning processes associated with licensing and approval of a nuclear reactor**

The current UK planning and licensing process for a new reactor would be expected to take a minimum of 4-5 years. Launch costs prior to start of construction (inclusive of Public Inquiry costs) are estimated to be in excess of £100M.

These costs are compounded by the requirement for further public consultation after construction and prior to commissioning, in order to justify the plant and gain a radioactive discharge authorisation. This has proved to be a prolonged and costly “double jeopardy” process in recent years (eg on BNFL’s Sellafield MOX Plant) with no certainty about the outcome. In addition, if the current draft regulatory guidelines which give primacy to the progressive reduction in radioactive discharges are pursued, this would make any proposal for new or replacement nuclear generating capacity in the UK unsustainable. Regulation must be commensurate with the risks and scientifically based.

If replacement nuclear build is to be a realistic prospect in the UK in the future, “fit for purpose” legislation, and more speedy and assured planning/regulatory approvals will be needed. The experience in the USA indicates a possible way forward. The following elements would be a helpful part of a new framework within the UK:

The adoption of a ‘generic approval’ process for a reactor design, which should embrace the wider public debate required, thereby avoiding unnecessarily repeated debate at public inquiries as happened at the Sizewell ‘B’ and Hinkley Point ‘C’ inquiries. This would be a “once and for all” process analogous to the Design Certification process in the USA.

Once the reactor design has a “generic approval” the local planning process should focus on site-specific detailed local issues.

Resources to carry out the above processes, in preparation for a future programme of new and replacement nuclear build, are not currently available within the regulatory bodies. The Government is encouraged to reinforce the regulators at the earliest opportunity and to give them an appropriate mandate to support a new nuclear “generic approval” process.

– **Review of how long-term supply contracts can be put in place.**

There must be a review of how long term electricity supply contracts can be put in place. This is important for any fuel type for baseload stations, not just for nuclear stations. The only mechanism being used today is the requirement on supply companies to have 10% of their output from renewable sources, where they give 20 year contracts at 3p per kW-hour.

– **An overall policy for radioactive waste management which recognises, firstly; current safe practice, secondly; the need to manage legacy wastes on a more**

commercial footing and thirdly; the need for clarity to be given to future nuclear generators in respect of their obligations for spent fuel management costs.

With respect to considerations of replacement nuclear build, it would be wrong to allow the legacy of the past to colour the positive contribution which modern nuclear designs can make to global environmental issues and future UK energy policy. The incremental wastes created by replacement reactor plant would only add marginally to the legacy of nuclear waste already being treated, conditioned and stored in the UK. However, there is uncertainty over the timescales for storage of waste arisings. A clear waste management policy is needed in order to create a level (and clearly understood) playing field for all participants in the construction, ownership and operation of future nuclear stations. This will allow plants to be built and run as efficiently and effectively as possible.

– **Commitment to encourage the provision of nuclear education, training and research and development.**

It is important for the UK Government to remove obstacles to delivery of replacement nuclear power by supporting both:

International collaboration in nuclear fission R&D, and

The provision and maintenance of UK training and education programmes in nuclear topics.

Through these measures, the Government can be assured that the skilled resources necessary to underpin existing reactor operations and delivery of a renewed nuclear programme will be available when called upon both by the UK industry and by the nation's regulatory bodies. In addition, early investment in international collaborative R&D projects offers a good potential return for the UK when the technology is exploited.

6. RECOMMENDED ACTION STEPS

6.1 Government action is required now to recognise the true contribution nuclear power is making, and can continue to make, to the achievement of UK Energy Policy objectives. Postponement of such action will impair, if not preclude, nuclear power from delivering these potential benefits for the foreseeable future. BNFL recommends that the Government puts the following enabling mechanisms in place:

- **Modify current climate change mechanisms, such as the Climate Change Levy, recognising that nuclear generation should benefit from the fact that it makes virtually no contribution to greenhouse gas emissions.**
- **Improve planning and regulatory approval processes to ensure that major nationally important infrastructure projects, such as new nuclear power stations, can be delivered effectively and efficiently.**
- **Review how long-term electricity supply contracts - which are required for any baseload station, not just nuclear - can be put in place.**
- **Decide on an overall policy for radioactive waste management which recognises:**
  - **that nuclear wastes are currently managed safely;**
  - **that prolonged safe storage is a viable approach to the management of intermediate and high level wastes, whether fuel is reprocessed or not;**
  - **the need to manage legacy waste on a commercial footing;**
  - **the need for clarity for future nuclear generators in respect of their obligations for spent fuel management costs.**
- **Encourage the provision of nuclear education, training and R&D.**