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Energy Policy Review

Submission by

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The Institution of Nuclear Engineers

The Institution of Nuclear Engineers was founded in 1959. The principal aims of the Institution are the promotion and advancement of nuclear engineering and allied branches of science and engineering and the encouragement of developments in these fields, which are beneficial to the community at large. In support of these aims the Institution works to improve and widen the understanding of nuclear engineering and its supporting scientific and technological bases and to promote contact between nuclear engineers throughout the world.

The Institution encourages advances in the education training and professional development of nuclear engineers and the maintenance of high standards in these areas.

The Institution has an unconditional licence to register applicants directly with the Engineering Council for Chartered Engineer, Incorporated Engineer and Engineering Technician for all sections of the Register. It also has arrangements for registering engineers in Europe as EurIng

The Institution is the leading Qualifying Organisation for nuclear professionals and is neither a trade association nor does it represent the nuclear industry.

The Institution's mission statement is ''to promote the highest professional and safety standards for the nuclear industry''

AIM

To submit evidence in support of the Government's Energy Policy Review and in particular to respond to specific issues raised in the PIU's Initial Scoping Note - Nuclear

INTRODUCTION

Current Policy

1. The Institution of Nuclear Engineers (the Institution) agrees with the Government that global warming, which is now accepted beyond reasonable doubt, is a phenomenon linked with the emission of so called 'greenhouse gases', and poses a substantial danger to the environment. Steps to curb the emission of such gases should therefore be taken by adopting policies that diminish the emission of these gases to the environment.

The Institution also believes that the use of 'renewables' and other forms of generation not involving the emission of greenhouse gases should be invoked in order to contribute to the achievement of the UK's emission targets and thus meet its international commitments - in particular the Kyoto Protocol.

The use of such renewables together with a mix of other energy sources will also contribute to the Government's aim of ensuring continued security and diversity of energy supplies over the long term and minimise the potential for shocks in energy supply to the UK.

2 . Under current arrangements the Government is confident that it will exceed its Kyoto target of reducing greenhouse gases by 12.5% sometime between 2008 and 2012, together with its domestic goal of a 20% reduction in CO_2 emissions following the implementation of further measures; thereafter a reduction of 60% by 2050 is suggested by the Royal Commission on Climate Change (RCEP) [1] a figure which corresponds to the UK's contribution in meeting the substantial changes proposed by the Intergovernmental Panel on Climate Change (IPCC).

3. In its report 'Energy - the changing climate' [2] the Royal Commission on Environmental pollution notes that *"the amount of energy the UK uses is still increasing and the factors that have lead to energy reductions over the decade are largely coincidental"*

The Commission continues by arguing that *"at this stage it looks as if making further substantial cuts in carbon dioxide emissions will be much more difficult for the UK after 2010.The UK is therefore poorly prepared, as yet, to face the long term challenge of reducing emissions from coal, oil and gas to far below present levels''*

4. In its Energy Report (1998) the DTI acknowledges the contribution nuclear has made in curbing CO_2 emissions *"... if the (nuclear) electricity currently generated in the UK were to be generated using fossil fuels, there would be an increase in carbon emissions amounting to between 11 and 22 Mtonnes depending on the mix of fossil fuels used"*
These figures correspond to a reduction in national carbon emissions of between seven and twelve and a half percent, a figure, which at the upper limit, corresponds to the Government's target to be achieved under the Kyoto agreement by 2008 - 2012. Furthermore it represents a very significant fraction of the Government's own domestic goal of a 20% reduction in CO_2 by 2010.

5. The importance of nuclear in contributing to the reduction of greenhouse gases is recognised by the Royal Commission, which notes in its Report that nuclear power stations are *"the main source of carbon free energy at present."* The Commission notes however that all but one of these stations

will have closed by 2025 and calls on the Government therefore to *"set out within the next five years a programme of energy demand reductions and development of alternative energy sources that will prevent this from causing an increase in UK emissions."*
The Commission notes further that *"large-scale non-carbon sources that are already well established and available in large quantities in the UK are nuclear power and hydro power"*.

6. Central to their collaborative Report entitled 'Nuclear Energy - the Future Climate' [3], the Royal Society and the Royal Academy of Engineering stated that economic instruments could help in reducing (or eliminating) the cost differential between fossil and non-fossil fuels and could provide additional incentives for enhancing the efficiency of fossil fuel generation.
Whilst their Report discussed the relative merits of a number of economic instruments, they concluded that a straight carbon tax would be the simplest and most effective; furthermore the disadvantages of such a tax on domestic bills could be overcome, albeit recognising that the issue was complex, dealing as it might with a range of technological, economic, sociological and political components. What was considered vital however is that any tax should discriminate between fossil and non-fossil use.

7. It was disappointing to note therefore that the Chancellor introduced into his Budget a 'Climate Change Levy' which, whilst laudable in recognising climate change as being one of the most significant threats facing the world, did not however differentiate between fossil and non-fossil generation.
In proposing an instrument which includes no incentive for energy switching, the levy fails to take advantage of the most powerful influence for reducing levels of CO_2 in the UK.

8. Even a modest carbon tax would suffice to give a major boost to non-fossil fuel and a figure of 1p/kWh has been suggested as taking a big step towards closing the energy gap without seriously distorting the balance of competition. Whilst the Government has resisted a carbon tax to date, reforms in the electricity market provide the Government with a mechanism to ascribe a carbon tax at source whilst excluding domestic customers from any direct effects.

   The proposed levy should be made to work as efficiently as possible not only in the short term but in the long term also, given that any low (or zero) carbon emitting sources of energy are to be encouraged and industry too receives the level of encouragement necessary in order to promote its future planning activities.

European Dimension

9. Whilst the foregoing narrative has addressed the UK picture the European Union (EU) is becoming increasingly concerned about the levels of external energy

dependency with 50% of current energy needs covered by energy imports, a figure which is predicted to rise to 70% in 30 years' time.
Additionally it will be necessary for the EU to address the challenge of climate change arising from energy production and use, since 94% of greenhouse gas emissions are attributed to the energy sector alone. In its green paper "Toward a European Strategy for the security of energy supply" the nuclear energy option needs to be evaluated against this background

10. Nuclear energy accounts for 35% of energy generated in the EU and this corresponds to a saving of 300 million tonnes of CO_2 emissions per annum. As such the nuclear option plays not only a significant role in the security of supply but is central to its commitment to reduce greenhouse gases.
The Royal Commission's Report on Climate Change, whilst recommending the imposition of a Carbon Tax for the UK, proposed that the UK should also press for a carbon tax at the EU level

11. The Vice President of the EU Commission has stated [4] that *"the nuclear industry needs to strive to renew efforts in terms of credibility and quality of information delivered to the public. Nuclear cannot develop without consensus which can only emerge from public reassurance about nuclear energy based on the availability of transparent, clear and accurate information with credible input from nuclear authorities in each member state"*.

12. Issue of the EU green paper is therefore timely not only for its wide ranging view on nuclear matters in the EU but also in light of the UK Energy Review, as it is likely to provide a useful comparator against which the UK Review is being conducted.

CURRENT & FUTURE REACTOR DESIGN & OPERATION

UK position

13. Currently operating in the UK is a mix of reactor types - Magnox, Advanced Gas Reactor (AGR) and a singleton Pressurised Water Reactor (PWR).
Altogether some 35 reactors are operating which represent some 25% of the UK's electricity generating capacity. Future operation (and lifetime) of these plants is subject to both regulatory scrutiny and commercial pressures

14. BNFL's fleet of Magnox reactors is scheduled to continue generating (in diminishing numbers) until the end of 2010. A phased programme for the cessation of generation was proposed in 2000 for the (then) remaining eight stations in order to allow future operational plans to be optimised.
A proposal to extend the life of units at Wylfa and Oldbury by introducing MagRox fuel (a close derivative of AGR fuel) held out a promise of operation beyond 2010; this proposal now appears to have been discounted with BNFL's

announcement that it has cancelled plans to use the new fuel, citing doubts about its economic viability.

The effects of cessation of Magnox operation will therefore cascade to other parts of the industry, with closure of the Magnox reprocessing plant at Sellafield and cessation of Magnox fuel production at Springfields.
The end of Magnox reprocessing at Sellafield will significantly reduce radioactive discharges to the marine environment even further and virtually eliminate the already low discharges of technetium (a radioisotope by-product of reprocessing) - currently a cause for concern for a number of Governments bordering both the Irish and North Seas.

15. Lifetime extension studies of British Energy's AGR plant are now underway and preliminary work is being undertaken at the Heysham 1 and Hartlepool sites. British Energy expects these and other cost reduction studies in conjunction with planned output improvements to reduce nuclear unit costs by 20% within three years.

16. British Energy's PWR Plant at Sizewell B is currently scheduled to cease operation in 2025.Whilst this Institution is not aware of any plans to conduct lifetime extension studies on this Plant, it is worth noting that such studies have been conducted on similar plant in the USA. The first of these, Calvert Cliffs (two PWR units first commissioned in the mid-70's) have recently secured licence renewals from the Nuclear Regulatory Commission (NRC) for a further 20 years following examination of safety and environmental issues related to operations.

The original licences due to expire in 2014 and 2016 have now been extended to 2034 and 2036 thus effecting a 60-year working life for this plant. Following this success it is now understood that some further 45% of utilities have applied for licence extensions with an expectation that up to 85% will apply in due course.

17. Although direct parallels cannot be drawn between practice in the USA and the UK, nevertheless given the same generic base and development programme for PWRs in each country, based solely on technical considerations, it would be surprising if a life extension were not granted for the British PWR.

Next Generation

18. Acceptability of future designs will be driven by a mix of safety, economics and public acceptability.
A number of plants have now been developed which are close to commercialization and each has a number of features, which characterize national requirements.

19. These must:
    - present the smallest risk to capital investment (capital of the order of £1000/kW and construction times of 3 to 4 years).

- be capable of demonstrating improved safety margins. In particular no severe core damage should result for plausible initiating accidents. This suggests the use of ceramic fuels that do not melt at accident temperatures, coolant materials that are not reactive and passive cooling and heat removal systems that constrain core temperatures under the most severe accident conditions.
- for any severe accident scenario, not result in any off-site emergency response.
- identify complete solutions to waste management issues

20. Amongst the contenders for 'next generation' plant is the Pebble Bed Modular Reactor (PBMR) being developed through ESKOM, the South African State Electricity Company, which in collaboration with the Industrial Development Corporation of South Africa has established an R&D Company which includes BNFL as a 20% stakeholder.
The PBMR is a simple design concept that is expected to be highly competitive with virtually all other forms of electricity generation.

21. With a design power output of 110 MWe the plant brings with it a step change in safety. Through its passive safety features it requires no human intervention following a fault and will shut down and release its heat on a decreasing curve without any failure of the fuel or release of radioactivity.
Although the foregoing description is an over simplification of the system, the design brings with it many features which are considered attractive to a potential operator, including short construction period, small unit size, competitive economics and low environmental impact, to name but a few.

22. Investment in this reactor compliments BNFL's ownership of the Westinghouse AP600 reactor, an advanced passive design.
Whilst it would be inappropriate to describe in detail the workings of this reactor (an overview can be found in [5]) the Westinghouse AP600 PWR is an evolutionary design which combines a range of innovative systems that rely on dependable forces and proven technologies. The design simplifies and reduces the number of plant systems and operational requirements by greatly reducing the number of components compared with todays PWRs. Moreover the plant's passive safety systems perform all the required safety functions which result in increased plant safety. Whilst drawing on over 40 years of operational experience the AP600 provides a high degree of public safety and has now been certified by the Nuclear Regulatory Commission.

23. Although the above two reactor types represent small to medium scale units, plans are well advanced for the European Pressurised Water Reactor (EPR) and the Advanced Boiling Water Reactor (ABWR) which at 1500MWe are both bigger than most current units.

24. As for the AP600 these plants prevent the release of radiation in the unlikely event that the core is "severely" damaged and contain passive safety features, which utilise natural forces to function. In addition to NRC approval, the ABWR was licensed to very high Japanese standards and continues to be reviewed as new

units are deployed in that country.

25. Whilst the above outlines of reactor types are not exhaustive they are indicative of a range of designs which would fit easily into a scenario which addressed the next generation of reactor types for construction in the UK.

Although some of the above designs (or derivatives thereof) are now operational or are moving towards operational status, work has commenced on Generation IV designs [6].
These will reflect even higher standards of safety compared with previous reactor designs.

RESEARCH AND EDUCATION

26. The decline of the nuclear industry has resulted in one of the most significant reductions in comprehensive high quality nuclear technology and associated research programmes at universities than ever before; the ability of universities to attract top quality students to these programmes, meet future staffing requirements for industry and conduct leading-edge research in nuclear topics is being seriously undermined. A number of concerns exist;

- a decreasing number and dilution of research programmes
- ageing research facilities which are not being replaced
- a significant fraction of graduates not entering the nuclear industry
- a decreasing number of students not taking nuclear subjects
- a lack of young faculty members to replace ageing and retiring members

Whilst the above pointers reflect a general view of the situation in the UK there remain a number of exceptions which run counter to the above trend and provide an indication to future opportunities.
A good example is the partnership between the University of Manchester and BNFL inaugurated in 1999 to establish a centre for radiochemical research at the University This centre which provides a unique research capability in the UK university sector is only one of a handful in the world. Equally BNFL is allowing University students and researchers access to its facilities at Sellafield so that they too can work alongside company employees at its facilities in the UK.

27. Currently much of the nuclear industry in the UK is competing in an aggressive energy market and the shortage of new build programmes is resulting in ever increasing pressures on resources available for research and education programmes. Funding for R&D is a key area which underlines future progress in the energy industry. Such funding normally derives from profit which in turn derives from economic rents of which there are few in the nuclear industry at present. Pressure arising from competition, keen regulation, and international diversification means that little is left for research. The conundrum facing industry is that rents which derive from being clean should in principle fund research and development

into clean technologies; that value is not yet present.

28. Against a background of an industry currently in decline, companies will tend to invest in existing plants to ensure they comply with regulatory requirements; maintaining safety competence for both the industry and the regulator becomes therefore a major challenge. This is exacerbated by small profit margins and the absence of new build programmes. Scope for maintaining current competencies and attracting high calibre people into the industry therefore becomes a major task.

29. Funding to address emerging issues is therefore at a premium given the focus on current issues. Difficulties in maintaining adequate levels of technical expertise become a downstream consequence of the funding issue and this in turn has a potential to dilute centres of excellence which as a consequence become unsustainable. Such losses are difficult to replace in the short to medium term.

    Only through higher levels of investment in R&D can the industry expect realistically to achieve greater efficiency, more public confidence in safety and non-proliferation and new markets for nuclear energy.

30. Looking abroad however new legislation before the US Senate calls for up to $240M to be spent in supporting university nuclear science and engineering over the next five years.
    The Department of Energy/University Nuclear Science and Engineering Act was introduced to develop a graduate and undergraduate fellowship. programme to attract new students and help universities to recruit and retain new students.

31. There is a clear need for better co-ordination of nuclear R&D in particular to concentrate skills, which are now too disparate across many fragmented commercial organisations. Whilst a UK Nuclear Research Foundation has been proposed it is incumbent on the industry to set in motion such an Organisation to tackle common industry-wide problems. Clearly there is a potential to establish co-operation with other European and international organisations in order to spread the costs of development and application of new technologies. As a priority the EU Commission is directing funds towards waste disposal issues in order to promote this element of research.

REGULATION AND SAFETY

32. During the 40 years since Her Majesty's Nuclear Installations Inspectorate was formed, many changes in the Industry have occurred during which its style of regulation has moved from one of being largely prescriptive to one involving less prescription in which the licensee has greater opportunity of demonstrating to the regulator how he meets the requirements of the Regulations.

In common with other Government bodies involved in the Regulatory process new challenges are presented to the Regulator, particularly in the areas of economic deregulation and restructuring.

33. Over this period the NII and other regulating bodies have seen nuclear safety research expand and subsequently decline with a legacy of ageing and redundant facilities, many of which are now being decommissioned.
Decommissioning of redundant reactors consumes money rather than create it and adequate funding for these exercises is a potential cause for concern for regulating bodies.

34. Whilst the above changes will bring new challenges one of the underlying concerns is the reduction in technical expertise to support future programmes within the industry and to provide sufficient manpower possessing the necessary expertise to meet manning requirements of regulatory bodies.
Staff and expertise have been lost from the industry and financial and other pressures on universities have reduced the flow of new entrants at undergraduate and postgraduate levels.

Impact of deregulation

35. With the impact of deregulation in the electricity market and increasing privatisation of the nuclear industry, the Government seeks to improve competitiveness and management and minimise its future liabilities and attendant pressures from environmental groups, who seek to minimise even further discharges to the environment. There is a clear potential that costs for nuclear operators are likely to increase in future years.

36. With the UK nuclear industry currently in a state of decline it is inevitable that tensions will develop between regulators and nuclear operators /licencees. It is clearly a challenge for the regulator to create an environment in which good management leads to improvements in both safety and commercial prospects for the industry rather than set them up as separate and opposing objectives.

37. Whilst this approach has much to commend it the British Nuclear Industry Forum (BNIF) has expressed a concern [8] that the demands of the three main (nuclear) regulators in the UK *"are often incongruent and sometimes conflict and their combined demands can be crippling"*. BNIF see this as being a major barrier both to operation and innovation.

38. Whilst the Government's intent is to ensure that the 'degree' of regulation should be commensurate with the risks, costs, and benefits the Chairman of BNFL [9] expressed a concern that, whilst accepting that regulation of the industry is (and should be) extremely strict, it might now (in some cases) be out of proportion to the risks involved.

39. HMNII and other regulators are aware of this swell of opinion from industry and in keeping with good regulatory practice are taking steps to examine their effectiveness and efficiency.

Although UK regulation has taken a pragmatic approach to regulatory issues the US Nuclear Regulatory Commission (NRC) has revised the way it regulates nuclear power plants. The 'new' system is performance-based and uses risk prioritised regulatory criteria, which are designed to remove what is perceived to be undue regulatory (and hence economic) burden without compromising safety.

Safety challenges and restructuring

40 Restructuring of the industry will continue to bring a range of challenges to the Regulators. In his paper addressing Regulatory Challenges [10] the NII's Chief Inspector highlighted specific issues facing his organisation. Amongst these were organisational changes by licencees which included divestments, mergers and change of ownership as licencees sought to maximise commercial benefit; these activities will almost certainly continue into the future.

41. Of particular concern to the NII is upper management decoupling from technical management where increasingly, management focus is directed towards commercial issues, particularly at times of commercial stress with a consequent threat of decoupling from technical issues.

42. On societal and infrastructure issues the NII has expressed concerns about de-skilling and loss of expertise as downsizing in the industry occurs. Mention has already been made of the reduction in the numbers of new entrants to the industry from universities and this is exacerbated as older and more experienced staff leave. Whilst an element of PWR design and build capability in the UK remains, through continuation of the Naval Nuclear Propulsion Programme, commercial design knowledge has diminished since no new plant has been ordered since 1986. Safety research is also in decline given the perceived view of many operators that the industry is now mature and such research is unnecessary.

43 Whilst the above concerns reflect an outward view from the regulators, there remain inward pressures also. In addition to the range of traditional competencies required by the regulator, new competencies in the fields of finance, change management and others are required. Commercial pressures in the industry are likely to lead to growing challenges to the regulatory regime and operators are seeking more consistency and proportionality in the regulators' decisions.

44 Management of change has been a constant challenge in the nuclear industry, regulators work from the principle that they should not put impediments in the way of safe business practices. Operators on the other hand need to recognise that business success and successful safety management are inextricably intertwined; business and safety success go hand in hand.

WASTE MANAGEMENT

45. Issues associated with the management of radioactive wastes are perhaps the most controversial for debate in the nuclear fuel cycle.
It is important to recognise that the technologies for the management of such wastes are established; the processes involved are proven and working, although subject to ongoing refinements; the major difficulty is one associated with public and political acceptance not only here in the UK but also in other countries involved in nuclear power production.

46. An IAEA convention held in Cordoba (March 2000) on the safety of radioactive waste management examined a number of important issues which included the state of knowledge and development of radioactive waste management amongst participating state members In his report on the Conference [11] HMNII's Chief Inspector stated (paraphrased);
"There was support for the IAEA's Joint Convention on the Safety of Spent
Fuel and the Safety of Radioactive Waste Management. This convention is an incentive convention which will facilitate discussion between contracting countries on their approach to the safety of spent fuel and radioactive waste management. Contracting countries agree to comply with the objectives of the Convention which is being incorporated into UK law although it was unclear when it will come into force. The Conference recognised that radioactive waste was an international issue that would require an international scientific consensus and that the Convention and International standards will provide the foundation for this".

47. It is clear that a number of principles are emerging which provide a baseline from which the UK might operate.
- Radioactive wastes exist and 'doing nothing' is not an option. This is based on the premise that the present generation has a duty to future generations not to impose undue burdens upon them.
- Continuous storage is not considered to be good practice. This offers no long-term solution as it is unsustainable, but offers an interim solution to the management of wastes. Monitoring and retrieving such wastes may be sustainable over a number of decades but progress must be made towards disposal.
- The overarching view within the scientific and wider international community is that an international scientific consensus needs to be developed on the state of knowledge on radioactive waste management and the viability of options.

Radioactive Waste Management in the UK

48. In the UK wastes are categorised as Low Level Waste (LLW), Intermediate Level Waste (ILW) and High Level Waste (HLW). Most LLW is disposed of at BNFL's Drigg site in Cumbria. Volume reduction by compaction and limits on key radionuclides will possibly allow this site to continue well into the 21st Century.

49. HLW is highly active (heat generating) material which arises from reprocessing spent fuel which is normally vitrified before storing in stainless steel canisters. It is planned to store these canisters for 50 years to allow them to cool prior to deep disposal. DETR has sponsored a two year study to formulate a programme for the development of a deep repository for HLW and to identify the key elements of an underpinning research and development programme [12].

50. Over the past ten years the prime focus for development for a deep repository has been for certain intermediate and low level wastes. Sellafield was selected as a candidate site and following further investigations into geological and hydrogeological safety assessment properties the NIREX'97 post closure report (NIREX'97) was published which enhanced the confidence in the ability to characterise the site adequately and to meet safety targets. The outcome of a plan to take the process forward by seeking planning permission (NIREX's ''Rock Characterisation facility'') led to its refusal in March 1997 based on conventional environmental issues, site selection process and a consideration that the application was premature

51. As a consequence of this decision NIREX terminated its investigation of the Sellafield site and is now concentrating on three areas which relate to deep disposal in the UK. In summary these are
    - The Nuclear industry and NIREX are in consultation with Government in a process of consultation to inform the development of an institutional framework that will enable a waste management and a disposal strategy to be implemented in the future
    - a number of generic issues continue to be addressed, associated with the repository development and these will enhance the scientific and engineering work conducted to date which have established good foundations for future development
    - Intermediate waste arisings continue to be packaged and processed by waste generating organisations in an acceptable manner commensurate with the first containment barrier of any system to be applied in the interim or long term.

52. Following rejection of the NIREX planning application it is now accepted by policy makers, regulators and the nuclear industry that the Government must take the lead in re-establishing policy and strategy for radioactive waste management in the UK. This view is supported by this Institution.

53. An important first step in that process was an enquiry by the House of Lords Select Committee which took evidence in 1998 and reported in 1999. The outcome of that Committee's deliberations are now well known and will not be repeated here except to say that the establishment of a 'Nuclear Waste Management Commission' with wide ranging powers and segregated funding provides the basis for an independent body whose credibility should rank high with the general public and the nuclear industry.
NIREX shares this view and concurs that a full public debate must take place to ensure that future policy and the framework to implement it are well founded.

54. To acquire stakeholder support for a repository programme broad agreement needs to be reached that the science of deep disposal is sufficiently mature to support site selection and evaluation. This selection process might need to be carried out by independent review in order to inform development of policy. Stakeholders need to be involved at all stages of the decision process on the principle that ''the polluter pays'' NIREX recognise that openness and transparency are key issues in the forthcoming process and this will become one of its core values.

Future prospects

55. The research programme on engineered barriers has now reached a mature stage. There is now sufficient confidence in the choice and science of materials that corrosion rates and other reactions would be sufficiently slow as to contain the wastes for many thousands of years and beyond.

56. NIREX has recognised that the importance of ensuring that long-term waste management options are left open and that wastes placed in a deep repository should be carried out in a staged yet reversible way. The design philosophy of NIREX therefore is to provide flexibility by offering options for a continued maintenance and refurbishment programme enabling future generations to extend the period of interim underground storage if so desired, whilst retrieval remains possible.

57. The NII believes that whilst current arrangements for the storage of ILW are satisfactory it concluded that further improvements could be made. In the next 50 years up to 20 additional waste stores would be required in the UK, which may involve a repeating cycle of refurbishment or new stores if storage periods on licensed sites extend beyond 50 years.
What is certain however is that it will be some time before a national facility is available in the UK.

In the meantime further wastes will be created as facilities shut down and decommissioning commences. It is estimated that over 99% of wastes that will require long term management are stored on nuclear licenced sites and are regulated by the NII.

58. If disposal is adopted as the preferred route then a stepwise process will need to be initiated to provide for on-going review and scrutiny and for transparency in decision making.

59. Scientific and engineering issues of a generic nature should continue to build on the firm foundations established both in the UK and abroad. In particular, issues associated with deep geological disposal are now pressing and the widest consensus of scientific opinion from stakeholders is now required to move this process forward.

International perspectives

60. Whilst the UK has been at the forefront of nuclear waste management initiatives there remains a significant international dimension to these processes particularly so through the IAEA who have been seeking to promote collaborative ventures between its member states; one of the most recent was the establishment of the Joint Convention on the Safety of Spent Fuel and on the Safety of Radioactive Waste Management referenced earlier in this section. The IAEA recognise that radioactive waste is an international issue that will require an international consensus and that the convention and international standards being developed will provide the foundation for this.

61. On the European front an EU green paper is promoting further research on the technology of waste management and its practical implementation under optimum safety conditions.
The European Commission's Vice-President, Loyola de Palacio, has stated [13] that research efforts in the field of radioactive waste have to be reinforced and this area is one of the European Commission's priorities for the next EU scientific research programme.

62. Elsewhere a bill is passing through the Duma, the Russian lower parliament, to allow the import of spent fuel from other countries with the incentive of storing and possible reprocessing of spent fuel. Whilst it is still early days, two potential business models appear as possibilities; the first involves Russia as a reprocessing contractor and secondly, as a location for final waste disposal.

In the former case there would be direct competition with BNFL and other world ranking organisations as fuel reprocessors, with separated elements being returned to the country of origin. In the second case Russia would become the location of a high level waste repository without reprocessing, along similar lines to those proposed for Australia by Pangea. Clearly a mix of both options is also possible.

63. Pangea's view [14] is underpinned by a "think globally act locally" belief, where it is argued that if a country has superior conditions for the development of a repository and being an economically and socially developed democracy, accepts the challenges of establishing an international repository, then its actions are

sustainable at every level. Clearly this philosophy, if pursued brings into focus potential concerns associated with the transportation of radioactive materials over long distances.
Transportation is nevertheless subject to International Regulations and protocols under the auspices of the IAEA and to date there have been few major problems in the transportation of such materials.

64. Against this proposal is the abundance of (relatively) cheap uranium which counters the arguments for reprocessing; arisings from such activities result in the release of plutonium which raises additional concerns associated with its future use.

Whilst solutions for the management of HLW in particular remain wanting in a number of countries, the Russian proposal may find favour in the long term, although a number of substantial hurdles remain to be overcome including revisions of nuclear trade agreements and political acceptability to say the least. However the Government must explore all options for the management of wastes including those possessing an international dimension

ECONOMIC CONSIDERATIONS

65. Publication of the Government's Energy Sources White Paper in 1998 made it clear that it wanted an energy policy developed in a competitive market framework.
The Government stressed that it was "absolutely essential" [15] that such a market should exist for both domestic and industrial users, whilst simultaneously addressing a number of further objectives including social, environmental, security and diversity issues.

66. Against the background of the White Paper other reports which addressed related issues were published subsequently including the Royal Society and Royal Academy of Engineering Report (1999) 'Nuclear Energy - the changing climate' [3] in which it was stated that it was vital to keep the nuclear option open against a background of uncertainty surrounding a combination of renewables conservation and efficiency to meet the needs of environmental protection and security of supply at reasonable cost.

67. Although arguments have been deployed and concerns expressed elsewhere in this submission [Chapter 1] about the structure of the Climate Change Levy and in particular its failure to differentiate between fossil and non-fossil fuel sources in its application, the Government's 'subsidy' of £100M to the coal industry announced last year does not sit easily alongside its commitment to the environment and is likely to prolong the period over which greenhouse gases are reduced.

68. Against a background of the Government's declared intent to develop an energy policy in a ***competitive*** market framework, in addition to the 'subsidy'

outlined above the Government is seeking to support the expansion of renewables and CHP by offering incentives such as exemption from the Climate Change Levy and a Renewables Obligation on electricity suppliers to obtain 10% of their supplies from renewables by 2010.

69. Whilst this Institution supports the Government's drive for diversity and security of energy supplies, the Government's intent to selectively 'subsidise' and 'incentivise' parts of the industry, runs counter to the concept of a competitive energy market.

It has been argued (quite properly) that life extensions/new nuclear build is a matter of commercial judgement for the companies involved although the financial environment within which such decisions are made will be influenced largely by Government policy.

70. Government decisions to support selectively other energy producing industries are likely to impact adversely on the nuclear industry's plans to extend plant life and /or build new nuclear plant to support the drive to reduce greenhouse gases; indeed BNFL's decision not to extend the life of two of its prime candidate sites (Wylfa and Oldbury Magnox stations) on economic grounds, reflects trends in the electricity market and the manner in which the Climate Change Levy has been constructed

71. The Government is clearly steering into danger, particularly so beyond 2012, when its ability to match the loss of nuclear capacity needs to be balanced off by other sources of energy supply in order to comply with its international commitments and meet the nation's energy demand.

Modifications to arrangements for applying the Levy

72. In its recommendations on climate change [16] the Royal Commission on Environmental Pollution argues that *"the price consumers pay for fossil fuels do not, for the most part, reflect the harm their use is doing and will continue to do as the impacts of increasing climate change make themselves felt"*. Calling for the introduction of a carbon tax the report backs a *"general carbon tax based upon the unit quantity of carbon dioxide emitted per unit of energy supplied. It should be applied upstream when fossil fuels are first purchased"*.

73. The Government's approach avoids any direct tax on domestic users which means that the levy has been designed as a downstream tax. It relies crudely on a general tax to achieve its purpose rather than a tax specifically targeted at carbon intensive fuels and therefore runs counter to recommendations made by the Royal Commission. Most importantly it does little to persuade users and generators to switch fuels thus removing perhaps the most powerful incentive in the Government's armoury to achieve its declared intent of reducing CO_2 emissions.

Implementation of a Carbon Tax

74. It has been proposed by Her Majesty's Customs and Excise that a levy rate of 0.6p/kWh would raise £1.2 billion based on electricity sales to non-domestic consumers assuming sales of 200TWh, or two thirds of the total £1.75 billion to be raised by the levy. If it is assumed that the rate were instead proportional to the carbon emission content of the fuels used to generate electricity the differential rate would appear thus:

Fuel Source	p/kWh
Nuclear/renewables	0
Gas	0.5
Coal	1.2
Oil	1.0
Average	0.6

75. This approach would provide the market with a clear view of the premium that zero or low carbon could command; it would provide the necessary incentives for decision making on fuel switching and allow long term planning to proceed with confidence. Given recent electricity market reforms it is now relatively easy to ascribe a carbon tax to different generating sources whilst excluding domestic consumers from any direct effects. This removes the difficulties the Government suggested at the time it applied its 'coverall' levy proposals.

Future challenges and solutions

76. Earlier chapters have addressed the merits and de-merits of potential new and developing reactor designs, concentrating largely on their design features and in particular associated safety aspects. A number of designs having a range of outputs have been produced for the world market over the recent past. Of interest to the UK market is the Westinghouse AP600 design which is an evolutionary development of earlier Westinghouse designs of which Sizewell 'B' is a UK derivative.

77. A recent analysis which examined the competitiveness of such reactors in the UK market [17] against a Sizewell 'B' design and a combined cycle gas turbine (CCGT) plant has indicated that the generating cost of two twin AP600 designs is more competitive than the Sizewell 'B' derivative and is strongly competitive with CCGT plants under a range of circumstances especially where realistic assumptions concerning AP600 are made.
An assessment of generating costs, under a range of pricing scenarios, concludes that the cost differential between AP600 and CCGT in a low price scenario is in the range 0.4-1.3 p/kWh with the corresponding break-even carbon tax in the range £20-85/tC.

78. In a more recent paper [18] BNFL's Chairman has stated *"the AP600.... offers significantly lower generating costs than any other nuclear station currently operating. With generating costs of less than 2p/kWh it would be competitive with gas fired stations"*.

79. Not only does the AP600 bring with it a number of generating cost benefits compared with other plants it also brings with it a simplicity of design and ease of procurement since it utilises standardised components. Constructed along modular lines most components can be factory tested before transporting easily to site.

Most impressive however is its three-year timetable for construction, which compares favourably with its gas-fired counterpart. Licensing by the NRC for use in the USA provides an important milestone of acceptability and will no doubt provide a strong signal to prospective purchasers from abroad as to its inherent safety features, which meet modern standards.

80. On mainland Europe, planning by the new consortium of Siemens/ Framatome (now Framatome ANP) for the European Pressurised Water Reactor, which at 1525MWe is significantly larger in output than AP600, is moving ahead. It is an evolutionary design and aims to achieve 92% availability over a 60-year service life.

It is stated that an evaluation of generation cost shows that it should be possible to obtain a value of 22.5Euromills/kWh at a discount rate of 5%. On this basis it compares favourably with its competitors.

81. Like other reactor systems currently in the pipeline, raised standards of safety are the norm, in this case by the adoption of a twofold strategy.
The first arm of the strategy has been to achieve improved accident prevention and the second - even if the probability of a severe accident is reduced - is to mitigate the consequences of a core melt accident.
The basic design of the EPR is now complete and has been extensively reviewed by the French and German safety authorities.

82. For existing reactors, plans are now being drawn up to maximise reactor lives in order to compete in the liberalised EU electricity market; in France operating lifetimes of Electricite de France's (EDF's) plants will largely dictate how the firm competes in the electricity pricewar. The average age of France's nuclear plants, which are currently licenced for 30 years, is 15 years and expectations are that operations will continue until they achieve 40 years operation with expectations of further extensions out to 60 years. With costs fully amortised, EDF has stated that a 900 MWe PWR Unit operating for one additional year beyond its originally planned lifetime, and with maintenance costs fully under control, saves millions of francs when compared with the costs involved in a new facility.

83. In Finland which has four units operational (built in 1970), supplying some 30% of the country's electrical power requirements, a recent costing exercise [19] has indicated, using a range of interest rates and sensitivity studies, that operating for 8000 hours per year corresponding to a planned load factor of 91% (cf average load factor of 91.2% over the past 10 years) nuclear generating costs are significantly superior to CCGT or coal fired systems.

84. Whilst there remain other reactor systems not addressed in this section (eg Advance Boiling Water Reactors (ABWRs)), the selection chosen is indicative of the potential for new and existing nuclear plant to compete against other forms of electricity generation should a decision be made to commence a new build programme in the UK.

PUBLIC PERCEPTION

85. In its climate change paper [2] the Royal Commission made it clear that the nuclear option needs to be acceptable to both the scientific community and the general public. Over the past few years a number of studies have been conducted which have addressed in whole or in part public perceptions and attitudes towards nuclear power.

86. In a paper by Grimston and Beck [20] entitled 'An enquiry into the future of civil nuclear energy' they explored the underlying reasons why there has been an absence of serious debate about the future of nuclear energy and proposed that the polarised nature of the debate together with the fact that decision makers often misinterpret society's views are undoubtedly some of the reasons for this deadlock.

87. In order to respond to this proposition, the Royal Institute of International Affairs (RIIA) set up an enquiry into the future of nuclear energy. Their paper discusses the current findings of Phase 1 of this exercise with the intent of responding to the question 'What is necessary to keep the nuclear option open?' Under the section 'Public Perceptions and decision making processes' the authors have published the outcome of a MORI Poll in the UK in 1999.
Whilst the response to a question seeking to identify those in favour of nuclear power (or not) resulted in equal numbers for and against from cohorts drawn from members of the general public and MPs (there were more 'don't knows' from the general public), when MPs were asked about their perception of what the public response to the above question might be, the vast majority thought the public would respond unfavourably towards nuclear power; clearly the decision makers were wide of the mark in assessing the public's response.

88. The article recognises the shift from the decide-announce-defend (DAD) model of

decision making to one of building legitimacy and consensus around specific issues. It also recognises the tactics and effects of organised protest in the decision making process and how such pressures might result in different outcomes were they to be absent.

Innovative approaches to ensuring that potential communities and society at large are involved in the decision making process have been developed in recent years. Sometimes referred to as a 'Stakeholder' approach this concept has been used for example in identifying solutions for the disposal and management of radioactive waste. Whilst there have been advances in the decision making process in society particularly with respect to a range of sensitive issues, HMNII recently conducted a survey of public attitudes [21] to matters covering a range of nuclear issues. Altough the report was wide ranging in its coverage the survey sought to establish:

- current level of concern about nuclear related issues
- identification of specific issues of concern
- The tolerability of risk with respect to those specific and in comparison with other industries

The Survey involved both a qualitative phase and a quantitative phase and interviewing was conducted by telephone. Population sampling involved a near group (from towns near a nuclear installation) and a remote group (from towns with no nuclear installation in their conurbation). The survey examined a profile of respondents, a general question of issues which concerned them in the UK today, preferred energy sources and so on. Questions were also asked about issues covering nuclear wastes and decommissioning plans. Whilst the reader is referred to the detailed text to assess the range of outcomes the survey revealed that:

- current spontaneous concern over the industry in general is low and lower still for nuclear waste.
- specific concerns about the industry were identified (as % responses) and are detailed below:-

nuclear waste	(34%)
risk of accidents	(30%)
health risks	(26%)

- Personal risk from nuclear waste is not of overt concern compared with cancer, road deaths etc.
- Awareness of the NII is poor; a majority of the sample consider that the NII could keep them better informed about its activities.

RECOMMENDATIONS

1. The Government should reappraise its use of economic instruments in order to ensure maximum effectiveness in meeting its Climate Change commitments. In particular the introduction of a carbon tax in the UK and the promotion of such a tax in the EU would provide a focus for achieving the UK and EU's Kyoto commitments.

2. The Government should reaffirm its commitment to a truly competitive energy market by ensuring even-handedness in its application and distribution of subsidies and incentives.

3. Should nuclear energy feature strongly as an outcome of this Review it will be necessary for the Government to ensure an appropriate infrastructure is in place for the promotion of a suitable research and development programme in support of the industry.

4. In concert with industry the Government should strive to give maximum exposure to this Review and its outcome(s) in order that informed views may be formed of the energy options available.

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