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A review by HM Nuclear Installations Inspectorate

Magnox Electric plc's strategy for decommissioning its nuclear licensed sites

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FOREWORD

This report sets out the findings of a review by the Health and Safety Executive's Nuclear Installation Inspectorate, in consultation with the environment agencies, of the Magnox Electric plc (Magnox Electric) decommissioning and waste management strategies for its nuclear licensed sites.

The review was undertaken in accordance with the 1995 White Paper "Review of Radioactive Waste Management Policy: Final Conclusions", Cm 2919, which stated that the Government would ask all nuclear operators to draw up strategies for the decommissioning of their redundant plant and that the Health and Safety Executive (HSE) would review these strategies on a quinquennial basis in consultation with the environment agencies.

The Magnox Electric strategy upon which this review is based was prepared subsequent to the merger of Magnox Electric with British Nuclear Fuels plc (BNFL) but whilst it still remained a separate nuclear site licensee under the Nuclear Installations Act 1965 (as amended). This report therefore considers Magnox Electric's decommissioning and waste management strategies as of April 2000 for its nuclear licensed sites at: Berkeley, Bradwell, Dungeness A, Hinkley Point A, Hunterston A, Oldbury, Sizewell A, Trawsfynydd and Wylfa; and at the Berkeley Centre; and for the financial liabilities for waste and decommissioning on other nuclear licensed sites (e.g. BNFL Sellafield).

The review compares Magnox Electric's strategy with national and international guidance, considers the underlying assumptions made and whether the plans are comprehensive and appropriate. The Company's internal mechanisms to quantify the tasks and the necessary liability provisions are reviewed.

The Magnox Electric strategy document is attached as an Appendix to this report.

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EXECUTIVE SUMMARY

The 1995 White Paper “Review of Radioactive Waste Management Policy: Final Conclusions”, Cm 2919, determined that the Government would ask all nuclear operators to draw up strategies for the decommissioning of their redundant plant and that the Health and Safety Executive (HSE) would review these strategies on a quinquennial basis in consultation with the environment agencies.

This review has considered Magnox Electric plc (Magnox Electric) arrangements for the identification of its responsibilities for decommissioning and radioactive waste management, the quantification of the work entailed, the standards and timing of the work, and the arrangements to provide the financial resources to undertake the work.

This is the second review by the HSE in response to Cm 2919 of Magnox Electric's nuclear power station decommissioning and radioactive waste management strategies and is based on the situation in April 2000. It reports the Nuclear Installations Inspectorate’s (NII) view that the strategies proposed by Magnox Electric are appropriate. The strategies are considered to be largely consistent with both national and international policy statements and guidance, and are potentially flexible enough to be able to accommodate lessons learned during ongoing decommissioning activities.

During the review the NII has considered whether Magnox Electric has identified all the tasks required to fully decommission its sites. Generally this has been found to be the case. Some additional tasks have been identified due, in part, to the reviewers’ noting the changes which have recently taken place in environmental expectations.

At this time, on the basis of the information presented, and with the provisos stated below, Magnox Electric’s provisioning for final dismantling after 85 years is considered to be reasonable. The NII expects Magnox Electric to further justify why a shorter timescale is not reasonably practicable before the next review. One of the purposes of this review process is to challenge the operator’s decommissioning strategy assumptions every five years. In particular, one such challenge is how far the prudent assumption by Magnox Electric that statutory requirements will be tightened in the future, for example on annual worker dose, has an effect on the timing of final dismantling. Future reviews will progressively clarify the assumptions used. It is noted that should Magnox Electric be required to bring forward commencement of its station dismantling programme to significantly less than 70 years from end of generation additional financing will be required unless predicted costs can be reduced proportionately.

The current Magnox Electric strategy assumes that the end point of decommissioning will be delicensing, but places a caveat on the interpretation of the ‘no danger’ clause in the Nuclear Installations Act 1965 (as amended). The HSE is currently reviewing its policy on the use of this clause and is working towards transparent and practical guidelines. Should delicensing be more difficult than currently assumed by Magnox Electric, there could be significant cost and liability implications.

The review has concluded that Magnox Electric's mechanism for quantifying its total liabilities is capable of determining the financial provisions required, subject to the full range of tasks and relevant factors being identified. The majority of the funding is to be provided from Government sources outside the Company's control. Arrangements are in place to regularly review, and where appropriate amend, the level of this funding.

The current report is one of a five-yearly cycle in what is in effect an evolutionary process. Future reviews will give the opportunity to consider the effectiveness of Magnox Electric's internal review process and the extent to which Magnox Electric has made progress in refining its plans.

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INTRODUCTION

1. The White Paper on radioactive waste management policy (Cm 2919, reference 1 paragraph 124) stated: *"The Government believes that, in general, the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors. In future it will ask all nuclear operators to draw up strategies for decommissioning their redundant plant. These will need to include justification of the timetables proposed and demonstration of the adequacy of the financial provision being made to implement the strategies."*

2. The White Paper concluded that there are a number of potentially feasible and acceptable decommissioning strategies for nuclear power stations available to the operator. To ensure that operators' decommissioning strategies remain soundly based as circumstances change, the White Paper placed a requirement (reference 1 paragraphs 126 and 183) that these strategies be reviewed quinquennially by the Health and Safety Executive (HSE), in consultation with the environment agencies [the Environment Agency (EA), and in Scotland the Scottish Environment Protection Agency (SEPA)]. The HSE requested HM Nuclear Installations Inspectorate (NII) to undertake the reviews on its behalf. The NII is one of the specialist inspectorates of the HSE.

3. The White Paper recorded the importance of ensuring that appropriate financial arrangements are in place to cover the costs of decommissioning nuclear facilities. It was concluded that segregated funds should be established for those parts of the industry which are privatised and that the Government would examine what improvements could be made in the way in which the state-owned sections of the industry report on their progress towards decommissioning and on their provisioning policies. It was decided (reference 1 paragraphs 131 and 184) that the quinquennial review should provide the right focus for improved reporting of this kind.

4. Currently, there are 40 nuclear licensed sites ('sites') in the UK operated by a total of 15 licensees. The funding of liability provisioning is a corporate matter and it is possible that expensive tasks will be required to be undertaken simultaneously on separate sites. In its statement (reference 1 paragraph 127) that: *"Proposals for dealing with .. (other nuclear facilities) .. will need to be included in the operators' decommissioning strategies"*, the White Paper implied that the quinquennial review should be comprehensive. For these reasons, the HSE is reviewing decommissioning strategies licensee by licensee, not site by site.

5. This report reviews the Magnox Electric decommissioning strategy for its sites as described in the document 'Magnox Electric plc Quinquennial Review of Decommissioning and Waste Management Strategies', Issue 1, April 2000 (Appendix 1). It also looks at the Magnox Electric plc (Magnox Electric) financial liabilities on other licensed nuclear sites (in particular at British Nuclear Fuels plc (BNFL) Sellafield).

6. This is the second review by the HSE of Magnox Electric sites in response to Cm 2919, the first considered the supporting documentation for the re-licensing of the Magnox Electric sites within the privatisation process submitted to the NII by Nuclear Electric plc in January 1996 (reference 2) (see 'Historical perspective' below). The findings of the first review were incorporated within the HSE report on the restructuring and privatisation of the UK nuclear power industry in 1996 (reference 3). This second review was brought forward by six months to inform strategic thinking on BNFL. This has had implications for the preparation of this report insofar as:

   - the supporting Company accounts for the financial year 2000 (reference 4) were not approved at the time of Magnox Electric's April 2000 submission. These were subsequently approved and submitted to the NII (Appendix 2) and constitute the basis of the NII's financial review; and
   - the Magnox Electric document (Appendix 1) was prepared prior to the completion of the formal Trawsfynydd nuclear power station 'safestore' safety case submission and assessment by the NII of that submission is still ongoing. This site specific safety case, when approved by the NII, will serve to support Magnox Electric's decommissioning strategy or influence future changes.

7. Licensees' plans for decommissioning are subject to revision as knowledge and circumstances develop. The quinquennial review process gives the opportunity to consider the adequacy of the plans at particular points in time, once every five years. The present report describes the review of Magnox Electric's strategy as established in April 2000 and the financial data are taken from the Company's 2000 accounts. The report has identified some issues which arise from developments since that date; however, account has not been taken of any changes to Magnox Electric's plans subsequent to the submission of its strategy document (see 'Current situation' below). Future reviews will consider Magnox Electric's responses to these developments.

8. This report considers the technical basis and adequacy of Magnox Electric's proposals and makes judgment on the cost of such proposals where costs form the basis for establishing the financial arrangements for Magnox Electric's decommissioning and waste management programme.

BACKGROUND TO THE REVIEW

The work required of the HSE

9. The White Paper identified two specific aspects of decommissioning for independent review to ensure that the work will be carried out. These are a "strategy" (i.e. overall approach and programme) for the work and "provisioning" (i.e. the funds to be available, when required, to undertake the task safely). The HSE was specifically given the task of reviewing, in consultation with the environment agencies, the decommissioning strategies of each nuclear operator. This is required to be carried out on a five-year cycle and, by inference, to include the arrangements for financial provisioning.

10. Consultation with the environment agencies has been achieved by discussion and by their having access to supporting documentation provided by Magnox Electric. The environment agencies have provided comments on the Magnox Electric documents to the NII and these have been incorporated into this report.

11. Although Cm 2919 does not specifically require publication of the outcome of quinquennial reviews, the document clearly envisaged that the findings of reviews would be reported.

12. The breadth, extent and detail of the review process were not specified in the White Paper. The HSE interpreted the task given as follows:

    a. consider whether the decommissioning strategy of each licensee is:
        i) appropriate;
        ii) realistic, technically practicable and appropriately timed;
        iii) comprehensive; and
        iv) appropriately costed.
    b. consider whether adequate arrangements are in place to:
        v) quantify; and
        vi) make available sufficient funds to undertake the work at the required time.
    c. consider whether appropriate review and revision procedures are in place.

13. In order to ensure all liability costs are addressed in this review, the term “decommissioning” has been interpreted to embrace all stages of decommissioning. This includes the decontamination and dismantling of all facilities, the management of all nuclear material and radioactive waste until it is removed from the site and the preparation of the site to a state suitable for it to be delicensed, after which time the licensees’ period of responsibility under NIA65 could be terminated.

14. The licensee’s period of responsibility for a site does not end until the HSE is satisfied that there is no danger from ionising radiations from anything on that site (reference 5). As removal of all radioactivity from the site could be the most expensive of any possible options for clearance of the sites, it is appropriate that the review should consider the adequacy of Magnox Electric's strategy for achieving this. As discussed in the “Contaminated land” section below, alternative scenarios may develop but the regulators (the NII and the environment agencies) are not in a position to pre-empt a national decision on this question. Therefore, whilst acknowledging that other management options may ultimately be selected by Government for contaminated land, the present review has considered Magnox Electric's strategy for achieving the work of fully decommissioning its sites to a state where termination of responsibility could be achieved and the site could be ‘delicensed’ by the HSE.

The legislative background

15. The main legislation governing the safety of nuclear installations in the UK is the Health and Safety at Work etc. Act 1974 (HSW74) (reference 6) and the associated relevant statutory provisions of the Nuclear Installations Act 1965 (as amended) (reference 5). Under the Nuclear Installations Act (NIA65) no site may be used for the purpose of installing or operating a nuclear installation unless a nuclear site licence ('licence') has been granted by the HSE. The NII is that part of the HSE with delegated responsibility for administering this licensing function and enforcing NIA65 and HSW74 on nuclear sites.

16. NIA65 provides the NII with powers to attach conditions to the licence in respect of safety and in respect of the management of nuclear matter, which includes radioactive waste. HSW74 provides the regulatory powers to enforce these conditions. Until recently each nuclear installation regulated by the NII under the provisions of NIA65 was subject to 35 standard licence conditions which are reproduced in reference 7. A further licence condition addressing control of the licensees' organisational changes related to management of safety was added in 1999.

17. One licence condition requires that adequate arrangements are made and implemented for the decommissioning of any plant or process that may affect safety and that adequate arrangements are made for the production and implementation of decommissioning programmes for each plant. Furthermore, the licensee is required to provide adequate documentation to justify the safety of proposed decommissioning and, where appropriate, provide this documentation to the HSE. By these provisions, the NII has the power to require each licensee to supply it with the details and programmes of its decommissioning proposals. This information is supplied to the HSE under the terms of HSW74 and hence has certain restrictions on disclosure.

18. The routine regulation of licensees' decommissioning work by the NII relates generally to individual plants and facilities. This decommissioning is overlain by the licensee's site-wide programme that prioritises the work and ensures the maintenance of facilities upon which other plants will depend for their decommissioning. The licensee's operating arrangements are regulated by the NII and incorporate good practice. They are designed to satisfy the obligations placed on licensees by the conditions attached to the licence and include:

- in the design of new facilities, taking account of the work that will be required to clean and dismantle the facility at the end of its life;
- during the active commissioning, operational and decommissioning phases of the plant, minimising the generation of radioactive waste and contamination of plant;
- decommissioning plans to be developed in the safety case for each operational plant, and reviewing these plans regularly with the NII;
- prior to the end of the operational phase of the plant, preparing detailed decontamination and decommissioning plans; and

- undertaking decommissioning work only in accordance with an adequate safety case.

19. In reviewing the decommissioning proposals presented by Magnox Electric, the NII would expect some gradation in the detail of proposals for specific plant. A plant not yet in operation is likely to have only outline plans for decommissioning. During operation of the plant the level of detail contained in the plans will be progressively increased until, nearing the end of operation, the plant will have a fully detailed decommissioning proposal. The progression described above could be represented by documentation prepared by a licensee as follows:

- decommissioning proposals as part of the pre-operational safety case;
- production of a pre-decommissioning plan (regularly updated);
- presentation of a safety justification for the option chosen in the decommissioning plans;
- establishment of a pre-decommissioning safety case;
- development of an environmental study for the chosen option;
- consultation on an environmental impact statement; and
- submission of a fully developed decommissioning safety case.

20. The authorisation of discharges and disposal of radioactive waste arising from operations and decommissioning is regulated by the relevant environment agency under the terms of the Radioactive Substances Act 1993 (RSA93) (reference 8). The management of nuclear matter, including radioactive waste, on nuclear licensed sites is regulated by the NII. Formal administrative arrangements ensure that the NII and the environment agencies work closely together to ensure compliance with requirements.

21. The NII regulates the work of decommissioning in the same manner as all other work undertaken on the site. This includes the assessment of licensees' proposals for work, and the inspection of work as it proceeds. Arrangements are in place to ensure, where appropriate, that the work is planned in phases with hold points. By this means, the NII regulates decommissioning work. The experience that the NII has gained from this regulation over many years has been used in this review.

22. In addition to these regulatory activities, and as part of the quinquennial review, the NII has examined Magnox Electric's activities in three other areas:

- first, to consider the adequacy of the long term plans for the eventual removal of all nuclear plant and facilities from each site;
- second, to consider the arrangements for discharging Magnox Electric's liabilities on other sites; and
- third, to consider the arrangements for funding Magnox Electric's decommissioning and liabilities discharge so that work may proceed unimpeded.

23. NIA65 places significant obligations and responsibilities on the licensee. Under current legislation the period of responsibility (reference 5 Sections 3(6) and 5(3)) does not end until the HSE is able to declare that there is no danger from ionising radiation from anything on the licensed site. It is generally assumed that a licensee will wish to be relieved of these responsibilities and will plan the decommissioning of individual sites to achieve this.

24. The White Paper Cm 2919 reported that the Government was intending to introduce legislation in respect of radioactive contaminated land. This has yet to be finalised. In the absence of other guidance, the NII expects the licensees to manage their sites to achieve a systematic and progressive reduction in the hazard presented (reference 1 paragraph 125), towards a situation where no danger from ionising radiation remains on the site and the licensee's period of responsibility under NIA65 could be terminated**.** That is the basis of the present review.

The review of Magnox Electric

Historical perspective

25. The nuclear sites covered in this report were originally operated by the Central Electricity Generating Board (CEGB), except Hunterston A which was operated by the South of Scotland Electricity Board (SSEB). In 1989, as a result of the electricity supply industry privatisation, all of the CEGB sites became the responsibility of Nuclear Electric plc (NE) and Hunterston A passed to Scottish Nuclear Limited.

26. In May 1995 the President of the Board of Trade announced the Government's intention to restructure the nuclear power industry placing all of the, older, Magnox reactors into one company. This led to the reconstituted and restructured company, Magnox Electric plc, applying for new licences for all of the sites covered in this report. In support of the application for licensing and to help provide public confidence for privatisation NE submitted to the HSE the Strategy for the Decommissioning of their nuclear power stations on closure (reference 2). In addition to its role as part of the submission for re-licensing the strategy formed the base submission by Magnox Electric in 1996 to the quinquennial review process.

27. The predecessor to Magnox Electric, Nuclear Electric plc, carried out a review of possible options for the decommissioning of gas cooled reactors which identified and then assessed the relevant financial, technical, safety and environmental aspects of each strategy option. Comparison of these strategies was then carried out using a formalised multi attribute analysis model to establish the preferred decommissioning option. The option selected by this process was that of "safestore" for up to 135 years as the maximum beneficial deferral period before the start of final dismantling.

28. NE's submission (reference 2) did not provide details of the safestore strategy itself but presented "Objectives and principles" upon which the detailed

planning for decommissioning will be based. In principle the strategy presented was for three stage decommissioning involving:

- Stage 1 - removal of fuel and preparatory site work.
- Stage 2 - safestorage / care and maintenance.
- Stage 3 - site clearance and delicensing.

29. The submission stated the intentions of Magnox Electric, as the successor to NE, to continue the process of strategic planning, review and appraisal of international experience as a basis for the development of appropriate site specific decommissioning proposals.

30. The NII's response to this submission stated that 'the decommissioning strategy is adequate for re-licensing' but noted that 'significant progress needs to be made before the next review to give confidence that the strategy remains soundly based'.

31. In 1998 Magnox Electric was brought under the ownership of BNFL but the power stations remained licensed to Magnox Electric. Since then Hunterston A power station has been relicensed to BNFL and re-Authorised under RSA93 as part of an ongoing process of integration.

Current situation

32. This report describes the quinquennial review of the decommissioning strategy, as of April 2000, for those sites operated by Magnox Electric plc: Berkeley power station, Bradwell power station, Dungeness A power station, Hinkley Point A power station, Hunterston A power station, Oldbury power station, Sizewell A power station, Trawsfynydd power station, Wylfa power station, and Berkeley Centre; and for the financial liabilities for waste and decommissioning on other nuclear licensed sites (e.g. BNFL Sellafield).

33. During the period between the HSE's first and second reviews in response to Cm 2919, the process of bringing Magnox Electric and BNFL under more integrated management has been taking place. In addition, external developments have occurred which have the potential to affect the Company's operations and liabilities. Amongst these is the agreement (reference 9) reached at the 1998 Ministerial Meeting of the Oslo and Paris (OSPAR) Commission, Contracting Parties to the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic to an OSPAR strategy for radioactive substances (reference 10). Also relevant are the review by the House of Lords Select Committee on Science and Technology (reference 11) of nuclear waste management and the UKCEED consensus conference (reference 12). The Magnox Electric strategy which this report reviews was prepared after these changes occurred but the multi- attribute decision analysis process on which it was based took place before 1998. A further development is the legislation contained in the Nuclear Reactors (Environmental Impact for Decommissioning) Regulations 1999 (reference 13). Such changes in the operating environment and in the industry are

anticipated to continue and as they occur they will be the subject of future HSE reviews.

34. This review has been undertaken against a background of change and the regulators (the NII in consultation with the environment agencies) have, of necessity, taken note of the evolving situation when preparing this report. In particular the announcement by BNFL (Appendix 3) in May 2000 of Magnox power station closure dates has been addressed. However, account has not been taken of any changes to Magnox Electric's plans subsequent to the submission of its strategy document except to obtain confirmation that BNFL's announcement in May 2000 did not affect the wording of its submission. This report therefore reflects the regulators' current understanding of the relevant potential liabilities of the licensee.

The Magnox Electric Sites

35. The United Kingdom's Magnox nuclear power programme effectively began with the operation of the first reactor of this type at Calder Hall, in Cumbria, in 1956. A total of 26 Magnox nuclear power reactors were constructed and are now owned and operated by two nuclear site licensees: BNFL and Magnox Electric. There are considerable differences in the detailed design of the nuclear reactors at each of these power stations, reflecting the methods adopted by the various design and construction consortia and successive advances in reactor technology. All the nuclear reactors have in common that they are fuelled by natural uranium (except for Oldbury which has some enriched uranium fuel) within magnesium alloy cans ('Magnox'), the moderator is graphite and the coolant gas is carbon dioxide.

Berkeley power station

36. The Berkeley power station was commissioned in 1962 and is located on the river Severn in Gloucestershire, approximately 15 miles north of Bristol. The station consisted of two reactors, each capable of generating 137.5 megawatts of electricity. The reactor core is mounted within a cylindrical mild steel pressure vessel. There were eight boilers arranged radially around each reactor, connected to the reactor pressure vessel by mild steel ducts. The reactors were shut down in 1989 and defuelling of the reactors was completed in 1992. The removal of auxiliary plant from the reactor buildings has now been completed, the primary circuit sealed and the external boilers laid down for long term storage. The ponds building has been decontaminated and is being demolished. Further work is ongoing to enable the site to enter a safestore period, including the construction of a purpose built interim intermediate level waste (ILW) store.

Bradwell power station

37. The Bradwell power station was commissioned in 1962 and is located on the river Blackwater estuary in Essex, approximately 50 miles from London. The station consists of two reactors, each capable of generating 150 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are six boilers arranged radially around each reactor,

connected to the reactor pressure vessel by mild steel ducts. The reactors are operating but are intended to be shut down in 2002.

Dungeness A power station

38. The Dungeness A power station was commissioned in 1966 and is located on the Kent coast, approximately 13 miles south west of Folkstone. The station consists of two reactors, each capable of generating 220 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are four boilers arranged radially around each reactor, connected to the reactor pressure vessel by mild steel ducts. The reactors are operating but are intended to be shut down in 2006.

Hinkley Point A power station

39. The Hinkley Point A power station was commissioned in 1965 and is located on the Somerset coast, approximately 8 miles north west of Bridgewater. The station consists of two reactors, each capable of generating 235 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are six boilers arranged radially around each reactor, connected to the reactor pressure vessel by mild steel ducts. The reactors were shut down in 2000 and defuelling of the reactors is expected to commence in the near future.

Hunterston A power station

40. The Hunterston A power station was commissioned in 1964 and is located on the Ayrshire coast south of Largs, approximately 25 miles to the west of Glasgow. The station consisted of two reactors, each capable of generating 150 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are eight boilers arranged radially around each reactor, connected to the reactor pressure vessel by mild steel ducts. The reactors were shut down in 1990 and defuelling of the reactors was completed in 1995. Some removal of auxiliary plant from the facility has now been completed but substantial work is still required to enable the site to enter a safestore period.

Oldbury power station

41. The Oldbury power station was the first to be built with pre-stressed concrete pressure vessels and was commissioned in 1966. It is located on the south side of the Severn estuary in Gloucestershire, approximately 12 miles north of Bristol. The station consists of two reactors, each capable of generating 215 megawatts of electricity. There are four boilers arranged radially around each reactor incorporated within the concrete pressure vessel containment. The reactors are still operating.

Sizewell A power station

42. The Sizewell A power station was commissioned in 1966 and is located on the Suffolk coast, approximately 25 miles north east of Ipswich. The station

consists of two reactors, each capable of generating 210 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are four boilers arranged radially around each reactor, connected to the reactor pressure vessel by mild steel ducts. The reactors are operating but are intended to be shut down in 2006.

Trawsfynydd power station

43. The Trawsfynydd power station was commissioned in 1965 and is located on the north shore of Trawsfynydd lake in Snowdonia National Park. The station consisted of two reactors, each capable of generating 290 megawatts of electricity. The reactor core is mounted within a spherical mild steel pressure vessel. There are six boilers arranged in groups of three at opposite sides of the reactor, connected to the reactor pressure vessel by steel ducts. The reactors were shut down in 1993 and defuelling of the reactors was completed in 1995. Some removal of auxiliary plant from the facility has now been completed but substantial work is still required to enable the site to enter a safestore period.

Wylfa power station

44. The Wylfa power station was the second to be built with pre-stressed concrete pressure vessels and was commissioned in 1971. It is located on the north side of Anglesey, approximately 15 miles from Holyhead. The station consists of two reactors, each capable of generating 580 megawatts of electricity. There are four boilers arranged radially around each reactor incorporated within the concrete pressure vessel containment. The reactors are still operating.

Berkeley Centre

45. The site is currently the headquarters of Magnox Electric plc, but also retains a number of research facilities including active chemistry laboratories and a shielded facility for undertaking irradiated fuel examination, destructive testing, and examination and testing of steel samples.

Liabilities

46. The responsibility for safety and the liability for harm under NIA65 rests exclusively with the licensee. In the case of this review this means Magnox Electric, which was the licensee of all of the sites described above at the time of the submission. However, because of the history of the UK nuclear industry, the situation is in practice more complex. In particular, this quinquennial review of Magnox Electric strategy included the Hunterston A power station noting that the site was re-licensed to BNFL at the end of July 2000.

47. Magnox Electric's strategic and technical submission for the quinquennial review dealt with liabilities existing on its power station sites and at the Berkeley Centre, including:

- reactor defuelling and associated post-operational clean-out;
- the conditioning and disposal of operational wastes accumulated on its sites;
- decommissioning activities and associated waste management in respect of plant and equipment on those sites; and
- arrangements for dealing with any contaminated land.

48. However Magnox Electric also has substantial nuclear liabilities on sites belonging to BNFL, its parent company, and accordingly Magnox Electric extended the scope of the financial aspects of the review to include the costs of:

- off-site storage and reprocessing of spent Magnox fuel, the treatment and storage of the resulting waste arisings, the storage of recovered plutonium and uranium, and flask maintenance;
- Magnox Electric's share of decommissioning liabilities at BNFL's Sellafield and Springfields sites, and at the BNFL Magnox reactor sites at Calder Hall and Chapelcross. For Sellafield this includes historic waste management (i.e. ongoing waste treatment and storage associated with fuel throughput prior to 1989); and
- the disposal costs for Magnox Electric's allocation of the wastes at BNFL Sellafield, including ILW and high level waste (HLW).

NII decommissioning policy

49. The HSE has produced (reference 14) a statement of policy relating to its responsibility for the regulation of decommissioning and radioactive waste management on nuclear licensed sites. This followed the publication of Cm 2919 and incorporates the policy lines presented in that document. In this report the Cm 2919 interpretation of the term "decommissioning" is used:

> *"Decommissioning is the set of actions taken at the end of a facility's economic life to take it permanently out of service and subsequently make its site available for other purposes."*

50. Decommissioning is not explicitly defined in the nuclear site licence. The NII/HSE interpretation quoted above is consistent with the definitions given by the International Atomic Energy Agency (IAEA) (reference 15) and the Nuclear Energy Agency (NEA/OECD) (reference 16). Hence, the adequacy of Magnox Electric's decommissioning strategy has been reviewed against this definition of the decommissioning activity.

The Magnox Electric submission

51. After discussions with the NII, Magnox Electric supplied a corporate decommissioning strategy document which forms the basis of this review. The document is reproduced in full at Appendix 1. It summarises the Company's decommissioning objectives and guiding principles, its strategy for implementing the decommissioning and for managing radioactive waste; and

the extent of the work and the general arrangements for costing and funding the programme of work.

52. In order for the NII to carry out the review required by Cm 2919, additional information was required beyond that normally required under HSW74. Magnox Electric expressed concern that some details of its decommissioning and waste management plans are commercially sensitive. Therefore, arrangements were made to segregate the general strategy from the large number of supporting documents, covering each aspect of the work associated with decommissioning and radioactive waste management, some of which contained the commercially sensitive information. Magnox Electric made available to the NII a full set of documentation in a data room at its Berkeley Centre site. Other additional information has been taken from published sources including the Company accounts, regulatory inspections and from Magnox Electric's responses to requests for clarification of specific points which arose from the review process.

53. This review assesses both the magnitude of the task posed by complete decommissioning of all of Magnox Electric's sites and of the arrangements to provide the necessary funding. The review also includes a brief consideration of Magnox Electric's proposals with respect to the discharge of its liabilities on other licensee's sites to ensure broad consistency with the quinquennial review of these liabilities. The NII does not routinely demand detailed business accounts and costings of nuclear licensees. The extent of the information requested from Magnox Electric for this review was agreed between the NII and Magnox Electric in advance.

THE TECHNICAL REVIEW

Guidance

54. The technical assessment has compared Magnox Electric's strategy with the following policy statements and guidance:

- UK national policy: Cm 2919 (reference 1);
- HSE Decommissioning and Waste Management Policy (reference 14); and
- International guidance of the IAEA (references 15, 17 and 18).

Review process

55. The Magnox Electric submission has been assessed by:

- comparison of the approach with the above policy statements and guidance;
- examination of the assumptions upon which the strategy, planning and estimation of costs are based to determine their validity and completeness;
- review of the Magnox Electric methodology, to determine its overall adequacy to maintain a continuing viable decommissioning strategy; and

- review of Magnox Electric's plans, to test validity against current practice in decommissioning experience.

56. There is an intimate interrelationship between decommissioning and waste management, especially the retrieval of accumulated material. Thus the NII reviewed the licensee's radioactive waste management strategy in association with the decommissioning strategy up to the point where the site has been brought to a condition when it could be delicensed by the HSE, in accordance with the provisions of NIA65 (reference 5).

57. The Magnox Electric strategy document (Appendix 1), the supporting documents and additional written amplifications in response to specific issues raised by the NII assessors have all been taken into account during the review. In preparing the technical review, the NII has consulted with the environment agencies, the DTI and the relevant NII site inspectors.

Findings

Magnox Electric's decommissioning policy

58. The Magnox Electric corporate decommissioning policy was confirmed by the Magnox Electric Board, in May 1997, stating that the decommissioning strategy is a component part of the Company's environmental policy. The Board policy lays down a number of principles and priorities, noting that the policy is inherited from NE and that the priorities are safety; environment; value for the taxpayer; and business benefit. The component strategies are identified as power station decommissioning; operational ILW strategy; spent fuel management strategy; and waste disposal strategy.

59. A separate Board paper dealt in more detail with the then strategy of deferred safestore (inherited from NE), breaking this down for power station decommissioning into six tasks spread over 145 years (starting Stage 3 final demolition at up to about 135 years after shutdown).

60. It was noted at an early point in the NII assessment that the Magnox Electric Board level policy and supporting strategy documents are 'out of phase' with current Magnox Electric thinking and somewhat dated. The processes which Magnox Electric has gone through to develop its current decommissioning and waste management strategies in time for this review, including the detailed multi-attribute decision analysis process, have meant that these strategies - whilst being fully endorsed by the Magnox Electric Board - preceded the revision of Board level policy. This could be seen to be a possible effect of bringing the Magnox Electric quinquennial review forward by 6 months. The NII has accordingly considered it appropriate to take the Magnox Electric Decommissioning and Waste Strategies, as submitted to the HSE in April 2000, Appendix 1, as currently representing the Magnox Electric Board's position on both policy and strategy.

Magnox Electric's decommissioning strategy

61. The White Paper Cm 2919 (reference 1) describes the then current UK national strategy for the decommissioning of nuclear power stations as being a three stage process. This is consistent with the international guidance of the IAEA (reference 15). This strategy is (reference 1, para 121) :

- defuelling [removal of nuclear fuel] (immediately after final closure);
- dismantling the buildings external to the reactor shield (5-10 years later); and
- dismantling the reactor itself (around 100 years after shutdown).

62. Alternative strategies raised in Cm 2919 (reference 1, paras 121 and 123) are:

- a 'safestore' strategy which would involve defuelling (as in para 61); removal of most inactive buildings and preparing the active buildings for an extended period of care and maintenance; at around 30 years after shutdown undertaking further work to secure the building to leave a structure which would require essentially no maintenance over a further period of around 100 years (safestore); routine surveillance throughout that period; at the end of the period the buildings and their contents, including the reactor core, would be completely demolished;
- as above, except to proceed with the 'safestore' without delay; or
- undertaking all stages of decommissioning as early as possible after the reactor shut down.

63. The current review has compared Magnox Electric's strategy with Cm 2919. The White Paper concludes that *"in general, the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors"* (reference 1 paragraph 181) and indicates that:

- *"the hazards presented by the plant (should be) reduced in a systematic and progressive way"* (reference 1 paragraph 125);
- *"the Government confirms its preliminary conclusion that there are a number of potentially feasible and acceptable decommissioning strategies for nuclear power stations available to the operator, including the 'safestore' strategy"* (reference 1 paragraph 126); and
- *"it would be unwise for operators of nuclear power stations to take steps which would foreclose technically or economically the option of completing Stages 2 and 3 on an earlier timescale should that be required"* (reference 1 paragraph 182).

64. The White Paper also expects *that "the rate at which the work proceeds will be determined by the potential hazards posed to the public, workers and the environment (recognising the benefits obtainable from radioactive decay), the availability of disposal routes for the wastes and - subject to ensuring public safety - the financial implications of proceeding on different timescales"* (reference 1 paragraph 125).

65. Listed in Appendix 1, paragraph 3.1, are the Magnox Electric objectives for decommissioning and radioactive waste management, which have been aligned with those of BNFL. These include: ensuring safety, minimising the expenditure of national resources and ensuring adequate resources, including financial, are allocated. The White Paper statements, such as decommissioning "as soon as it is reasonably practicable to do so, taking account of all relevant factors" are not specifically listed as key objectives but are listed in Appendix 1, paragraph 3.2, as the principles that are used by Magnox Electric to provide guidance in developing strategies and plans for reactor decommissioning and waste management. For example, they include: *"decommissioning and waste management will be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors, such that there is a systematic and progressive reduction in hazard."*

66. Thus Magnox Electric recognises Government policy as the basis of a number of principles, including timing of decommissioning, to be used to provide guidance in developing its strategies and plans for decommissioning. It is noted that other aspects, including financial implications and minimisation of costs, are also guiding principles.

67. The White Paper requires the application of the principle of sustainable development (reference 1 paragraphs 50 and 162) to radioactive waste management policy. For the purposes of this review the NII has used the definition of sustainable development given in Cm 4345 (reference 19), *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs".* The Magnox Electric submission (Appendix 1) includes in Annex 2 statements as to how it considers it complies with the sustainable development requirements stated in reference 1. Also, the 'Company objectives' include: *"to ensure that adequate resources are allocated to decommissioning and waste management, including the provision and maintenance of financial arrangements in order to fund these future liabilities"* and the 'guiding principles' include: *"solid wastes arising from decommissioning sites will be packaged in a form, agreed in advance with UK Nirex Ltd [Nirex], suitable for interim surface storage".*

68. This indicates Magnox Electric's intention to undertake decommissioning, to leave operational waste in a state potentially suitable for management by future generations and to provide funds for future work. It is recognised that there are uncertainties about the meaning and application of sustainable development to decommissioning and it is noted that Magnox Electric has ongoing studies to investigate this further. Future quinquennial reviews will consider the extent to which Magnox Electric has further developed its plans regarding the requirements of decommissioning and radioactive waste management policies in relation to sustainable development.

69. Cm 2919 requires that *"each of the component parts of the industry, regulatory bodies and government itself should continue to be responsible for commissioning and funding of the research and development (R&D) necessary to support their respective functions in relation to radioactive waste management and that they should do so on the basis of clearly stated aims and objectives"* (reference 1 paragraph 155). Magnox Electric's 'guiding

principles' identify that: "*a research and development programme will be maintained to ensure awareness of developments in technology and to review the applicability of these to the decommissioning and waste management process*" implying collaborative work with other organisations. An ongoing R&D programme is maintained by the Company in waste and decommissioning. It was noted that reactor dismantling techniques are not listed in Appendix 1, although Magnox Electric has separately provided assurances that this is being addressed.

70. In its strategies document (Appendix 1) Magnox Electric's second objective is *"To minimise the expenditure of national resources on decommissioning and waste management ..".* The possible implications of this strategic statement will continue to be an area of review by the NII to ensure that decommissioning is carried out to a timescale which minimises, so far as is reasonably practicable, any adverse safety and waste management implications for each plant and also that adequate resources are made available.

Development of Magnox Electric's decommissioning strategy

71. Cm 310 (reference 20) and the associated regulatory guidance (reference 21) was followed by Magnox Electric in developing its strategies for decommissioning and the management of accumulated volumes of waste at its nuclear power stations, as they approach the end of their operating life. These are intended to represent the 'best practicable environmental option' (BPEO). Magnox Electric recognises that its methodology is more extensive than that recommended in the guidance, because it includes consideration of factors other than environmental and economic attributes. The environment agencies agree that Magnox Electric's approach is broadly acceptable and consistent with the 'flexible framework' approach identified in the guidance.

72. Nuclear Electric (the predecessor to Magnox Electric) first carried out a BPEO study for the decommissioning of Magnox power stations in 1989/90 (see 'Historical perspective' above). In accordance with the underlying principles described in Appendix 4, Magnox Electric carried out a more extensive revised BPEO study in 1997/98. The revised study excluded the management of accumulated operational ILW and of contaminated ground as these are covered in a mixture of separate generic and site specific studies.

73. The objective of the study was *"to generate strategies for decommissioning of steel pressure vessel (SPV) and prestressed concrete pressure vessel (PCPV) Magnox power stations which are acceptable to both stakeholders within Magnox Electric and the regulators. The preferred strategy should involve the minimum environmental impact which can be reasonably achieved with regard to technical feasibility and cost.*" For the purposes of the study Bradwell and Oldbury were selected by Magnox Electric as sites representative of the SPV and PCPV power stations respectively. The subsequent multi-attribute decision analysis (MADA), used to develop the BPEO, was therefore based on two sample stations, rather than Magnox Electric's family of stations. Consequently the MADA excludes consideration of a continuing programme of work on decommissioning of reactor sites that

could have advantages in terms of retention of expertise and gaining of experience. Work by Magnox Electric following the MADA did give some consideration to a continuing programme for the final dismantling phase, but the programme only started after a set period of deferral for all sites.

74. The MADA process was initiated, using options generated by a representative group of Magnox Electric internal stakeholders, in June 1997. Separate options were considered for each of the three decommissioning stages (see 'Historical perspective' above). The process of refining the initial options involved filtering out those considered unacceptable on safety or feasibility grounds, with these grounds being recorded. For Stage 1 the initial options were reduced to one - prompt defuelling and off-site disposal. One of the options, the retention of fuel in a purpose built store, was excluded, in view of ongoing contractual discussions, from being considered further in the BPEO. For Stage 2, the initial options were reduced to five variants. For Stage 3, fifteen options were reduced to four variants; two options (immediate and deferred underwater dismantling) were rejected on the basis of insufficient data available at that time. The combination of these variants produced a final list of twelve decommissioning options.

75. Magnox Electric should review the appropriateness of its decisions to exclude or reject the three options noted above and justify any proposals not to progress further work to address each of these before HSE's next quinquennial review. Additionally, the decision to reject certain options was made by Magnox Electric on the basis of its experience and perception of how external stakeholders (regulators, planning authorities etc.) would respond. The adequacy of this should be tested by Magnox Electric, before HSE's next quinquennial review, by engaging a wide range of its external stakeholders in dialogue on each of the original decommissioning options to confirm the decisions to retain or reject.

76. Once the options had been agreed, a 'decision conference' was held in January 1998 to evaluate the options. At this conference, attended by a much larger group of Magnox Electric internal stakeholders (plus an NE participant), the attributes upon which each of the options would be judged were agreed, scored and weighted. The potential attributes of 'sustainable development' and 'intergenerational equity' were considered by the conference but not progressed separately. The participants felt that these were adequately covered by the BPEO process itself together with other attributes.

77. The NII considers that the key Government Policy statement that "the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors" (Ref 1, para 124) should be a major consideration in any strategy options analysis. The NII has some concerns as to whether this was sufficiently addressed in the MADA process applied by Magnox Electric. The NII acknowledges that it would be inappropriate for the full phrase to be used as a separate and specific attribute in a MADA. However, the NII considers that an attribute on the 'timing of decommissioning' should be used, and weighted such that the desirability of earlier decommissioning has a more significant

influence on the MADA results. Magnox Electric stated that the range of attributes included in the MADA process covered the 'taking account of all relevant factors', and that the timing of decommissioning was addressed by including within the strategy options analysed a range of decommissioning timings, including immediate reactor dismantling. The NII considers that Magnox Electric should continue its ongoing research on the attributes to be used and give further consideration to a revised MADA before the next HSE quinquennial review.

78. The evaluation of the identified options was carried out under the premise that *"all decommissioning activities will be designed, constructed and operated to an acceptable level of safety... {and} The cost of such safety measures is included in the total cost of decommissioning..."*

79. In the conference the options were scored for each of the attributes. A weighting exercise then followed, reflecting the difference in performance between best and worst options for each attribute. Magnox Electric considered this difference to be small for many of the attributes, such as safety, so those attributes' weightings, and their influence on the MADA results, were small. Because Magnox Electric calculated the differences between options to be large for the 'net present value' (NPV) attribute, it was given a large weighting with the result that this attribute heavily influences the MADA results. Attribute scores and weightings were combined to give a total weighted score for each option and a ranking of the options. Sensitivity analyses were than carried out by Magnox Electric to see if the ranking of the options would be altered by changes to attribute scores or weightings (or combinations thereof). The sensitivity analyses by Magnox Electric demonstrated the robustness of the MADA outcome e.g. weighting of the NPV attribute would have to be changed significantly in order to affect the outcome, but this again may reflect the dominance of the NPV attribute. Although Magnox Electric has applied the MADA process, including the scoring and weighting, in a logical and consistent manner, it acknowledges that there are significant presentational problems in the apparent dominance of NPV. The NII suggests that Magnox Electric, in its review of the MADA process, considers initially excluding NPV from the analysis, so that the effects of other attributes can be more clearly identified, and including NPV as an attribute as part of a second or final analysis. The NII considers that, in addition to engaging each of the external stakeholders in dialogue on each of the original options, Magnox Electric should also, through dialogue, inform itself as to the acceptability of the scoring and weighting decisions.

80. Magnox Electric's MADA process concluded that the BPEO is a safestore option with final dismantling or in-situ disposal deferred for a period of 70 years or more following shutdown; that there is no overall advantage between early or deferred safestore; and, immediate dismantling is not optimum on the grounds of safety, waste minimisation and cost.

81. The NII recognised, at the time of their first review of the Magnox Electric reactor decommissioning strategy in 1996, that while the 'safestore' option is acknowledged in Cm 2919 as a potentially viable strategy, it was a concept

pending progress by Magnox Electric with the development of an acceptable safety case for a specific site.

82. Following the first HSE review Magnox Electric was advised that at the year 2000 quinquennial review the HSE would be expecting to see development of safestore strategy beyond the conceptual stage to a point where a judgment on regulatory acceptance could be made. The formal Trawsfynydd power station 'safestore' safety case has now been submitted to the NII and is being assessed. This site specific safety case, when approved by the NII, will serve to support Magnox Electric's decommissioning strategy or influence future changes.

83. The NII has also noted that care must be taken not to underestimate the costs during a care and maintenance period. In particular, Magnox Electric must ensure that the risk margin for the care and maintenance period is sufficient in respect of such issues as the potential need to maintain a permanent on-site presence, licensing costs, insurance, cost of maintaining emergency arrangements, etc It is noted that such a risk margin is included within the provision (see 'Costing issues' below)

84. Having reviewed the MADA process, and noting the weaknesses identified above, the NII acknowledges that it provides a useful tool to assist Magnox Electric's choice of an optimum decommissioning strategy. The NII considers that the process should be capable of further development.

85. The MADA process does not generate the Company strategy regarding power station decommissioning and waste management, however it clearly goes a long way towards influencing that strategy. During internal management discussions subsequent to the MADA, Magnox Electric developed a revised safestore strategy which involved early decommissioning of all of the site, with the exception of the reactor buildings, and the creation of a new ILW store. The financial costing models supported this as a viable approach, it was consistent with the findings of the MADA analysis, and so the Magnox Electric decommissioning and waste management strategy was drafted accordingly.

86. Magnox Electric's current decommissioning strategy has reduced the period between shutdown and dismantling, from the 'up to about 135 years' proposed in 1996, to around 100 years. These strategy changes are considered by the NII to be in the right direction. Magnox Electric's documentation indicates that the " '*start date' and duration will be decided at the appropriate time in light of circumstances prevalent at that time*". The NII, whilst recognising that some deferral period appears to be appropriate, considers that the documentation does not provide sufficient evidence that a further reduction in the deferral period would not be reasonably practicable. Magnox Electric's own financial provisioning allows for bringing dismantling further forward to 85 years after shutdown, with a risk provision to reflect the potential for shorter deferral periods (as required by reference 1). The process by which the submitted strategy was reached after the MADA is not transparently auditable, although the final outcome was properly endorsed at Magnox Electric Board level.

87. In future quinquennial reviews the NII would expect Magnox Electric to have a revised corporate policy, which more explicitly reflects Government policy (currently outlined in Cm 2919, reference 1), and from which the corporate strategy can be demonstrated to have been consistently and auditably developed. The NII recognises that strategy reviews are carried out at present but consider that Magnox Electric should formalise its review process to develop and update its strategies and provisioning in response to changes and experience. Future quinquennial reviews by the HSE will monitor the effectiveness of the Magnox Electric review process in these respects.

Magnox Electric decommissioning proposals

88. During this review, the NII has examined a number of assumptions incorporated in the Magnox Electric strategy and has confirmed that the majority are reasonable and remain valid. However, it has identified some assumptions which are currently subject to uncertainty and which may be affected by future developments.

89. In developing its decommissioning strategy Magnox Electric has recognised the limitations of the assumptions on which the strategy is based and developed a “risk list” approach based on estimation of the probability and financial consequences that any particular part of the overall decommissioning plan will not take place as planned. As a consequence of this generic approach, particular site specific events which may hinder decommissioning progress have not been explicitly addressed.

90. The NII has identified a number of such events which could potentially prevent, delay or undermine the Magnox Electric strategy. These events were checked against the Magnox Electric approach to assist in judging its adequacy and completeness. The more significant of these were:

a. in November 1997 the NII advised all major licensees that they should review and amend as appropriate their arrangements for decommissioning and radioactive waste management in the light of DETR advice on the anticipated effects of global warming. Although Magnox Electric has acknowledged the financial risk which global warming represents it has not demonstrated in its decommissioning strategy that it has acted on the NII advice on this matter, nor does Magnox Electric appear to have given adequate attention to the environment agencies' available advice. Where Magnox Electric has started work to address global warming in the context of decommissioning, it should clearly identify and assess the key climate variables to which decisions about decommissioning are sensitive. Further studies should take into consideration the draft decision framework issued by the Environment Agency (reference 22). In particular, the timescales for the proposed 'safestore' structures are sufficiently long for coastal changes to become a potential issue and are likely to have an impact on the detailed measures to maintain the site in a satisfactory state in the longer term. This is considered to be a weakness in the Magnox Electric decommissioning strategy and Magnox Electric's progress in addressing this will be examined by the HSE in greater detail at the next quinquennial review.

b. the Magnox Electric strategy contains a presumption that authorised discharge limits for gaseous and liquid discharges can be increased (e.g. for dismantling during Stage 3) by the environment agencies subject to consultation (in accordance with UK legislation). Recent experience and draft Government statutory guidance to the environment agencies on the regulation of radioactive discharges indicate that there is a presumption of progressive reductions in discharges and limits and any increases would be exceptional. However, one of the circumstances where exceptions might be envisaged could be to deal with decommissioning wastes. Each case will be considered on its merits. The NII notes that Magnox Electric has included as a risk the possibility that gaseous or liquid discharges may not be authorised from decommissioned sites at some time in the future.

c. granting of any future Authorisations is a matter for the environment agencies. In the case of transfer authorisations for ILW this may have a significant impact on potential future management options such as consolidation of ILW at BNFL Sellafield. In the continuing absence of progress on provision of an ILW disposal route and uncertainties regarding transfer authorisations, the only guaranteed waste management strategy in the medium term is on site passively safe storage. The NII notes that this is Magnox Electric's decommissioning and waste management strategy. Magnox Electric should continue to review the financial risks which the uncertainty over ILW disposal introduces. At an appropriate time, Magnox Electric should also seek to open up discussions with EA and SEPA regarding future solid waste transfer authorisations.

91. Magnox Electric's current approach to the 'risk list' appears to be cautious. However, the NII would expect these issues to have been further addressed in Magnox Electric's annual reviews of the 'risk list' before the next quinquennial review by the HSE.

92. There is a requirement for public consultation on an Environmental Impact Assessment (reference 13) to be presented to the HSE for all future reactor decommissioning proposals. Until these, and site specific safety cases have obtained regulatory approval and until the outcome of the forthcoming consideration of proposals for decommissioning of Trawsfynydd power station is known, it is considered appropriate (as required by Cm2919) for Magnox Electric to continue to retain, both technically and economically, the option to dismantle its reactors sooner than the 'around 100 years' after reactor shutdown proposed in the Company strategy. Progress in this area will be monitored at the next quinquennial review of Magnox Electric by the HSE.

93. The Magnox Electric strategy envisages that defuelling would commence as soon as practicable following the shutdown of the reactor and would be planned to be completed within 2 - 3 years. This would be immediately followed by dismantling the radioactive and inactive items that are external to the biological shield of the reactor but this would not include the gas coolant ducts and heat exchangers. This stage would take a further 5 - 7 years to complete. The final stage would not commence until after around 100 years after reactor shutdown. This dismantling stage is expected to take a further 8 years to complete.

94. Magnox Electric has experience of decommissioning power stations at Berkeley, Trawsfynydd and Hunterston A which, inter alia, substantiates its strategy timescale for defuelling. In the case of its other sites, decommissioning will commence on the proposed final shutdown dates shown in the BNFL plan (Appendix 3). With respect to the technical plans for reactor decommissioning, there has been a significant exchange of information between Magnox Electric, BNFL and British Energy, and through the Nuclear Research Index which is a list of current UK generic nuclear safety research compiled by the HSE. BNFL has also been involved with decommissioning other power reactors both in the UK and abroad. Therefore, the current strategies and liability estimates for decommissioning Magnox reactors are based on a substantial body of research and development experience.

95. The techniques employed by Magnox Electric for decommissioning power stations are monitored by the NII as part of its routine regulatory activity: thus the regulators have detailed knowledge of Magnox Electric's standards of work. Under the terms of the nuclear site licence, Magnox Electric is required to have, and to implement, arrangements that ensure that all operations are based on fully documented safety cases and that work of high safety significance is considered by its Nuclear Safety Committee (reference 7). For the more safety significant work the NII's agreement is needed before work commences on stages of work which might significantly affect safety. In parallel with this process, the appropriate environment agency will be supplied with relevant safety case documentation and the NII will take into account the

agency's views concerning impacts on its area of regulatory responsibility prior to issuing to the Company an agreement to proceed.

96. By these processes, the NII is aware of the standards of the safety cases, waste management practices and work undertaken by Magnox Electric in the decommissioning of its facilities and has generally found these to be satisfactory. In advance of its assessment of detailed decommissioning plans for the operating Magnox reactors, the NII has no cause for concern that the totality of the necessary decommissioning work has been significantly underestimated by Magnox Electric (with the possible exception of the 'risk list' issues noted above). However, the NII currently considers that an alternative balance of all relevant factors including safety, environmental, social and financial considerations could be made, leading to a period shorter than 100 years for deferral before dismantling. Whatever deferral period is finally selected, the NII will require the licensee to maintain, to acceptable modern standards, all necessary structures, operational facilities, monitoring and control during any period of deferred dismantling or radioactive waste storage.

Radioactive waste management

97. Magnox Electric has a well developed and comprehensive set of site specific strategies for the management of used fuel and ILW radioactive waste.

98. Regarding LLW, the Magnox Electric strategies for management of radioactive waste do not make presumptions on the availability of BNFL Drigg as a disposal route. The anticipated life of Drigg is until about 2050, so only those wastes which arise from the early decommissioning stages will depend on Drigg and the volumes / inventories associated with these wastes are not a significant concern. There may be some future concern regarding the availability of a facility to dispose of LLW once Drigg is closed, however this is a national issue rather than one specific to the decommissioning of Magnox Electric sites.

Contaminated land

99. A liability existing on some of the Magnox Electric sites for which the strategy is not fully developed is contaminated land. Radioactive material and radioactive waste on a nuclear licensed site must be adequately controlled or contained in accordance with the requirements of the site licence (reference 7). In the event that it is not adequately contained, contamination of the land may occur by:

- spillage either directly or indirectly onto the surface of the ground;
- leakage into the ground due to loss of containment from storage facilities or buildings, or failure of underground pipes; or
- burial either unauthorised or authorised in accordance with the appropriate Radioactive Substances Act.

100. Magnox Electric has carried out extensive programmes of work to establish the extent and radioactive inventory of contaminated land on its sites. The NII is generally satisfied with the work carried out by Magnox Electric to establish adequate knowledge of contaminated ground on its sites. Further work to provide increased confidence in that knowledge has been identified by Magnox Electric and the NII expects to see continued development in this area as part of programmed work. It was noted that work has been completed on all the sites to carry out general land surveys. It was also noted that consideration of non-radioactive land contamination, which will be regulated by others e.g. the environment agencies, was not as well developed as for radioactive contaminated land.

101. Whilst it is acknowledged that Magnox Electric has made progress in assessing these issues further work is required to provide confidence that knowledge of contaminated land on all its sites is sufficient to ensure that adequate records of contaminated land can be established; and therefore, whether financial provision for future management and clean up is adequate. In the meantime Magnox Electric has reflected in its provisions a liability based on a 'worst case' approach to remediation, and which includes a substantial contingency allowance (see 'Magnox Electric's methodology for estimating the cost of decommissioning work' below). The NII recognises that the Company has started a major programme of work to address these issues and will monitor Magnox Electric's progress at the next quinquennial review by the HSE.

Delicensing

102. It is a key strategy assumption of Magnox Electric (Appendix 1) that the end point for reactor site decommissioning is delicensing (which is understood to be when the site licence could be revoked by the HSE and Magnox Electric's period of responsibility under NIA65 could be terminated). Magnox Electric however places a caveat on that assumption i.e. *"provided that there is a reasonably practicable interpretation of the NIA65 'no danger' clause"*. In order to allow operators to plan for delicensing their sites and make the land available for other uses the HSE's policy on 'no danger' must be clarified. There will be liability implications if sites cannot be delicensed.

103. Whilst the NII considers that Magnox Electric's caveat on the implications of delicensing and the Company's work to identify options are reasonable and constructive initiatives, it is concerned that Magnox Electric's declared decommissioning end point might not be viable. The HSE is currently reviewing its policy on the use of the 'no danger' clause of the NIA65 and is working towards transparent and practical guidelines. However, until such a time as this work is completed, it will remain difficult to predict with certainty the degree to which sites could be 'delicensed'. Until a site is 'delicensed' the NII will require any man made radioactivity in the ground to be managed as accumulated nuclear material, in accordance with the nuclear site licence and, where necessary, that appropriate remedial action is taken.

104. Magnox Electric's strategy for clearing up non-reactor areas of site has been based on a presumption that some of those areas were not used for the

processing and treatment of radioactive materials. So, in accordance with its current civil engineering practices, Magnox Electric has only removed some building foundations etc. to about one metre below ground. The NII considers that this may make it more difficult for Magnox Electric to demonstrate 'no danger' under the current policy. However, the NII notes that some small research reactor sites in the UK have already been delicensed under NIA65 with parts of the original building structure left in place.

105. In the NII's view, these factors have the potential to lead Magnox Electric to underestimate the site management and decommissioning liability. It is therefore recommended that, before the next HSE quinquennial review, Magnox Electric undertakes further work to assess whether an inability to delicence would increase or decrease its provisions requirements.

Records management

106. The continued absence of a UK disposal route for ILW and LLW in the longer term i.e. beyond the currently anticipated life of Drigg, places an increased emphasis on the need for the nuclear industry to maintain adequate records of radioactive materials and the facilities within which they are stored. Whilst the present generation requires that these materials are managed safely, future generations are entitled to expect that they inherit adequate and sufficient information, not only to allow the eventual disposal of the material but also to support safe economic management until that time. This need, which may be considered to be an aspect of the inter-generational equity principle, has been recognised by Magnox Electric in its guiding principles (Appendix 1).

107. Magnox Electric has accepted that safe management for the long term of both unconditioned and conditioned stored radioactive wastes requires the maintenance of adequate records. In confirmation of this, Magnox Electric has increased its involvement in the British Radwaste Information Management System (BRIMS), the development of which was facilitated in the UK by the HSE in seeking to address record keeping for the long term management of radioactive waste.

108. The provision of records to aid decommissioning for the future is a significant issue. Many of the identified references made available for this review are based on work done some years ago by CEGB and NE, as the forbears of Magnox Electric. Magnox Electric corporate arrangements have recently been established which should ensure the availability of the many research reports and other references for the future. However, it is not clear that all appropriate records are being identified and retained, which coupled with the weaknesses (noted below) to fully feedback decommissioning experience for planning and liability use, indicates the need in Magnox Electric to take a more positive line on the long term arrangements for decommissioning records. Progress in this area will be monitored at the next quinquennial review of Magnox Electric by the HSE.

Magnox Electric organisational arrangements

109. With the incorporation of Magnox Electric under BNFL ownership the arrangements for decommissioning and liability management have been subject to a number of reorganisations. This changeable environment, unless carefully managed, increases the potential for corporate memory loss and general loss of expertise.

110. Whilst the Magnox Electric arrangements for collection of information on decommissioning seem to be acceptable, the arrangements for use of this feedback are not yet fully effective. Ineffective feedback could prevent improvements in safety and reductions in future costs which would otherwise have been achievable. This apparent failure to fully learn from decommissioning experience appears to stem from resource limitations. This may also prove expensive for Magnox Electric in the longer term as the opportunities of real decommissioning experience are not learnt or inadequately recorded.

111. The Magnox Electric risk list approach attempts to quantify the cost risk of failing to capture learning from work which has been completed but it is considered that, based on Magnox Electric's demonstrated performance in this respect to date, either it will need to demonstrate improvements or the risk estimate should be increased. Magnox Electric should review the adequacy of its resource commitment to feedback and learning on decommissioning, radioactive waste and liabilities management.

Comparison with international "best practice"

112. Magnox Electric policies, strategies, general arrangements and actual practice for decommissioning compare favourably with international standards, advice and best practice. This is perhaps not unexpected in view of the significant contribution which Magnox Electric decommissioning and radioactive waste management experts make to the work of the IAEA, NEA/OECD and other international bodies. However, in terms of the timing of final dismantling, it appears that Magnox Electric is not in line with international practice or intent with France, Spain, Italy and Japan planning to dismantle their Magnox type reactors on a significantly earlier timescale. Magnox Electric's explanation for this is that there are specific factors which apply in these countries that do not apply in the UK. A more rigorous justification, supporting why Magnox Electric believes that its strategy is more appropriate than that of other countries with Magnox type reactors, should be developed before the next quinquennial review of Magnox Electric by the HSE.

THE FINANCIAL REVIEW

Aims and objectives

113. The general aim of the financial review has been to consider whether Magnox Electric has made adequate arrangements for financial provisions to meet its long term nuclear liabilities in line with the requirements of the White Paper

Cm 2919 (reference 1). The NII has reviewed the licensee's process for calculating decommissioning and associated waste management liabilities and its arrangements for funding these liabilities. This is to satisfy the NII that the process is robust and that Magnox Electric's current forecasts and underlying assumptions reasonably show that adequate funding will be available when required. The review also had regard to the arrangements for financial guarantees from the Government (through the 'Magnox Undertaking' (reference 23)) to the extent that the strategy funding indicates that such arrangements or guarantees will be called upon.

114. In preparing the financial assessment, in addition to reviewing the submitted documentation (Appendix 1), the NII assessors had discussions with representatives of Magnox Electric and BNFL's Finance and Liabilities Management departments.

115. As a fundamental part of its regulatory activity, the NII continually assesses the appropriateness and quality of the work Magnox Electric undertakes and, where costs are argued, judges these to decide whether risks are as low as reasonably practicable and whether higher safety standards could be achieved. The NII has based its consideration of Magnox Electric's estimation of its decommissioning costs on this experience. The NII has not audited the licensee's specific costings of individual decommissioning projects.

Topic areas reviewed

116. The NII's assessment of the financial aspects of the licensee's decommissioning strategy addressed whether:

- the licensee has an adequate process for establishing the costs of decommissioning activities;
- the costs are compatible with the totality of the work that needs to be done;
- underlying technical and corporate assumptions are prudent;
- any discount rate used is appropriate;
- funding to meet the output of the above process has been allocated and is being appropriately managed;
- the funding will be available when required to meet the decommissioning strategy timetable;
- there is some flexibility to cope with decommissioning on shorter timescales should this become necessary; and
- the arrangements are subject to adequate auditing.

Accounting standards

117. The NII has also had regard to the observance of current accounting standards. The main statutory requirements on accounting for provisions and contingencies are set out in Schedules 4 and 4A of the Companies Act 1985 (reference 23). Paragraph 12(b) of Schedule 4 states the general

requirement that *"all liabilities and losses which have arisen or are likely to arise in respect of the financial year to which the accounts relate or a previous financial year shall be taken into account..."* Provisions are one means by which this general requirement is met, and they are defined in paragraph 89 of Schedule 4 as follows:

> *"References to provisions for liabilities or charges are to any amount retained as reasonably necessary for the purposes of providing for any liability or loss which is either likely to be incurred, or certain to be incurred but uncertain as to amount or as to the date on which it will arise."*

118. In terms of current accounting standards, Financial Reporting Standard 12 (FRS12), requires companies to make provision to cover liabilities which are of uncertain timing or amount, a description which encompasses nuclear decommissioning and waste management liabilities. The need to recognise a provision will arise if:

- there is a present obligation; and
- it is probable that a transfer of economic benefits will be required; and
- a reliable estimate of the amount can be made.

If a reliable estimate cannot be made then the circumstances should be disclosed as a contingent liability.

Findings

Magnox Electric's methodology for estimating the cost of decommissioning work

119. Magnox Electric's costings for its current strategy for decommissioning the Magnox nuclear power stations are based on information from three sources:

a. engineering cost estimates generated by external contractors, in particular a series of studies undertaken in the early 1990s. These comprised thorough engineering assessment and quantity surveying exercises which set out the activities required to decommission each site, identify and quantify the materials to be removed, and attach costs;
b. estimates generated by the licensee internally; and
c. experience drawn from the decommissioning activities already undertaken.

120. The costings for the Berkeley Centre were derived through a similar process.The 'external' engineering studies were originally undertaken to derive 'base costs' by a detailed analysis of each individual activity that must be undertaken during a decommissioning programme. Consequently Magnox Electric has been able to use them as building blocks and to adapt them to inform other strategies, involving different sequences and timescales, than

that for which they were originally intended. The base costings include allowances for other cost streams including the overhead costs of running Magnox Electric's internal reactor decommissioning management unit and regulatory charges.

121. Whilst the techniques and costs of the decommissioning process are well understood by the licensee there is less certainty about the strategy and the methods to be employed in dealing with contaminated ground. Consequently there is also uncertainty about potential costs. The strategy that has been assumed for liabilities cost estimation and financial provisioning is considered by Magnox Electric to be the most pessimistic one as it assumes that all the contaminated ground on each site is dug up in the early phases of decommissioning and sent to BNFL Drigg for disposal. The resulting base cost has been enhanced by a contingency allowance of over 170% to recognise the uncertainties inherent in the current position. Magnox Electric believes that as it has assumed the most pessimistic strategy, the earliest timing, and a very high contingency level for the work there is no need to allow for alternative scenarios or risks that could result in increased costs.

ILW Disposal

122. The costs associated with the handling, treatment, packaging, on-site storage and off-site transport of these wastes are included in the estimates described above but the disposal costs are in a separate liability. The disposal liability estimate includes a probabilistic model of when a suitable disposal facility or repository might be available. The earliest date assumed in this disposal model is 2040 which coincides with the date when transport off-site, e.g. to a central waste store or disposal site, is assumed to occur in the reactor sites and Berkeley Centre liabilities estimates. The disposal model also includes probabilities that a repository might not be available until dates later than 2040, up to 2140 at the latest. Should a repository not become available until later than 2040 there would need to be continued packaged waste storage after 2040. Such costs are not included within the reactor sites and Berkeley Centre liabilities estimates and so, to ensure completeness, any storage costs beyond 2040 are included within the disposal liability estimate. Disposal costs are calculated taking into account the latest costing advice from Nirex.

Costing Issues

123. The fact that the base costs used by Magnox Electric are now approaching 10 years old gives rise for concern on two counts:

a. although no radically new relevant technologies have been introduced since the engineering studies were undertaken, it seems likely that working methods and plant and equipment will have improved incrementally over the period. Consequently the studies may no longer fully reflect contemporary productivity levels; and
b. to bring the original costings to current prices an escalation factor is applied to the figures each year. Whilst this is an entirely reasonable approach to updating prices over the short term it may be prone to an increasing margin of error as time elapses.

124. Arguably, therefore, there is a need for the base data to be updated systematically to ensure that both the licensee and other stakeholders can have confidence in its currency. As previously noted, the Company should further develop and formalise its review process to update strategy and provisioning in response to changes and experience. Subsequent quinquennial reviews will consider the effectiveness of the Magnox Electric review process in these respects.

125. One issue yet to be resolved is whether the safestore surveillance period (during Stage 2) will be unmanned, as Magnox Electric proposes, or whether there should be a permanent security presence on each site. In response to the NII's enquiries Magnox Electric has provided information which showed that the size of the allocated risk margin is heavily influenced by recognition of the risk that manned surveillance may be necessary. If it becomes apparent that manned surveillance is necessary, whether for reasons of regulatory requirement or public perception, this will no doubt be factored into the routine reviews of the Magnox Undertaking (reference 24).

Corporate Assumptions - Station Lifetimes

126. Under a condition attached to the standard nuclear site licence (reference 7) the operators of nuclear power plant are required to carry out Periodic Safety Reviews (PSRs). PSRs are complementary to day-to-day regulatory controls and their objectives are:

- to review the current total safety case for the station and confirm its adequacy;
- to compare the safety case against modern standards, evaluate any deficiencies and implement reasonably practicable improvements to enhance safety;
- to identify any ageing process which may limit the life of the plant; and
- to revalidate the safety case until the next PSR, subject to the outcome of routine inspection, maintenance and monitoring by the licensee and regulation by the NII.

127. The PSRs are assessed by the NII and, depending upon the results of that assessment, the regulator may require the licensee to undertake a specified programme of safety related improvements. The NII is unable to predict the operational lifetime of a station on the basis of a PSR. However the NII will indicate whether it expects the station to be able to operate safely until its next PSR, subject to continuing satisfactory results from regulatory oversight in the meantime.

128. Four Magnox power stations have already entered decommissioning and BNFL recently announced the closure programme for the remaining operational stations (Appendix 3). The planned closure dates for three of the stations - Bradwell, Dungeness A and Sizewell A - coincide with the due dates for their next PSRs. For the remaining two stations - Oldbury and Wylfa - Magnox Electric has opted to provision on the basis of conservative estimates of operational lives. The table in Appendix 5 shows the station lifetimes

assumed for provisioning purposes with the due dates for completion of the next round of PSRs where appropriate.

Contingency Allowance and Risk Margin

129. The base costings have been enhanced by two factors, contingency allowance and risk margin, to allow for uncertainties which may affect the decommissioning programme. Contingency is applied to base cost estimates at the activity level, to reflect the uncertainty of the cost estimates in the proposed strategy (i.e. in-model uncertainties). This allowance is intended to accommodate estimating inaccuracies, including minor omissions and undercounts, and minor unforeseen problems. Magnox Electric uses a 'probabilistic contingency' process which reflects the degree of uncertainty involved. Where a specific work activity has been done previously directly relevant experience and data will be available and hence there can be confidence in the base cost estimate. Where proposed activities have not previously been done in precisely the manner proposed, or not at all, there will be greater degrees of uncertainty. Contingency values can normally range up to 100% of the base cost, but for contaminated ground increase to 170%.

130. Risk margin is an allowance added to base-cost-plus-contingency values at the stage cost level to account for out-of model uncertainties. These risks can be associated with external impacts (e.g. delays in getting the necessary consents or off-site transport problems) or internal impacts (e.g. industrial disputes or finding unexpected radioactivity) during decommissioning operations. For each risk item a minimum, mode and maximum value of its financial impact is identified along with a probability of occurrence and these figures are used to derive the probabilistic value of each risk.

Discount rate used by Magnox Electric

131. Discounting is the process of comparing quantities which are distributed over time by converting them to a present value. In this context the effect of using a discount rate is to reduce the value of a projected future cost or benefit to its value as seen from the present day. As the licensee's projected cashflows include a risk margin it is appropriate for them to use a risk-free real rate of interest applying to debt with long-term maturity, e.g. a government bond rate. On this basis the licensee's chosen discount rate of 2.5% appears soundly based.

Timing of Decommissioning

132. Magnox Electric's strategy embodies the concept of deferring dismantling of the reactor until around100 years after the end of generation. The decommissioning cashflows have been calculated on the basis of a model in which all UK Magnox reactors (including those at the BNFL power stations at Calder Hall and Chapelcross) are decommissioned in a phased programme lasting more than 50 years which leads to deferrals ranging from 85 to 105 years (with an average deferral period of 97 years) (see Appendix 5). Magnox Electric argues that this sequenced programme of reactor

dismantling reflects a realistic view of resource availability and will also allow the lessons learned through experience to be applied to later projects.

133. On current provisioning arrangements the flexibility to shorten the period of safestore is limited. A 'timing risk margin' has been built into the costings to make some allowance for this possibility. This would allow dismantling of the first station to be brought forward to 72 years, with the other stations following on in accordance with the planned phased sequence (i.e. reducing the average deferral period to 84 years). Alternatively the timing risk margin would allow the dismantling of a single station to be brought forward to 30 years after the end of generation; this could accommodate, for example, the early dismantling of a power station if unforeseen difficulties arise.

134. The effect of this explicit allowance for timing risk shows that, taken together, contingency, phase risk margin and timing risk margin constitute 40% of the discounted costs of defuelling and decommissioning Magnox Electric's reactor sites.

Decommissioning Liabilities on BNFL Sites

135. There are cost reimbursable contracts with BNFL for the costs attributable to Magnox Electric for the decommissioning of facilities at the BNFL sites at Springfields, Sellafield, Calder Hall and Chapelcross. For BNFL Sellafield the same contracts also cover historic waste management, i.e. ongoing waste treatment and storage associated with fuel throughput prior to 1989. The liabilities for decommissioning facilities at BNFL sites are reflected in Magnox Electric's accounts (reference 4).

Spent fuel management and radioactive waste management

136. The White Paper (reference 1 paragraph 52) makes it clear that the producers and owners of radioactive waste are responsible for:

- bearing the costs of managing and disposing of their wastes; and
- making provisions accordingly.

Magnox Electric has included these liabilities within the scope of its submission to the HSE's quinquennial review.

137. Magnox Electric's liabilities in this area include:

- fixed price contracts between Magnox Electric and BNFL for the storage and reprocessing of the spent Magnox fuel, the treatment and storage of the resulting waste arisings, the storage of recovered plutonium and uranium, and flask maintenance;
- liability for the disposal costs for its allocation of the wastes at BNFL Sellafield, including ILW and HLW; and
- some minor liabilities associated with historic uranic residues at BNFL Springfields, and the disposal of fuel transport flasks and flatrols.

The Magnox Electric Annual Report and Accounts (reference 4) for 1999/2000 reflect the value of these accrued discounted liabilities.

Provisioning - Magnox Undertaking

138. The Government's principal aim in integrating Magnox Electric into BNFL was to improve the arrangements for managing public sector nuclear liabilities and drive down costs for the benefit of the taxpayer. The merger was also intended to end the mismatch by which responsibility for dealing with the majority of the Magnox liabilities rested with BNFL, whilst the costs fell to Magnox Electric.

139. As part of the new arrangements the pre-existing Magnox "undertaking" and "letter of comfort" provided by the Secretary of State were replaced by a new Magnox Undertaking (reference 24). The value of the new Magnox Undertaking was £3.7b at 31 March 1998, to be escalated at an annual rate of 4.5% real. The payments are to be made in accordance with a schedule contained within the Undertaking; the first payment is due to be made in 2008 and the last in 2116.

140. The payment schedule reflects assumptions, made at the time of integration, about the operational lifetimes of the Magnox stations, the timing and sequence of decommissioning activities, the availability of disposal routes etc. Details of those assumptions were not made available to the HSE at the time, but the DTI confirmed that through assets already available to BNFL, assets transferred with Magnox Electric, and the Magnox Undertaking, the integrated group would be able to meet its decommissioning costs and continuing liabilities.

141. The DTI indicated at the time of integration that it would maintain its sponsorship role for the enlarged group, and that this function included financial monitoring, considering Corporate plans etc. In addition the Magnox Undertaking includes a provision for reviews to be conducted every five years, with the first scheduled for 1 April 2003. In addition to the regular, general reviews, the parties to the agreement - Magnox Electric, BNFL and the Secretary of State for Trade and Industry - have the right to seek special reviews in certain circumstances. The outcomes of each review will be considered by the Secretary of State and, if appropriate, the payment schedule may be adjusted to reflect the revised amount and timing of the liabilities.

142. The outcomes from the reviews of Magnox Electric's liabilities and provisions, executed in accordance with the Magnox Undertaking, will be monitored at future quinquennial reviews of Magnox Electric by the HSE. The arrangements described above provide adequate confidence in the ability of funds.

Availability of funding to meet decommissioning cashflows

143. The review process outlined above provides a degree of comfort that funds can be made available, via adjustment of the payment schedule, if there is a

material change in the value of the liabilities or if the assumptions which were made in devising the original payment schedule prove incorrect. Such a situation might be brought about, for example, by enforced reduction of station operating lifetimes or if regulatory or other pressures resulted in a foreshortening of the planned period of care and maintenance. However these arrangements all depend on the necessary funding being made available at the time through the Government's 'Comprehensive Spending Review' process.

144. Magnox Electric's Annual Report and Accounts for the period to 31 March 2000 (reference 4) confirm at Note 18 that the Company has estimated the costs of meeting its obligations to decommission nuclear reactors and has provided for these and for its share of the costs of decommissioning BNFL's sites and facilities. These provisions cover complete demolition together with disposal of associated waste. In addition, the BNFL Group Report and Accounts (reference 25) for the same period state at Note 28, Contingent Liabilities, that: *"Letters of support have been provided to certain subsidiaries, in particular Magnox Electric plc, in order for them to continue operating safely and to meet their liabilities as they fall due for the foreseeable future."*

145. Further comfort that funds will be available when required is given by the fact that the Government has power under Schedule 12 of the Electricity Act (reference 26) to make grants if the cash resources available to the integrated group prove inadequate to meet its liabilities.

146. In the course of the NII's assessment of Magnox Electric's decommissioning strategy the licensee was asked what work was in hand to verify that the projected cash flows derived from its modelling of decommissioning expenditure could be accommodated within the existing payment schedule for the Magnox Undertaking. The licensee indicated that since payments under the Undertaking do not start until 2008, and with a review of the Undertaking due to take place in 2003, there is no immediate need for detailed management of the Undertaking. Consequently the main management effort by BNFL relates to the annual report and accounts requirements. However, BNFL's Liabilities Management Unit monitors changes to the liabilities estimates that may have a bearing on the terms of the Magnox Undertaking and is establishing a detailed process that will provide the necessary input to the 2003 review.

BNFL's investment growth assumptions

147. Magnox Electric's decommissioning funds are managed together with those of the BNFL Group. Note 11 to the BNFL Group accounts (reference 25) for 1999/2000 sets out the Company's investment policy for the nuclear liabilities investment portfolio and shows, amongst other things, that:

- the Group has invested £2,449 million of the portfolio in index-linked gilts, which returned an average of 2.59% pa after tax in 1999/2000; and
- a further £1,438 million is invested through fund managers.

The auditing of Magnox Electric decommissioning funds

148. The Magnox Electric Annual Report and Accounts (reference 4) for the period to 31 March 2000 were audited by Ernst and Young. The auditors' endorsement of the accounts confirms that the audit included:

- examination, on a test basis, of evidence related to the amounts and disclosures in the accounts;
- assessment of the significant estimates and judgments made by the Directors in the preparation of the accounts; and
- assessment of whether the accounting policies were appropriate to the Company's circumstances, consistently applied and adequately controlled.

The auditors noted the fundamental uncertainties associated with the estimation of nuclear liabilities, but indicated that their opinion was not qualified in that respect.

CONCLUSIONS

149. The NII regards the strategies proposed by Magnox Electric for decommissioning its power stations and for radioactive waste management to be appropriate. They are largely consistent with both national and international policy statements and guidance and are potentially flexible enough to be able to accommodate lessons learned during ongoing decommissioning activities.

150. The current report is the second of a five-yearly cycle in what is in effect an evolutionary process. Future reviews will give the opportunity to consider the effectiveness of Magnox Electric's review processes; to report the extent to which Magnox Electric has made progress in refining its strategies and plans; to examine the continued validity of Magnox Electric's assumptions; and to review the reduction in uncertainties as more decommissioning work is completed. In particular, the NII will expect to see work on programmes completed or in hand to address the omissions and enhanced requirements that have been identified in the current report.

Technical aspects

151. The NII expects Magnox Electric to have a revised corporate policy, which more explicitly reflects Government policy (currently outlined in Cm 2919, reference 1), and from which the corporate strategy can be demonstrated to have been consistently and auditably developed. The NII recognises that strategy reviews are carried out at present but consider that Magnox Electric should formalise its review process to develop and update its strategies and provisioning in response to changes and experience.

152. The NII considers that the following aspects of Cm 2919 have not been fully addressed in the development of Magnox Electric's strategy:

- the principles of sustainable development;
- intergenerational equity; and
- justification of the timetable proposed.

Ongoing research by Magnox Electric on these issues may enable them to be addressed in more detail before the HSE's next quinquennial review.

153. Whilst there is not as yet a national consensus on the period over which it is acceptable to retain redundant nuclear reactors, the NII nonetheless welcomes aspects of Magnox Electric's decommissioning strategy insofar as:

- Magnox Electric has carried out an extensive programme of work to develop the decommissioning and radioactive waste strategies since HSE's 1996 quinquennial review;

- this programme has resulted in a strategy where a great deal of the work to decommission a nuclear power station is to be carried out soon after station shutdown; and

- the period between shutdown and dismantling has reduced, from the "up to about 135 years" proposed in 1996, to "around 100 years".

Magnox Electric needs to continue to balance the financial, environmental, technical, social and sustainable development issues within the overall requirement to decommission as soon as it is reasonably practicable to do so, taking account of all relevant factors, and to achieve a systematic and progressive reduction of hazard whilst ensuring that each facility is maintained at all times in a safe condition.

154. It is the view of the NII that until site specific safety cases have been examined it is prudent for Magnox Electric to continue to retain the option to dismantle its reactors sooner than its current proposal. At this time, on the basis of the information presented, Magnox Electric's provisioning for final dismantling after 85 years, with a risk provision to reflect the potential for shorter deferral periods, is considered to be reasonable. The NII expects Magnox Electric to further justify why a shorter timescale for deferral is not reasonably practicable, and how far its prudent assumption that statutory requirements will be tightened in the future, for example on annual worker dose, has an effect on the timing of final dismantling, before the next HSE review.

155. A major input to Magnox Electric's selection of their decommissioning strategy was a multi attribute decision analysis. This was limited in certain respects, as noted in the report; however, it is considered that Magnox Electric can reasonably claim that it has adopted a logical approach and in part provided an auditable trail leading to the decisions reached in the decommissioning and waste management strategies document.

156. From the information provided for the present review, the NII considers that most technical aspects of Magnox Electric's decommissioning proposals are largely practicable and feasible. However, Magnox Electric's strategy

submission is perceived to contain some areas for future improvement regarding consideration of global warming, the ease with which future regulatory regimes might grant Authorisations, the extent to which the contaminated land strategies have been developed, and the extent to which Magnox Electric is learning from the experience of current decommissioning activities.

157. It is a key assumption of the strategy that the end point for reactor site decommissioning is de-licensing. Magnox Electric however places a caveat on that assumption i.e. *"provided that there is a reasonably practicable interpretation of the NIA65 "no danger" clause"*. There may be significant cost and liability implications if sites cannot be delicensed. The HSE is currently reviewing its policy on the use of the 'no danger' clause of the NIA65 and is working towards transparent and practical guidelines.

Financial aspects

158. Magnox Electric has a soundly based process for establishing the cost of its decommissioning liabilities. It has systematically allowed for both in-model and out-of-model uncertainties via the use of contingency allowance and risk margin. However some of the base costings are now somewhat dated.

159. The licensee's assumptions on station lifetimes appear suitably prudent, as does the chosen discount rate.

160. The decommissioning programme assumes that the final dismantling of the first station will commence 85 years after the end of generation. However the average period of deferral is 97 years. The use of a 'timing risk margin' provides some limited flexibility to shorten the period of safestore. The present value of that margin would allow the start of the programme to be brought forward to approximately 72 years (and thus reduce the average period of deferral to 84 years).

161. The licensee's liabilities will largely be funded from the Magnox Undertaking, which is underwritten by the Government. These provisioning arrangements afford some further flexibility to cope with shorter timescales via variation of the payment schedule, which may be an outcome of the agreed review process. The first review is due in 2003. These arrangements are considered to be adequately robust but may be capable of further enhancement e.g. by a segregated fund.

162. Should Magnox Electric be required to bring forward commencement of the station dismantling programme to significantly less than 70 years from end of generation additional financing will be required unless predicted costs can be reduced proportionately.

163. Magnox Electric's accounts, and those of its parent company, BNFL, have been subjected to the normal audit scrutiny. The auditors have endorsed the account noting the fundamental uncertainties with estimating nuclear liabilities but not qualifying their opinion in this respect.

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GLOSSARY OF TERMS AND ABBREVIATIONS

BNFL	British Nuclear Fuels plc.
BNFL sites	Calder Hall, Capenhurst, Chapelcross, Drigg, Sellafield and Springfields.
BPEO	Best Practicable Environmental Option
BRIMS	British Radwaste Information Management System: a database of UK radioactive waste storage funded by the industry, the HSE and government.
CSR	Comprehensive Spending Review undertaken by government departments.
DETR	Department of Environment, Transport and the Regions.
Discount rate	Annual percentage rate at which financial provisions to cover liabilities are assumed to grow, i.e. the investment rate after, after tax and inflation..
DTI	Department of Trade and Industry.
EA	The Environment Agency
Facilities	Plant, process equipment, stored radioactive material and contaminated items.
HLW	High Level Waste: radioactive waste whose temperature may rise significantly as a result of its radioactive decay.
HSE	Health and Safety Executive.
HSW74	Health and Safety at Work etc Act 1974.
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste: waste with radioactivity greater than LLW but the heat it generates is insufficient to affect the design of storage facilities.
IPC	Integrated Pollution Control
Licensee	Holder of a nuclear site licence
LLW	Low Level Waste: radioactive waste inappropriate for disposal with ordinary refuse but with specific activity not greater than 4 GBq/te alpha or 12 GBq/te beta/gamma.
MADA	Multi attribute decision analysis
Magnox	Nuclear reactor fuel clad in magnesium aluminium alloy.
Magnox Electric	Magnox Electric plc
NE	Nuclear Electric plc
NEA/OECD	Nuclear Energy Agency / Organisation of Economic Cooperation and Development
NIA65	The Nuclear Installations Act 1965 (as amended).
NII	HM Nuclear Installations Inspectorate, part of HSE.
Nirex	United Kingdom Nirex Ltd: responsible for providing ILW disposal facilities.
NPV	Net present value
OSPAR	Oslo and Paris (OSPAR) Commission, Contracting Parties to the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic.
PCPV	Prestressed concrete pressure vessel
PSR	Periodic safety review, as required under a condition of the nuclear site licence
RSA93	The Radioactive Substances Act 1993.

"safestore"	Preservation of reactor buildings, their contents and any other structures on the site to facilitate an extended delay period before dismantling.
SEPA	The Scottish Environment Protection Agency
Sintra	Sintra, Portugal: the location of the 1998 OSPAR Conference.
Site	Nuclear licensed site
SPV	Steel pressure vessel
UKAEA	United Kingdom Atomic Energy Authority.
UKCEED	UK Centre for Economic and Environmental Development

APPENDIX 1

Magnox Electric plc

Magnox Electric plc Quinquennial Review of Decommissioning and Waste Management Strategies

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Executive summary

Government Radioactive Waste Management Policy (Cm 2919, July 1995) requires The Health and Safety Executive, Nuclear Installations Inspectorate (NII) to review nuclear operators' decommissioning strategies every five years.

Although Magnox Electric plc (hereinafter referred to as Magnox Electric) is now part of the BNFL Group, it is still a separate Nuclear Site Licensee under the Nuclear Installations Act 1965 (as amended) (NIA65). As a Nuclear Site Licensee, the Company is required to produce detailed strategies, plans and programmes in preparation for decommissioning.

The first five yearly, or Quinquennial, Review submission by Magnox Electric was made in January 1996. This is the second such submission and sets out Magnox Electric decommissioning and waste management strategy for review by NII. The key points of this strategy are:

- Reactors will be defuelled as soon as practicable after shutdown
- Predominantly caesium contaminated plant will be dismantled when it is no longer needed
- All buildings except the reactor buildings will be dismantled as soon as practicable after they are no longer needed
- Boilers will remain in position until the reactors are dismantled, but appropriate decontamination technology will be regularly reviewed
- Operational ILW, except some MAC, will be retrieved and packaged during the Care and Maintenance preparation period. All wastes will be stored on site, and handled in the long term in accordance with Government policy
- Reactor buildings and some of their contents will be placed in a passive safe storage Care and Maintenance condition as soon as possible, as appropriate for the site
- Contaminated land will be managed to maintain public safety and minimise the need for security
- The reactors will be finally dismantled in a sequenced programme with a start date and duration to be decided at the appropriate time in the light of circumstances prevalent at that time
- Currently, Magnox Electric is considering a sequenced programme across all sites, notionally beginning around 100 years from station shutdown, leading to a range of deferral periods
- For provisioning purposes, Magnox Electric has costed a strategy involving reactor dismantling deferrals ranging from 85 to about 105 years in order to demonstrate prudent provisioning to meet its liabilities. A risk provision to reflect the potential for shorter deferral periods is included in the cost estimates
- The end point for reactor decommissioning strategy is site clearance and de-licensing, based on the assumption that a reasonably practicable interpretation of the "no danger" clause in the Nuclear Installations Act 1965 (as amended) can be developed
- Magnox Electric is committed to ensuring that funds are available to meet long-term nuclear liabilities as they fall due.

The decommissioning strategy contains two fundamental changes from that presented in the previous Quinquennial Review:

- Only the dismantling of the reactor buildings is to be deferred for a period, notionally around 100 years from station shutdown.
- A sequenced programme for reactor dismantling will be followed to allow realistic resource commitment and learning from experience.

This strategy will be subject to ongoing review and development over the coming years, and may be modified in the light of circumstances prevalent at the time. The strategy will be reviewed using the processes described in this document, in line with Government policy, taking account of all relevant factors. The strategy will also be reviewed should there be changes to Government policy. Magnox Electric remains committed to:

- Maintaining an ongoing research programme to investigate alternative options and to make strategic decisions based on best available data
- Continuing existing strategy implementation and learning from experience
- Seeking consensus on waste and decommissioning strategies with all stakeholders.

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1 Introduction

The Government White Paper 'Review of Radioactive Waste Management Policy' (Cm 2919, July 1995) states that "To ensure that operators' decommissioning strategies remain soundly based as circumstances change, they will be reviewed quinquennially by HSE [The Health and Safety Executive]" [126][1]. The first Quinquennial Review submission by Magnox Electric plc (hereinafter referred to as Magnox Electric) was made in January 1996 and this is the second submission. The first submission addressed the decommissioning strategy associated with the reactor sites. This submission, at the request of the nuclear industry regulator, HSE Nuclear Installations Inspectorate (NII), has been expanded to address both waste management and decommissioning, and Magnox Electric's nuclear liabilities on non-reactor sites.

Cm 2919 requires that "all nuclear operators … draw up strategies for decommissioning their redundant plant … [which] … include justification of the timetables proposed and demonstration of the adequacy of the financial provision being made to implement the strategies" [124]. It also states that "producers and owners of radioactive waste are responsible for developing their own waste management strategies …[and that] …They should cost radioactive waste management and disposal liabilities before these are incurred and make appropriate financial provisions for meeting them" [52]. The aim of this submission is to demonstrate that sound and safe decommissioning and waste management strategies exist, that they are regularly reviewed and that appropriate financial provision is being made. The submission also demonstrates compliance with the other requirements stated within Cm 2919.

2 Scope of the Quinquennial Review

Although Magnox Electric became part of the BNFL Group in 1998, it is presently (April 2000) still a separate Licensee under the Nuclear Installations Act 1965 (as amended) (NIA65). Magnox Electric holds the Nuclear Site Licence for the nine nuclear power station sites it operates, and Berkeley Centre. This submission is specific to Magnox Electric and focuses on those nuclear licensed sites. However, Magnox Electric is also financially responsible for some waste and decommissioning liabilities on other licensed sites (e.g. at Sellafield where the licence is held separately by BNFL). These financial liabilities are also referred to in this submission. The arrangements for managing the liabilities at Sellafield are described in the 1998 BNFL Quinquennial Review of Decommissioning.

2.1 Magnox Electric Nuclear Sites

Magnox Electric is the operator and licensee for the following nuclear sites:

Berkeley Power Station, Gloucestershire
Bradwell Power Station, Essex
Dungeness A Power Station, Kent
Hinkley Point A Power Station, Somerset

[1] Numbers in [ ] refer to the specific paragraph of Cm 2919

Hunterston A Power Station, Ayrshire
Oldbury Power Station, Gloucestershire
Sizewell A Power Station, Suffolk
Trawsfynydd Power Station, Gwynedd
Wylfa Power Station, Anglesey
Berkeley Centre, Gloucestershire

Of the nine nuclear power stations named above, three of them (Berkeley, Hunterston A and Trawsfynydd) are shutdown and in the process of being decommissioned. The other six stations are still operational. It has been announced that Bradwell Power Station will cease generation in March 2002 but it is planned to keep the other five stations operational as long as it remains safe and economic to do so.

The Magnox nuclear power stations at Calder Hall, Cumbria and Chapelcross, Dumfries and Galloway are licensed to BNFL. The strategy for decommissioning these sites is contained in the 1998 BNFL Quinquennial Review of Decommissioning.

2.2 Magnox Electric Liabilities

This submission recognises the following as Magnox Electric's major nuclear liabilities:

1) Dismantling plant and buildings on Magnox Electric nuclear power station sites and managing the associated radioactive waste.

2) Management of radioactive waste accumulated on the Magnox Electric nuclear power station sites during reactor operation.

3) Management of contaminated ground on Magnox Electric nuclear power station sites.

4) Dismantling plant and buildings and managing accumulated waste and contaminated ground at Berkeley Centre.

5) The costs of fixed price contracts between Magnox Electric and BNFL for the storage and reprocessing of the spent Magnox fuel, the treatment and storage of the resulting waste arisings, the storage of recovered plutonium and uranium, and flask maintenance.

6) The costs attributable to Magnox Electric for decommissioning associated with the Sellafield and Springfield sites and for the Calder Hall and Chapelcross reactor sites. For Sellafield the same contract also covers historic waste management, i.e. ongoing waste treatment and storage associated with fuel throughput prior to 1989.

7) The disposal costs for Magnox Electric's allocation of the wastes, including ILW and HLW, at Sellafield.

Magnox Electric, as licensee, is responsible for the technical strategy for the liquidation of only the first four of these liability areas.

All of the power station sites contain two nuclear reactors of the gas cooled, graphite moderated, Magnox type. These are located within either one or two reactor buildings which also contain other plant such as boilers for reactor heat removal and steam production, and equipment for loading new fuel into the reactors and for removing used fuel from them. Other buildings and plant on these sites, associated with the nuclear operations, include fuel cooling ponds (Wylfa has a dry store instead of a pond), radioactive effluent treatment plant, laundry and workshops. In addition, there are extensive conventional plant and buildings on the sites including the turbine and generator plant, cooling water systems, offices, etc.

The dismantling and removal of these plant and buildings comprises the decommissioning activities that will be undertaken following the shutdown of the sites.

A considerable effort has gone into characterising the expected radioactive inventory of the reactors and other structures. This inventory is based on sampling, *in-situ* measurements and calculation. The inventory of radioactive wastes arising from decommissioning (for the strategy described in the previous submission) is given in 1998 UK National Radioactive Waste Inventory. These data will be updated in the next full National Inventory exercise.

As a result of the operation of the power stations, a number of different types of radioactive waste have been produced. Most of these wastes contain low levels of radioactivity and, following treatment, have been sent as solid low level waste (LLW) to the national disposal facility at Drigg or have been discharged, after treatment, as liquid or gaseous effluents. These disposals and discharges are undertaken in accordance with authorisations issued by the Environment Agencies under the Radioactive Substances Act 1993 (RSA93). Those operational radioactive wastes that cannot be sent for disposal at Drigg, or discharged under Authorisation, are retained in storage facilities on the sites. Most of these wastes are operational intermediate level wastes (ILW) and include slurry form wastes (sludges and ion exchange materials) resulting from effluent treatment, solid wastes such as Magnox metal stripped from used fuel elements (known as fuel element debris or FED), other miscellaneous contaminated or activated materials and reactor gas dryer desiccant. The further treatment, storage and eventual disposal of this operational ILW is recognised as a liability area, and is described in this submission. Full details of these waste streams are provided in the 1998 UK National Radioactive Waste Inventory. The data provided are based on a programme of sampling and radiochemical analysis and calculation over many years.

Another liability area is also recognised. During the operation of the stations there have been a number of leakages or spillages, e.g. of oils or radioactive liquids. Many of these were cleaned up at the time of occurrence but there are some areas where residual ground contamination remains. The management of any radioactively contaminated ground is the third liability area that is described in this submission.

In addition to the reactor sites, Magnox Electric is also responsible for Berkeley Centre, which is adjacent to Berkeley Power Station. This site consists mainly of office buildings but also includes active facilities, for example for the examination of radioactive materials, including used nuclear fuel and components removed from reactors. The eventual decommissioning of these facilities, and the management of

associated radioactive wastes and any contaminated ground, are recognised as a liability and this is also described in this submission.

It should be noted that there is no high level radioactive waste (HLW) held on the sites, and, once power stations are shutdown, used fuel is not retained long-term on the sites. The used fuel is sent to Sellafield and responsibility for its management is transferred to BNFL under contractual arrangements between Magnox Electric and BNFL. Under these arrangements Magnox Electric is financially responsible for meeting costs incurred by BNFL for the management of wastes resulting from the handling of fuel and for the decommissioning of the facilities used. These financial liabilities are described later in this submission.

3 Decommissioning and Waste Management Objectives and Principles

3.1 Company Objectives

Following integration with BNFL, Magnox Electric objectives for radioactive waste management and decommissioning have been aligned with those of BNFL. The key objectives associated with the development and implementation of decommissioning and waste management strategies, including those relevant to contaminated ground, are:

i) to ensure the continued safety of the public, the workforce and the environment

ii) to minimise the expenditure of national resources on decommissioning and waste management with due regard for the environment, visual impact and eventual use of the land

iii) to ensure that adequate resources are allocated to decommissioning and waste management, including the provision and maintenance of financial arrangements in order to fund these future liabilities

iv) to demonstrate that decommissioning and waste management will be safely and economically carried out, both for existing nuclear plant and for a continuing nuclear power programme

3.2 Guiding Principles

In addition, the following principles are used by Magnox Electric to provide guidance in developing strategies and plans for reactor decommissioning and waste management. These principles are broadly compatible with BNFL's decommissioning policy and will be further aligned as integration proceeds:

a) the safety of the public and the workforce, together with the protection of the environment, are of paramount importance and will be considered ahead of all other factors

b) all activities will conform to the Company's health, safety and environmental protection policies and requirements which, as a minimum, will be in accordance with legislative and regulatory requirements in force at the time

c) strategies will maintain a flexible approach and avoid, where possible, the premature foreclosing of options to maximise the capability to accommodate changes related to, for example, technical and regulatory developments and waste repository availability

d) radioactive wastes will not be unnecessarily created and, where they are created, the quantities will be minimised as far as is reasonably practicable

e) decommissioning and waste management will be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors, such that there is a systematic and progressive reduction in hazard. Relevant factors will include: the potential hazards posed to the public, workers and the environment; benefits obtainable from radioactive decay; the availability of disposal routes; and, subject to ensuring public, worker and environment safety, the financial implications of proceeding on different timescales

f) in particular, defuelling will commence as soon as reasonably practicable after the cessation of generation, so that the most active and potentially mobile radioactivity is removed on a relatively short timescale. All radioactive materials remaining on the site following defuelling will be retained or placed in a passively safe state, being immobilised or contained in such a way as to minimise the need for maintenance, monitoring or other human intervention

g) where any decommissioning or waste management work is to be deferred, appropriate records will be retained and maintained throughout the period

h) the sites will be managed to maintain a passively safe state, through deployment of appropriate suitably qualified and experienced resources, throughout any decommissioning deferral period

i) the sites will remain subject to nuclear site licences, and all the safety conditions and controls that this imposes, throughout all decommissioning and waste management activities, including any deferral period, e.g. periodic safety reviews will be performed

j) the development of decommissioning and waste management strategies and plans will learn from experience gained in progressing such work on Magnox Electric's own sites, and similar work being progressed on or planned for others' sites, e.g. via collaboration and contact with other liability owners and national and international bodies

k) decommissioning and waste management strategies, plans, processes and technologies will be developed to be cost effective and to minimise as far as is reasonably practicable the overall costs, in net present value terms, of discharging such liabilities

l) the end point for decommissioning for Magnox Electric sites is that sites should eventually be cleared, de-licensed and made available for appropriate alternative use

m) a research and development programme will be maintained to ensure awareness of developments in technology and to review the applicability of these to the decommissioning and waste management process

n) solid waste arising from decommissioning sites will be packaged in a form, agreed in advance with UK Nirex Ltd, suitable for interim surface storage.

The above principles accord with the requirements of Government Policy as stated in Cm 2919. Further commentary on compliance with Government Policy, and hence the above principles, is provided in Annex 2 of this submission.

3.3 Strategy Assumptions

The development of the waste management and decommissioning strategies described in this submission are based on the following set of assumptions:

- The end point for reactor site decommissioning is de-licensing, provided there is a reasonably practicable interpretation of the "no danger" clause in the NIA65
- Strategies should reflect only currently available technologies
- Strategies must optimise against all relevant factors as required by Government Policy
- There is an adequate safety case for deferment of reactor dismantling
- The regulatory regime is unlikely to be static and safety case acceptance criteria will prudently be assumed to become even more stringent.

The validity and implications of these assumptions are subject to on-going assessment.

4. Strategy Options Analysis and Selection

To identify the preferred generic decommissioning and waste management strategy options described in this submission, a systematic and transparent process has been applied to consider a comprehensive range of potential options against the relevant factors. The process is used to rank potential options in terms of their overall acceptability. The details of the process are given in Annex 1. The results from the process are documented and retained for future reference.

An important principle within the process is that safety and technical feasibility are considered first, followed by a range of other relevant factors including cost effectiveness.

Some of the key points resulting from the application of this generic options analysis and selection process to Magnox Electric decommissioning and waste management strategies are presented below.

4.1 Reactor Site Decommissioning

Since the first Quinquennial Review submission, further strategy options analysis and selection has been undertaken. In this analysis, the initial full list of options for the decommissioning of reactor sites, generated by brainstorming, included well over a

hundred potential strategy options. These included options as diverse as immediate and complete site clearance through to leaving the reactors with fuel in core, i.e. doing absolutely nothing. From this very broad range, the initial screening produced a short-list of options judged to be safe and technically feasible. The short-listed options range from complete dismantling and clearance of the site as soon as possible following shutdown through to disposing of wastes on-site. Other options between these two extremes, e.g. various timings of dismantling for different categories of plant and buildings, were also included in the short-list. Options that include leaving fuel on the site over extended periods were judged not to be safe or technically desirable.

There were 12 different options in the short-list and these were assessed and compared against 20 relevant factors, grouped into the categories of safety and environment, technical feasibility, political and public relations and cost. They include public and worker safety issues, waste minimisation, disposal route availability, compliance with regulations, public and regulator acceptability, etc. The 12 options include three basic strategies for the reactors: early dismantling, deferred dismantling and on-site disposal. Some of the arguments for and against these are summarised below.

4.1.1 Early Reactor Dismantling

Dismantling reactors early, although technically feasible, would require the use of complex, remotely operated and maintained machinery. With such complex machinery and systems, there are hazards to workers in day to day operation. In installing, operating and particularly maintaining this machinery, workers could be exposed to significant radiation doses. There are also risks that the consequences of faults could lead to more serious injury to workers, and potentially greater damage to the environment, than faults during deferred dismantling.

Furthermore, early dismantling would give rise to significantly larger volumes of packaged ILW for which there is presently no disposal route. This is unlikely to be available until later this century and hence there would be a need for construction of an on-site store of considerable size. Benefits of early dismantling include that the site is available for re-use, apart from the large store, and that existing knowledge is used without risk of it being lost, although knowledge of the internals of the reactors are largely recorded in station records rather than in individual experience.

4.1.2 Deferred Reactor Dismantling

Deferring dismantling allows radioactivity to decay naturally, which not only reduces the radiation exposure levels for workers and simplifies dismantling but also the consequences of any faults. The radioactive waste quantities are also reduced with greater volumes of inactive material available for recycling and re-use. It is also possible that a suitable waste disposal facility would be available to take the waste as it arises, thus avoiding construction of a large storage building and double handling of the material. Deferral also carries some disbenefits, e.g. transferring responsibility for undertaking the final dismantling and site clearance to future generations and the potential degradation of knowledge.

4.1.3 On-site Reactor Disposal

If converting the site to a disposal site were to be the chosen option, possibly involving mounding over of the reactors, the site would not be available for re-use for a long period. Institutional control may have to extend for 300 years before such re-use can be considered. As time passed radioactivity would decay as in the deferred option. There would be little risk of harm to workers and little waste generated for transfer off-site. However, the long-term risk to the general public from such a facility may not be so straightforward to quantify, and could be of concern to local people.

4.1.4 Preferred Options for Reactor Dismantling

The final results of the analysis showed that the highest ranking options all included the deferral of dismantling of the major radioactive plant and structures on the site, e.g. the reactors. The analysis results also showed that the option involving the earliest dismantling and clearance of the site was markedly the lowest ranked option. Sensitivity analysis showed that the rankings are robust.

Consideration of this detailed analysis of the potential options, and all the relevant factors, has led to the redefinition of the preferred Safestore strategy which involves the deferred dismantling of the reactor buildings, and the majority of their contents. This strategy is described more fully in Section 5.1.

4.1.5 Other Radioactive Plant

The benefits of deferring reactor dismantling apply similarly to other components in the reactor buildings, e.g. boilers, main gas ducts and some fuel handling plant, and hence it is planned to defer the dismantling of these as well. The dominant radionuclide hazard associated with plant and structures in the reactor building comes from Cobalt-60 (Co60). This has a short half-life of 5.3 years which means substantial reductions in radiation dose rates occur over any deferral periods. Furthermore, the plant and structures in the reactor buildings are substantial, robust structures within which the radioactivity is either naturally immobile or fully contained in high integrity vessels. They can therefore readily be retained in a passively safe state, presenting minimal hazard to the public and workers, for an extended period following shutdown.

For other plant and structures, such as radioactive effluent treatment plant and fuel cooling ponds, the dominant radionuclide is Caesium-137 (Cs137) which has a longer half-life of 30 years and hence the rate of natural radioactive decay is slower than for Co60. In these particular plant and structures, the radioactivity is more mobile and the integrity of the radioactivity containment may degrade more quickly with time. Although it would be feasible to retain these in a safe state, and defer their dismantling, in general, the buildings are not so robustly constructed as the reactor buildings. Therefore, these non-reactor buildings and plant will be dismantled during the Care and Maintenance Preparations period (See Section 5.1).

4.2 Reactor Site Operational ILW

ILW of various types arises on the reactor sites during operations, and also during defuelling and the early part of the Care and Maintenance Preparations period. These waste streams are generally accumulated on the sites in their raw form within tanks and vaults. The basic strategy selection process described in Annex 1 is applied to each operational ILW stream to generate a preferred option. A range of strategy options has been assessed for each of the operational ILW waste streams. Technology assessments have, for example, included solidification or wet oxidation of ion-exchange materials; solidification, high temperature treatment or drying of sludges; dissolution or encapsulation of Magnox fuel element debris. Timing options have included treating wastes in the period after defuelling or deferring the treatment for a period. The results of the analysis of these options, and consideration of the relevant factors, has led to the selection of the preferred strategies as described in Section 5.2.

4.3 Reactor Site Contaminated Ground

A similar strategy analysis and selection process is being applied on a site-specific basis to the issue of contaminated ground but is not yet complete. However, once sufficient data have been generated, management options for areas of contaminated ground will be subject to a process similar to that in Annex 1 to aid in the selection of the preferred option.

4.4 Berkeley Centre Decommissioning

A simplified form of the process was applied to Berkeley Centre decommissioning and waste management where the options of early or deferred dismantling were considered and early dismantling selected.

5 Decommissioning and Waste Management Strategies

The generic decommissioning and waste management strategies that are currently applicable to the Magnox Electric sites are described below, followed by a comparison with the strategies presented in the first Magnox Electric Quinquennial Review submission in 1996.

5.1 Reactor Site Decommissioning

The decommissioning strategy now being applied to the three shutdown reactor sites, and to be applied to the other six operational reactor sites, continues to be a Safestore strategy. However, the strategy has been reviewed since the first Magnox Electric Quinquennial Review submission of 1996. The review has lead to the modification of the strategy in the light of changed circumstances, experience gained and to reflect a considered balance of all relevant factors. The revised Safestore strategy consists of the following sequential phases, the first of which starts as soon as practicable following the shutdown of the stations. It should be noted that these activities can be carried out only when an adequate safety case is in place, which has received the necessary level of independent scrutiny both internally and from the Regulator.

5.1.1 Defuelling

The spent nuclear fuel held within the reactors and in the fuel cooling ponds at the time of shutdown is by far the most hazardous material on the site, comprising more that 99.9% of the total radioactivity. In order to meet the principle of systematic and progressive reduction in hazard, and therefore to increase the intrinsic safety of the site, the first and main task following shutdown is to defuel the reactors and cooling ponds, and to transfer all spent fuel off-site. Once off-site, all spent fuel is managed by BNFL under the terms of a contract between BNFL and Magnox Electric. Any new fuel that remains on the site is also returned to BNFL at this time.

During the defuelling period of around 2 to 3 years, as systems and plant are no longer required to remain operational, they will be shutdown, de-energised, drained of working fluids and gases, isolated and placed in a quiescent or passively safe state. Stocks of potentially hazardous materials, chemicals, gases and combustible materials that are no longer required (e.g. carbon dioxide, hydrogen, lubricating oils) will also be removed from the site. Work will also proceed to remove asbestos and other hazardous materials that may exist on the site, such as thermal insulation materials on pipework and plant.

During the defuelling period, there will continue to be arisings of radioactive wastes requiring disposals of LLW to Drigg and discharges of radioactive gaseous and liquid effluents. These will be similar to those arising during the operational life of the stations, will be managed in similar ways and will be subject to formal authorisations. There will also be some continuing arisings of ILW, similar to the operational ILW waste streams, which will initially require storing on the site.

5.1.2 Care and Maintenance Preparations

Prior to the period of care and maintenance, dismantling and preparatory work will be undertaken to remove both radioactive and non-radioactive plant and buildings. Some of this work may be done in parallel with defuelling. The specific details of what will or will not be dismantled in this period will be subject to a case-by-case assessment, and hence may vary from site to site, but it is generically expected to include the dismantling, and the disposal of resulting wastes as appropriate, of the following:

- Fuel cooling ponds and associated plant
- Active effluent treatment plant and buildings
- New fuel stores
- Active workshops and laundry
- Turbine hall and associated plant
- Cooling water systems and structures
- Offices, workshops, laboratories

Some partial dismantling and de-planting may occur on and within the reactor buildings but the major plant items such as the reactors, the reactor biological shields, the main gas ducts, the boilers, and possibly some fuelling machinery, will not be dismantled. These will be stored for a potentially extended period prior to their eventual dismantling.

Appropriate work will be performed on and within the reactor buildings to put them into a passively safe and secure state for the period of quiescent Care and Maintenance that follows. This will be done on a timescale (for future programmes, of the order of 7 to 10 years from station shutdown), and in a manner, most appropriate for each individual site. The buildings and their contents will be appropriately prepared to ensure the containment of radioactivity and to prevent inadvertent human intrusion. The reactor building structures and external cladding will be maintained, refurbished or replaced as necessary to ensure they remain weather-proof and to minimise any potential for water ingress. This will not necessarily involve the reduction in height of the reactor buildings. In addition, it should be noted that where the existing fabric of the reactor buildings is in good condition, it may not need to be replaced or re-clad, and there may be no need for a new purpose-built high integrity weather-proof envelope. Also, it may not be necessary to re-clad using high durability materials that will last the full length of any deferral period. Standard cladding materials have a reasonable life span and could be used, to be replaced periodically. The extent and timing of any construction, building re-cladding, and the cladding material to be used, will be decided on a site-by-site basis.

Any necessary equipment and samples will be installed to enable appropriate monitoring of conditions within the reactor buildings, to enable confirmation of the continuing safe status of the plant, structures and radioactivity containment.

During the Care and Maintenance Preparations period, discharges of radioactive gaseous and liquid effluents, as well as disposals of solid LLW to Drigg, will continue. It is expected that annual gaseous and liquid discharges will reduce, although there may be some peaks resulting from certain activities, such as pond clean out, but quantities of solid LLW for disposal will increase. This reflects the change from operation to decommissioning, but will still be subject to formal authorisations issued by the EA in England and Wales or SEPA in Scotland.

All work undertaken in this period will be subject to safety assessments, as well as environmental impact assessment under Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 and Article 37 of the Euratom Treaty, as appropriate.

5.1.3 Care and Maintenance

Following the Care and Maintenance Preparations period, reactor sites will remain in a quiescent Care and Maintenance state for a prolonged period, to allow the benefits associated with radioactive decay to be gained. During this period, no significant dismantling work will be carried out but the site will continue to be managed, monitored and maintained to ensure it is retained in a passively safe and secure state.

During the Care and Maintenance period, safety is assured and public exposure is prevented by the immobility of the majority of the radioactivity within the reactors. The greatest inventory of radioactivity is within activated solid materials, and is not readily available to be released to the environment. Loose contamination that could be re-suspended will be either contained, removed or fixed, as practicable, during Care and Maintenance preparations.

The remaining buildings will have been modified, as appropriate, to comply with the principles of passive safety. The majority of the radioactive material is in solid form and will be multiply contained for most reactors within the typically 100mm thick steel pressure vessel, the 1.5m thick reinforced concrete shields and the reactor building weather envelope. For Oldbury and Wylfa containment is afforded by the more than 3m thick concrete pressure vessel and by the weather envelope. The inspection, monitoring and maintenance regime will be based on the requirements of the safety case and relevant legislation, and will be designed for minimum human involvement.

The robust nature of the modified reactor buildings and storage facilities will ensure minimal need for human intervention during this period. Nonetheless regular visits will be made to the sites by trained and competent personnel to confirm the continuing security and safety of the sites and to perform any necessary maintenance and monitoring work. It is intended that these regular visits and inspections will be sufficient to monitor the site and that there will be no continuous human presence or supervision on the sites. However, there will be appropriate security and condition monitoring installed on the sites which will transmit signals to a permanently manned off-site location, so as to enable appropriate and timely responses to be made to any unusual occurrences. The staff at this off-site location will form a suitably qualified and experienced team to manage safety case production and maintenance, manage records and maintain learning from experience, in addition to deploying resources on-site as required. The approach described in this paragraph is subject to continued discussion with stakeholders.

During Care and Maintenance, containment of the radioactivity is provided by the concrete structure, the reactor vessel, storage tubes, reactor building cladding and roof and by sealing of the basements. Shielding from radiation is provided by the concrete structure. The continued integrity of the containment is assured by prevention of weathering effects by the cladding and roof, by prevention of accumulation of detrimental gases or liquids by the natural circulation of air and by the Care and Maintenance regime. General inadvertent access is prevented by the security arrangements.

From work done to date, it is concluded that only standing water can credibly cause corrosion leading to a structural problem over a long time period: atmospheric corrosion cannot do this. An internal drainage system will ensure that standing water is not able to collect in areas where it may enhance corrosion.

Any consideration of long term safety must assess the effects of global warming. Work by UKCIP indicates that changes to air temperature, rainfall, frequency of storms and sea level can all be expected. For example, upper bound changes expected to the climate for the area that includes Trawsfynydd over the next 80 years or so may be: 3ºC increase in average annual temperature, 10% increase in average annual rainfall and a possible increase in the frequency of severe gales. Global warming will be treated within deferral safety cases as an external hazard, and hazard analysis demonstrating that continued deferral is safe will be presented for independent internal assessment and to the NII for agreement.

Ultimately, the continued assurance of safety relies on the inspection, monitoring and maintenance regime, supported by the Company's safety management system. The

Company is a responsible nuclear operator and will ensure that the safety management system is maintained. Additionally, as the Company seeks to develop a global nuclear business, a record of safe operation will be in the Company's commercial interests.

It is possible that the eventual licensee for the decommissioned sites will not be Magnox Electric, or even BNFL, but a future successor company. Any such transfer of licence responsibility will, under current legislation, require approval by the NII. It is notable that the Magnox reactors were operated safely and effectively as generating plant under a number of different licensees over the last decade.

The continued assurance of safety is reinforced by law and the legal instruments that are available to the Regulator. As with all other decommissioning periods, this period will also be subject to the conditions and controls associated with the relevant Nuclear Site Licence, including periodic review of safety cases. During this period it is expected that any gaseous or liquid effluent discharges will be very low, but still subject to authorisations granted by EA or SEPA.

5.1.4 Site Clearance

The final period of decommissioning involves the dismantling of the remaining structures, appropriate clearance of any residual radioactivity and de-licensing of the site to make it available for re-use.

The main activity in this period, which is expected to take around 8 years for each site, will be the dismantling of the reactors, which will still be radioactive at this time, but at much lower levels than at the time of shutdown.

It is proposed that dismantling of the reactors be performed in a sequential programme, starting at one site and gaining experience before starting work on the next site. After dismantling reactors on several sites in this way, sites could be worked on in pairs, to reduce the length of the programme.

The sequenced programme approach will allow the systematic build-up of suitable infrastructure and of dedicated and experienced resources. Clearly, suitably qualified and experienced people will be required to perform the dismantling work. Such people will be available from the dismantling work being carried out at other UK sites, including Sellafield, and from overseas. It is anticipated that the suitably qualified and experienced team maintained by the licensee to assure ongoing safety during the Care and Maintenance period will also contribute to the larger dismantling teams, transferring experience and information as resources are built up.

Currently, Magnox Electric is considering a sequenced programme across all sites, leading to a range of deferral periods notionally beginning around 100 years from station shutdown, subject to an adequate safety case being available. After periods of this order, the benefits from radioactive decay have largely been gained, such that worker doses will not significantly reduce further with time and waste volumes and complexity of dismantling operations are minimised.

However, the precise start date and duration of the dismantling programme will be decided at the appropriate time, in the light of prevailing circumstances, after review and

consultation with stakeholders. In the meantime, the Company proposes to maintain a degree of flexibility over the deferral timescale to allow for uncertainties on such issues as changes in the regulatory regime and the availability of a deep waste repository.

For provisioning purposes, Magnox Electric has costed a strategy involving reactor dismantling deferrals ranging from 85 to about 105 years in order to demonstrate prudent provisioning to meet its liabilities. A risk provision to reflect the potential for shorter deferral periods is included in the cost estimates (see Section 7.4).

The dismantling of the reactors will produce both LLW and ILW, with additional LLW being produced from the dismantling of the other remaining plant. These wastes will, as during the other decommissioning periods, be appropriately treated and packaged to allow off-site disposal. It is assumed that suitable waste repositories will be available at this time for both LLW and ILW. The dismantling work will also generate gaseous and liquid effluents. These will be treated appropriately and discharged in accordance with the regulations and authorisations in force at that time.

Magnox Electric assumes that Government Policy will continue to dictate the ultimate disposition of packaged radioactive waste.

5.2 Reactor Site Operational ILW

The management strategies to be applied to operational ILW waste streams are identified below. In general, the strategy for these wastes is to ensure passive safe storage as soon as possible after shutdown of the relevant site, to retrieve and encapsulate those not already in a safe passive state. Where operational ILW is to be encapsulated for disposal, packaging arrangements are agreed in advance with UK Nirex Ltd, confirming that the waste package should be acceptable for disposal.

There is an extensive ongoing development programme to ensure the wastes can be successfully encapsulated and that the waste package will be acceptable for long term storage, and eventual disposal. All waste management work will be subject to appropriate safety cases being prepared and agreed.

5.2.1 Slurry Form Wastes

Slurry form wastes consist of sludges and ion-exchange materials that result from the filtration and treatment of liquids, e.g. from fuel cooling ponds and active drains.

The preferred option for slurry form wastes is to retrieve them from the tanks, during the Care and Maintenance Preparations period, and to solidify them in cement within stainless steel containers. This solidification process will be undertaken using purpose designed plant. An exception to this is at Trawsfynydd where there is an existing process for resin wastes. These wastes are encapsulated in an organic resin matrix in steel drums and these are placed in concrete outer containers.

5.2.2 Fuel Element Debris

Following removal of used fuel from the reactors, external components of the fuel elements are removed and stored on the site, prior to fuel shipment to Sellafield. This fuel element debris consists mainly of Magnox metal, although at two stations (Berkeley and Hunterston A) it also includes graphite.

Magnox fuel element debris will be retrieved from the storage vaults during the Care and Maintenance Preparations period. There are two processes available for dealing with the waste. These are dissolution and encapsulation.

The dissolution process dissolves the Magnox metal within a weak carbonic acid solution and retains the bulk of the radioactivity as a residue. This residue is then solidified in cement within containers in a similar manner to the slurry form wastes. The dissolved metal is discharged to the sea as a very weak solution of magnesium bicarbonate, following any necessary filtration and ion exchange to ensure compliance with the associated discharge authorisation. A demonstration dissolution plant is currently successfully operating at Dungeness A.

The encapsulation option for fuel element debris involves packaging the waste in a cement grout within containers suitable for eventual disposal. At Berkeley and Hunterston A, where the waste has a significant graphite component, and at Trawsfynydd where the discharge route is to a fresh water lake, the dissolution process would not be suitable. In these, and perhaps other cases, purpose designed solidification plants are being or will be installed. Magnox metal is currently being successfully encapsulated at Sellafield and the necessary retrieval and packaging plant has been designed and is being commissioned at Berkeley and Trawsfynydd.

Both processes are under review at present to evaluate new information and changing circumstances. The experiences at Sellafield, Berkeley, Trawsfynydd and Dungeness A and the effect of OSPAR will be taken into account during the review.

5.2.3 Miscellaneous Contaminated Items

A number of contaminated operational solid waste items arise on sites which are too radioactive to be disposed at Drigg as LLW, e.g. as a result of maintenance and replacement of fuel cooling pond equipment. These miscellaneous contaminated items (MCI) are stored as ILW in their raw form on the site, typically within concrete vaults.

The strategy for the MCI is to retrieve them during the Care and Maintenance Preparations period for encapsulation in a cement grout within containers suitable for eventual disposal.

5.2.4 Miscellaneous Activated Components

Activated operational waste items arise from maintenance and replacement of items used in the reactors, which are classified as ILW. These miscellaneous activated components (MAC) are normally accumulated within concrete vaults and storage tubes purpose built into the reactor biological shields. The radioactivity in MAC is fixed by being bound

within the material rather than being on the surface. Therefore the existing storage arrangements for MAC can generally be considered to be passively safe, provided that the waste remains dry, with negligible possibility of leaching radioactivity into groundwater. Also, the MAC is stored within the reactor buildings that are to be retained for a prolonged period.

The strategy for the MAC is therefore, where it can be justified as passively safe, to retain it within its existing storage facilities in the reactor buildings, to gain the benefit of radioactive decay, and to retrieve and treat it at the same time as reactor dismantling. Where a justification for continued passive safe storage cannot be made, the MAC will be retrieved and encapsulated in a grout matrix within containers in a manner suitable for eventual off-site disposal.

5.2.5 Desiccant

Desiccant materials are used during the operational period within dryers to treat the reactor gas. During this process, radioactivity, principally tritium, becomes fixed within the desiccant material. Small quantities of this material, which is classified as ILW, exist at the time of shutdown and are held in their raw form in the dryer vessels or within drums.

The strategy for the desiccant is to solidify it in cement within containers in a similar manner to the slurry form wastes.

5.2.6 Packaged Waste Storage

As stated above, the strategies for the various waste streams will produce containers of solidified or encapsulated wastes. As an off-site waste repository for ILW is not presently available, and is assumed will not be available until 2040 or even later, it will be necessary to store these packages until such a repository is ready to accept them. It is therefore planned to provide facilities on each of the sites for the passive safe storage of the packages. This will either be in the form of a new purpose built storage building or, where this is safe, feasible and appropriate, within existing buildings specifically converted for that purpose. Waste packages will be stored such that they are readily retrievable and can be inspected.

Where new storage facilities are required, these will be subject to the granting of any necessary planning approvals.

5.3 Reactor Site Contaminated Ground

There is some radioactively contaminated ground on the reactor sites as a result of past spillages and leakages. The extent and nature of contaminated ground varies between sites but the areas of contamination are largely known and the levels of radioactivity are generally low. Where it has not been appropriate to remove the contamination it has been managed and monitored *in-situ* to ensure the safety of the public, workforce and environment. However, it is recognised that as sites move into the decommissioning phase, it is appropriate to review this approach to ensure continuing long-term safety.

Specific strategies and detailed plans for the individual sites are still being developed but the approach being taken to achieve this includes the following steps:

- Review of site records related to spills, leaks and contaminated ground management and monitoring
- Review of existing hydro-geological information on the site
- Detailed isotope dependent surface radioactivity measurements across the site
- Borehole monitoring for radioactivity measurement and hydro-geological purposes
- Review and development of appropriate technologies and options for ground contamination management and remediation
- Identification of preferred options for management of contaminated ground
- Development and maintenance of a land contamination safety case

This work provides detailed information on the extent and nature of any contaminated ground, and the hydro-geological conditions, thus facilitating the development of strategies for the management of contaminated ground on the sites.

The strategy options will be considered, analysed and compared (as described in Section 4.3) to enable the most appropriate strategy for each case to be identified and justified. The strategy options being considered range from the early removal and disposal of contaminated ground through to contain, maintain and monitor, possibly with the introduction of some ground water movement barriers or other containment measure. Techniques such as phytoremediation (which the Company is currently actively researching), for removal of contamination, are also under consideration. Further work is required before the strategy proposals and plans can be made firm. These will be discussed with the relevant bodies and be subject to the production and approval of safety cases.

5.4 Berkeley Centre Decommissioning and Waste Management

There are facilities on the Berkeley Centre site that are used for the examination of radioactive materials. The main one is a series of caves and cells that are used for the post-irradiation examination of fuel elements and materials removed from reactors. There are also radioactive waste management facilities, including an ILW store on the site.

The decommissioning strategy for the radioactive facilities on this site is to fully dismantle them as soon as practicable following the end of their operational life. The resulting radioactive wastes, and wastes already stored on the site, will be treated and packaged appropriately for disposal as LLW or ILW. The LLW will be sent off-site for disposal at Drigg. Any ILW will need to be stored, in a passive safe form, until a suitable repository becomes available. This storage of ILW packages could be done on the Berkeley Centre site or on the adjacent Berkeley Power Station site.

6 Comparison with the 1996 Quinquennial Review Submission

The 1996 Magnox Electric Quinquennial Review submission described the Safestore decommissioning strategy as it was then defined. It assumed that only limited dismantling of radioactive plant and buildings would be undertaken in the period

following defuelling. Other buildings, such as fuel cooling ponds and active effluent treatment plant as well as the reactor buildings, would be retained on site and not be dismantled for up to about 135 years following station shutdown.

The Safestore strategy as defined in the 1996 submission has been reviewed as the submission stated it would be. This review has taken into account all relevant factors, including the experience gained on decommissioning the three shutdown sites and the requirement not to foreclose the option of undertaking decommissioning on a shorter timescale. This has resulted in modifications being made to the Safestore strategy.

There are two fundamental changes from the 1996 Safestore strategy:

- Only the dismantling of the reactor buildings is to be deferred for a period, notionally around 100 years from station shutdown.
- A sequenced programme for reactor dismantling will be followed to allow realistic resource commitment and learning from experience.

The earlier submission also referred to 'Deferred Safestore' and 'Early Safestore' options. Deferred Safestore, the lead option, included the assumption that high integrity weather envelopes would be created about 30 years or so after station shutdown, and Early Safestore assumed this work would be done in the period directly following defuelling. The terms Deferred and Early Safestore have been dropped. The extent and timing of any construction, building re-cladding, and the cladding material to be used, will be decided on a site-by-site basis.

In addition, the earlier Quinquennial Review submission focused mainly on reactor site decommissioning. However, it also touched on reactor site operational ILW and stated that these would be retrieved and immobilised, but without stating any specific timing. This earlier submission was made at the time when an ILW repository was expected to be available in a shorter timescale than is now envisaged. As a result of the delay to the repository availability it is now recognised that it would be appropriate to retrieve and package potentially mobile wastes rather than continue to store them in their raw state for an undefined period.

The 1996 Quinquennial Review submission did not refer to contaminated ground or decommissioning and waste management on the Berkeley Centre site. This new submission includes these issues.

7 Strategy Development and Implementation

The above decommissioning and waste management strategies have been derived following extensive research, design and development programmes carried out over more than twenty years. A variety of technologies and options has been investigated in detail prior to the selection of the preferred options and their incorporation into the above strategies. This work provides the preferred strategies with firm foundations and justifications.

7.1 Research into Alternative Options and Future Work

Although preferred options have been selected, other options are maintained should they be needed, e.g. encapsulation could be used instead of dissolution for Magnox fuel element debris. Magnox Electric maintains contact with other utilities in the UK and abroad, keeping an open mind to determine whether technology developments might enable improvements to be made to strategies and implementation plans. There is a continuing technical work programme to identify, investigate and develop any existing or promising techniques, technologies or technical understandings so that the strategies can be reviewed and amended as appropriate and to ensure that decisions are based on the best information. The present and future work programme includes:

- development of stakeholder consensus, with work proposed to discuss reactor decommissioning within BNFL's National Stakeholder Dialogue process facilitated by The Environment Council
- investigation of the application of the concept of sustainable development to waste management and decommissioning
- work to update the input to the National Radioactive Waste Inventory
- investigation into decontamination techniques for boilers, concrete, steels etc
- ground contamination remediation and management techniques
- work to build on existing confidence in the long term integrity of plant and structures that could remain on site for prolonged deferral periods
- development of cement formulations for waste encapsulation
- assessment of the effects of long-term storage conditions on packages
- investigation of new waste treatment technologies
- monitoring statements on global warming and assessing such effects
- assessment of the validity and implications of the strategy assumptions

Some of this work is performed in collaboration with others, such as within the Industry Management Committee (IMC) R&D programme, monitored by NII, and as part of other national and international programmes like those run under the auspices of IAEA, NEA/OECD, the European Commission and EPRI.

7.2 Site Implementation

Steady progress has been made in implementing the preferred decommissioning and waste management strategies at the three reactor sites that have been shutdown.

At Berkeley, buildings and plant have been dismantled with large quantities of the resulting materials released as non-radioactive and recycled, with the residual quantities of radioactive wastes being treated, packaged and sent to Drigg for disposal. Reactors and reactor buildings have been prepared for a prolonged Care and Maintenance period. Equipment has been installed and commissioned so that operational ILW can be retrieved and solidified with the resulting packages being placed in an on-site waste store.

At Trawsfynydd, some de-planting and dismantling has been completed, for example the reactor building basements have been cleared to provide interim space for packaged waste storage, and fuel chutes between the reactor buildings and the ponds have been

removed. The retrieval and packaging of resins is ongoing. The retrieval and packaging of sludges, FED and MAC will be started in the near future. Work is in hand to dismantle parts of the boilers, to make space for lowering of the roof height and construction of the weather-proof envelope, if Regulatory approval and planning consent are granted. Investigations into land contamination have largely been completed.

At Hunterston, the turbine hall has been demolished to make way for a store for encapsulated ILW. Planning consent has been granted for this store. Work to improve the safety of existing buildings is underway and plans are being drawn up to retrieve and encapsulate the fuel element debris. The ponds are being de-planted. Work to investigate the status of contaminated land on the site is underway.

The prototype dissolution plant at Dungeness A is working successfully at above design throughput.

All of this work has been performed safely and has demonstrated confidence in the strategies and technologies being applied.

7.3 Reactor Decommissioning Management within BNFL

It is recognised that the decommissioning and waste management programme is growing, particularly with respect to reactor sites, and that this requires appropriate resources and management arrangements to be applied to ensure that it is undertaken safely, effectively and economically. For this reason, a dedicated Reactor Decommissioning Unit (RDU) has been set up within BNFL (of which Magnox Electric is a wholly owned subsidiary) to implement the decommissioning and waste management work, and to develop and maintain the strategies and appropriate technologies and to learn lessons from implementation. These arrangements recognise the need for a strong safety management emphasis, and that the sites must be retained in a safe and secure state for potentially long periods of time until final site de-licensing. Appropriate management arrangements and resources will continue to be retained over these long periods, and the necessary records and technologies required to support future work will be maintained.

The decommissioning and waste management phase of Magnox Electric's nuclear programme has commenced and continues on the three sites, providing valuable experience in developing and implementing strategies. This feedback information, and all the preceding development, is being used not only to support the ongoing work on these three sites but also in updating and developing plans for the decommissioning and waste management work that will be performed on the other sites in the future.

7.4 Decommissioning Programme Risks

Consideration is given to risks to timescales and costs associated with the implementation of strategies. A comprehensive register of risks provides input to the derivation of risk margins. The risks are subject to a management process to ensure they are captured, quantified and managed. The provisions include an allowance for the risk of earlier site clearance. It should be noted that this is a risk provision, and as such, would be insufficient to fund all conceivable reactor decommissioning strategies.

8 Peer Review and Public Consultation

The decommissioning and waste management strategies and technologies have been publicised and disseminated by Magnox Electric and its predecessors, including within the public domain, over the years as they have been derived and developed. For example, the first major study into the decommissioning of a reactor site, and the proposal that reactor dismantling be deferred for about 100 years, was first published in the early 1980s. Numerous opportunities have been taken to present and debate the proposals via articles in journals and papers presented at national and international conferences. Magnox Electric also participates in national and international working groups (e.g. IAEA), has wide contacts with the media and presents information to local communities, through the Local Community Liaison Councils and through answering inquiries. In particular, Magnox Electric has taken every opportunity during the recent strategy review to debate its proposals with NII, seeking to understand and reach a consensus with the Regulatory viewpoint.

One example of this effort was the public consultation exercise that was undertaken in 1994 to seek the views of various representative bodies (e.g. Local Councils and Trade Unions) and the local population concerning the decommissioning plans for Trawsfynydd Power Station. Various presentations and displays were used to provide information related to the range of potential decommissioning options, including early and deferred dismantling options. Members of the public were encouraged to give their views on this information, and their responses were collected and analysed, internally and by an independent organisation. As a result of this exercise the strategy proposals for Trawsfynydd were amended to take account of views expressed. There was support for, or recognition of, the benefits of deferring the final clearance of the site for a prolonged period and this aspect of the strategy was retained.

Magnox Electric has embarked on a programme to understand how the principles of sustainability and intergenerational equity apply to nuclear power station decommissioning. Research so far has identified several key areas where these principles can be expected to impact. These are:

- safety and waste management
- deferral of reactor dismantling
- funding and discounting
- public understanding/political acceptability
- local impacts

Work is in hand to explore the environmental, social and economic factors that are key to sustainable development. As part of this work, the views of stakeholders on decommissioning strategy will be sought, recognising that there is no national consensus on the period over which it is acceptable to retain reactors in a Care and Maintenance regime. This work will allow Magnox Electric to understand stakeholders' views, take them into account in considering all relevant factors and make progress towards reaching consensus.

Magnox Electric is aware of decommissioning activities in other countries. Internationally there is a mix of strategies involving either early dismantling or deferral, for a range of reasons. Some utilities in a number of countries have chosen to follow an

immediate dismantling route. Utilities generally adopt this strategy when they are dealing with water-cooled reactor technologies, which involve smaller plant, pressure vessels and structures that can be dismantled relatively easily or, if necessary, transported in one piece for disposal, where radioactive waste disposal facilities are available. Magnox reactors are very large in comparison and must be dismantled on-site using dedicated facilities. Deferral is an internationally recognised strategy for dealing with decommissioning reactors. In the USA the NRC is supportive that it remains an option available to utilities.

9 Financial Provisions and Funding

The costs of discharging all of Magnox Electric's decommissioning and waste management liabilities are identified and financial provisions included in the annual accounts. These financial liabilities relate to those associated with Magnox Electric's own licensed sites as well as the contractual obligations associated with spent fuel management, decommissioning and waste management activities at other licensees' sites.

The liabilities at other licensee sites relate to three main areas associated with BNFL. Firstly there are fixed price contracts between Magnox Electric and BNFL for the storage and reprocessing of the spent Magnox fuel, the treatment and storage of the resulting waste arisings, the storage of recovered plutonium and uranium, and flask maintenance. Secondly there are cost reimbursable contracts with BNFL for the costs attributable to Magnox Electric for decommissioning associated with the Sellafield and Springfield sites and for the Calder Hall and Chapelcross reactor sites. For Sellafield the same contract also covers historic waste management, i.e. ongoing waste treatment and storage associated with fuel throughput prior to 1989. Thirdly, Magnox Electric is liable for the disposal costs for its allocation of the wastes, including ILW and HLW, at Sellafield. In addition to these main areas there are also some minor liabilities associated with historic uranic residues at BNFL Springfields, and the disposal of fuel transport flasks and flatrols.

Provisions for the costs of discharging Magnox Electric's nuclear liabilities are built up in the balance sheet as those liabilities arise in accordance with current accounting standards. The provisions are based on extensive technical assessments of the likely costs and risks involved in dealing with each liability, and take account of experience gained from performing such work. A contingency element is included to cover uncertainties in the costings, and a risk element is included to take account of possible future changes (e.g. performing work earlier than stated.) In including these elements, the level of confidence in the adequacy of the provision is increased.

The financial provisions stated in the accounts are presented in net present value (NPV) terms by applying a discount rate, presently set at a level of 2.5% per annum, to the underlying cashflows. The liabilities arise over a long period and it is therefore appropriate to discount the associated cashflows to take account of income earned from funds set aside to pay for them. The 2.5% discount rate applied by Magnox Electric to its provisions is based on the post tax real rate of return expected from the BNFL Group investment portfolio (and achieved for the year end 31 March 1999), and has been agreed with the Company auditors and Government.

The provisions are reviewed and audited annually as part of the year-end accounts process. Details of the provisions set aside at each year-end can be found in the Company's annual accounts. At 31 March 1999, the last available published set of accounts, Magnox Electric held provisions of £8,694M, made up as follows:

	£M
Fuel reprocessing and waste management:	4,548
Decommissioning:	4,023
Other (non nuclear provisions)[2]	123
	8,694

The BNFL Group, of which Magnox Electric is a part, is committed to ensuring that funds are available to meet long-term nuclear liabilities as they fall due. Liabilities funds for the whole BNFL Group, including Magnox Electric, are managed together rather than separately and are covered by nuclear liabilities investment portfolios and a Government Undertaking which are specifically earmarked for this purpose. (The Government Undertaking was put in place at the integration of Magnox Electric and BNFL and is an agreement between Her Majesty's Secretary of State for Trade and Industry and Magnox Electric plc to pay Magnox Electric plc, over the period from 2008 to 2116, £3.7B together with interest at a rate of 4.5% above inflation on the outstanding amount. The Undertaking includes a review mechanism that allows values to be adjusted where actions by persons or bodies external to the BNFL Group cause a reassessment of the liabilities.) At 31 March 1999 the BNFL Group had earmarked funds to cover almost 90% of the Group funded future discounted cash expenditure in respect of existing liabilities.

10 Review Processes

Magnox Electric's decommissioning and waste management strategies are subject to ongoing monitoring and review and are updated as required to take account of changing circumstances, developments (such as in technology) and feedback from experience gained in implementing the strategies and technologies and other national and international information. That such review is actively occurring is demonstrated by the changes made to the strategies between the first Quinquennial Review submission made in 1996 and this submission. As well as reviewing and amending the generic strategies, and recording these changes, the individual site specific plans and programmes are also regularly reviewed and amended to reflect the generic strategy changes as well as any local issues.

In support of strategy development and review Magnox Electric runs a number of ongoing technology research and development and monitoring programmes. These are also routinely reviewed and adjusted as appropriate to ensure they continue to meet the objectives of optimising the waste management and decommissioning process. One of the benefits of integration with BNFL has been the opportunity to learn from similar programmes run by BNFL.

[2] The 'other' provisions included in the Magnox Electric accounts relate to restructuring, insurance and contract loss provision

As well as strategy and technology reviews, the liabilities cost estimates, provisions and funds are subject to regular review, normally on an annual basis as part of the Company business planning and accounting processes.

The provisions are also independently reviewed each year as part of the auditing of the Company Annual Accounts.

11 Conclusions

Magnox Electric, as a Nuclear Site Licensee, is required to produce detailed strategies, plans and programmes in preparation for decommissioning. Government policy requires these strategies to be reviewed every five years by NII.

This submission sets out Magnox Electric's decommissioning and waste management strategy for review by NII. The key points of this strategy are:

- Reactors will be defuelled as soon as practicable after shutdown
- Predominantly caesium contaminated plant will be dismantled when it is no longer needed
- All buildings except the reactor buildings will be dismantled as soon as practicable after they are no longer needed
- Boilers will remain in position until the reactors are dismantled, but appropriate decontamination technology will be regularly reviewed
- Operational ILW, except some MAC, will be retrieved and packaged during the Care and Maintenance preparation period. All wastes will be stored on site, and handled in the long term in accordance with Government policy
- Reactor buildings and some of their contents will be placed in a passive safe storage Care and Maintenance condition as soon as possible, as appropriate for the site
- Contaminated land will be managed to maintain public safety and minimise the need for security
- The reactors will be finally dismantled in a sequenced programme with a start date and duration to be decided at the appropriate time in the light of circumstances prevalent at that time
- Currently, Magnox Electric is considering a sequenced programme across all sites, notionally beginning around 100 years from station shutdown, leading to a range of deferral periods
- For provisioning purposes, Magnox Electric has costed a strategy involving reactor dismantling deferrals ranging from 85 to about 105 years in order to demonstrate prudent provisioning to meet its liabilities. A risk provision to reflect the potential for shorter deferral periods is included in the cost estimates
- The end point for reactor decommissioning strategy is site clearance and de-licensing, based on the assumption that a reasonably practicable interpretation of the "no danger" clause in the Nuclear Installations Act 1965 (as amended) can be developed
- Magnox Electric is committed to ensuring that funds are available to meet long-term nuclear liabilities as they fall due.

The decommissioning strategy contains two fundamental changes from that presented in the previous Quinquennial Review:

- Only the dismantling of the reactor buildings is to be deferred for a period, notionally around 100 years from station shutdown.
- A sequenced programme for reactor dismantling will be followed to allow realistic resource commitment and learning from experience.

This strategy will be subject to ongoing review and development over the coming years, and may be modified in the light of circumstances prevalent at the time. The strategy will be reviewed using the processes described in this document, in line with Government policy, taking account of all relevant factors. The strategy will also be reviewed should there be changes to Government policy. Magnox Electric remains committed to:

- Maintaining an ongoing research programme to investigate alternative options and to make strategic decisions based on best available data
- Continuing existing strategy implementation and learning from experience
- Seeking consensus on waste and decommissioning strategies with all stakeholders.

Annex 1 Process for Strategy Options Analysis and Selection

This annex sets out the steps of the process for options analysis and selection that Magnox Electric has used to generate preferred strategy options. The basic steps in the process are:

- Identification of the nature of the issue
- Brainstorming to generate as wide a range of options as possible
- Filtering the wide range of options, by adding to a short-list only those options that are judged to be safe and technically feasible
- Identification of the relevant factors applicable to the analysis and comparison of the options, e.g. including a wide range of safety, environmental, technical, economic, political and regulatory factors
- Development and detailing of each short-listed option to enable quantitative and qualitative information to be derived for all relevant factors
- Holding a decision conference attended by a wide range of experts at which all the relevant factors for all the options are scored and then weighted to reflect their relative importance
- Ranking the options according to their total weighted scores. (A formal, computer aided, multi-attribute decision analysis process has generally been used for this step. This compiles all the data, scores and weights and produces an output showing the ranking of each of the options relative to each relevant factor, group of factors and all factors combined.)
- Checking that there are no 'cliff-edge effects' and that the analysis and rankings are robust, through a sensitivity analysis of the decision conference output by analysing the effects of changing the applied weightings and scores
- Identification of the preferred strategy option resulting from the above analysis.

The results from this process are kept under review and as necessary the process is repeated and the results and the preferred strategies updated.

Annex 2 Demonstration of Compliance with Government Policy

Magnox Electric requires that its decommissioning and waste management strategies comply with Government Policy. The most recent statement of Government Policy is the White Paper Cm 2919 of July 1995. The key statements within Cm 2919 are shown below together with commentary on how the strategies presented in this submission are compliant with these requirements.

'Radioactive waste management policy should be based on the same basic principles as apply more generally to environment policy, and in particular on that of sustainable development. ... A widely quoted definition of this concept is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." ...[other] supporting principles [are]:

- *decisions should be based on the best possible scientific information and analysis of risks;*
- *where there is uncertainty and potentially serious risks exist, precautionary action may be necessary;*
- *ecological impacts must be considered, particularly where resources are non-renewable or effects may be irreversible;*
- *cost implications should be brought home directly to the people responsible – the polluter pays principle.'* **[50]** [3]

Sustainable development, as it applies to decommissioning and waste management, is not clearly defined or understood, but Magnox Electric has work in hand to clarify this and develop an agreed position. However, decisions on what actions to take, and when, take due account of the above supporting principles:

- decisions result from a detailed development and analysis of scientific and technical information;
- risks are identified, analysed and mitigated;
- the precautionary principle is employed, for example, packaging of wastes is a precaution taken against failure of existing containments;
- environmental impacts are addressed;
- costs for all activities, present and future, are provided for.

The preferred strategies potentially defer some decommissioning work to future generations but only where this can be achieved safely, and with confidence, and where there are overall benefits in doing so, e.g. gaining significant benefits from natural radioactivity decay while maintaining full radioactivity containment. The deferral of this work does not compromise the ability of future generations to meet their needs. The necessary technology and financial resources are available and being provided now so as to aid these future generations and minimise the impact on them. All necessary steps will be taken to ensure these resources remain available.

[3] The numbers given in bold in brackets **[ ]** relate to the paragraph numbers in Cm 2919

'radioactive wastes should be managed and disposed of in ways which protect the public, workforce and the environment.' **[51]**

The safety and protection of the public, workforce and the environment is the basis of all Magnox Electric's decommissioning and waste management strategies and plans.

'it is recognised [by Regulators] that a point is reached where additional costs of further reductions in risk exceed the benefits arising from the improvements in safety achieved and that the level of safety, and the resources required to achieve it, should not be inconsistent with those accepted in other spheres of human activity.' **[51]**

As stated here, there is a balance to be achieved between safety and costs, but, in preparing the decommissioning and waste management strategies, the primary emphasis is on safety. Magnox Electric's safety principles recognise that there is a point beyond which input of resources is not justified by the further gain in safety benefit. All safety assessments for waste management and decommissioning implicitly recognise this. Current estimates of the risk to the public from deferring reactor dismantling are in the region of 10^{-9}/y. The use of resources to reduce this minimal risk would clearly be inconsistent with risks accepted in other, comparable, spheres of human activity.

'the Government will maintain and continue to develop a policy and regulatory framework which ensure that:
(a) radioactive wastes are not unnecessarily created;
(b) such wastes as are created are safely and appropriately managed and treated;
(c) they are then safely disposed of at appropriate times and in appropriate ways;
so as to safeguard the interests of existing and future generations and the wider environment, and in a manner that commands public confidence and takes due account of costs' **[52]**

The decommissioning and waste management strategies are consistent with the above framework. For example, emphasis is placed on waste minimisation (e.g. deferring reactor and other dismantling reduces waste quantities through radioactive decay) and wastes are managed safely and subject to safety assessments. Wastes are disposed of as appropriate, taking account of repository availability, and utilisation. Although Drigg is available for LLW disposal, it has a finite capacity as a national resource and must prioritise and limit the wastes it receives. For example, there are limitations on the quantity of decommissioning waste it will accept and hence this is a consideration in developing decommissioning strategies and timings. With respect to public confidence, actions are taken to present and debate decommissioning and waste management within the public domain with an aim of achieving this. Finally, with respect to costs, all necessary activities are fully costed and provided for.

'producers and owners of radioactive waste are responsible for developing their own waste management strategies ... They should ensure that:
(a) they do not create waste management problems which cannot be resolved using current techniques or techniques which could be derived from current lines of development;

(b)where it is practical and cost-effective to do so, they characterise and segregate waste on the basis of physical and chemical properties and store it in accordance with the principles of passive safety …
(c) they undertake strategic planning, including the development of programmes for the disposal of waste accumulated at nuclear sites within an appropriate timescale and for the decommissioning of redundant plant and facilities. These programmes should be acceptable to the regulators and discussed with them in advance.' **[52]**

Magnox Electric's decommissioning and waste management strategies are based on the application of present day technologies. These technologies have been purposely developed where necessary and have been demonstrated. Wastes are generally stored in a segregated form and, although some wastes are presently stored safely in a raw form, the strategies and plans include proposals to retrieve, treat and package these wastes and place them into a passively safe state. This will be completed as soon as reasonably practicable after they cease to arise. The strategies arise from strategic planning, programmes for disposal and decommissioning are available and these are discussed with the Regulators. Magnox Electric has invested significant resource into characterising all of its radioactive waste streams.

'The producers and owners of radioactive waste are responsible for bearing the costs of managing and disposing of the waste, including the costs of regulation and those of related research undertaken both by themselves and by the regulatory bodies. They should cost radioactive waste management and disposal liabilities before these are incurred and make appropriate financial provisions for meeting them. They should regularly review the adequacy of these provisions.' **[52]**

All waste management, and decommissioning, activities (including all those mentioned above) are identified and costed and appropriate financial provisions are made and regularly reviewed.

'the Government believes that where the demands of safety are overriding, waste must be treated as necessary to improve storage conditions' **[113]**

Safety is the primary consideration in preparing Magnox Electric's decommissioning and waste management strategies. All wastes are stored in a safe manner and, where appropriate, action will be taken to improve safety levels. For example, the strategies include plans to retrieve, treat and package wastes stored in a raw form so that passive safe storage conditions can be achieved. However, for radioactive wastes or materials that are already, and can be demonstrated to be, in a passively safe state in their raw or original condition, e.g. MAC wastes and reactor structures after defuelling, no further significant action is generally required or planned, prior to site clearance.

'Decisions by operators and regulators will need to have regard to all relevant factors, including the following:
(a) the need for continuing safe storage of the waste, treated and/or contained as necessary;

(b) the benefits of placing the waste in a chemically and physically stable form, so that safety may be achieved by passive means;
(c) the risk that treated waste will be incompatible with future disposal requirements and the practicability of re-working treated waste in the future, for disposal or for a period of further storage, should this be necessary;
(d) the state of storage facilities, including the benefits which would be derived from refurbishment or upgrading;
(e) the need to minimise waste degeneration, secondary waste arisings and releases to the environment;
(f) the need to minimise dependence on active safety systems, maintenance, monitoring and human intervention;
(g) the retrievability of the waste for disposal.' **[113]**

Due regard has been taken of these factors as indicated in the commentary above against other extracts from Cm 2919.

'The Government believes that, in general, the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors.' **[124]**

The decommissioning strategies assume that the work will start as soon as practicable following the shutdown of a site, with the initial focus being on the activity which achieves the most safety benefit: defuelling. However, when account is taken of all relevant factors, it is considered that some of the decommissioning activities should, and can safely, proceed on a later timescale. All of Magnox Electric's strategy decisions including those related to the timing of reactor dismantling are based on the optimisation of a wide range of relevant factors.

'In future, it [the Government] will ask all nuclear operators to draw up strategies for decommissioning their redundant plant. These will need to include justification of the timetables proposed and demonstration of the adequacy of the financial provision being made to implement the strategies.' **[124]**

This submission is part of the process to demonstrate that decommissioning strategies exist for all redundant plant, that there is justification for the proposed timetables and that financial provisions have been made and are adequate.

'decommissioning will be undertaken in accordance with conditions attached to the nuclear site licence and subject to HSE/NII controls, in order to ensure the safety of the site, workers and the public. Disposal of wastes arising during decommissioning will be subject to regulation under RSA 93.' **[125]**

The continuing applicability of the site licence and the attached conditions, and disposal authorisations, throughout the complete decommissioning period until final site clearance is fully recognised. The continued existence of the relevant legislation and HSE/NII controls gives additional public confidence that the strategy of deferral will be safely managed.

'In considering proposals for decommissioning nuclear plant put forward by the operators, HSE/NII will assess them to ensure that the proposals assure the safety of the site at all times, and that the hazards presented by the plant (or site in the case of nuclear power stations) are reduced in a systematic and progressive way.' **[125]**

Safety cases will be prepared for all reactor site decommissioning activities, and for the site overall, and these will be subject to the appropriate level of independent nuclear safety assessment within the Company. The decommissioning strategies will achieve a systematic and progressive reduction in the hazards presented by the plant. The initial actions of defuelling, caesium contaminated plant dismantling and raw waste retrieval are designed to remove the major hazards. The plant and structures that it is planned to leave on the site for a potentially prolonged period are very robust, passively safe and can be readily maintained in this state for a long period. They will not therefore present a significant hazard or risk to the public, workers or environment. Natural radioactive decay over this deferral period will result in a substantial reduction in radioactivity levels and hence the hazards, such as they are, will continue to reduce in a systematic and progressive way.

'The expected outcome ... will be a plan to remove and/or immobilise the most active and potentially mobile radioactivity on a relatively short timescale, with further actions following at appropriate intervals consistent with the hazards they seek to address.' **[125]**

As stated above, Magnox Electric strategies initially focus on the most active and potentially mobile radioactivity in the early phase of decommissioning. The remaining hazards are less significant and, when account is taken of all relevant factors, it is considered appropriate to defer some further actions, eg reactor dismantling, for a period.

'The rate at which the work proceeds will be determined by the potential hazards posed to the public, workers and the environment (recognising the benefits obtainable from radioactive decay), the availability of disposal routes for the wastes and – subject to ensuring public safety – the financial implications of proceeding on different timescales.' **[125]**

The relevant factors that have been taken into account in deciding which decommissioning actions should be deferred include those stated in the above extract. There are not considered to be any safety problems in deferring the dismantling of some plant and structures and safety will be demonstrated, monitored and maintained throughout the deferral period. Deferral will allow significant benefits to be obtained from radioactive decay. It is Government Policy that disposal routes (e.g. for ILW) will become available in the longer term, in addition public safety will be ensured, and there will be financial benefits.

'it would be unwise at present for the operators of nuclear power stations to take steps which would foreclose technically or economically the option of completing Stage II and III on an earlier timescale should that be required' **[126]**

Whilst the reactor decommissioning strategy defers some activities, there are no technical reasons why the work could not be brought forward. As noted in Section 9, the costs of decommissioning have been discounted at 2.5%. £100 spent in 40 years time discounts to around £40, whilst £100 spent in 100 years time discounts to around £10. The assumption with respect to reactor decommissioning timing is therefore crucial to the level of provisioning. In order not to foreclose earlier reactor decommissioning, the provisions include an allowance for the risk of earlier decommissioning. It should be noted that this is a risk provision, and as such, would be insufficient to fund all conceivable reactor decommissioning strategies.

In addition to not foreclosing alternative timings technically or economically, the strategies are also sufficiently flexible to accommodate other potential changes that could happen over time. For example, dates other than the presently assumed ILW repository availability dates can be accommodated. Changes are not expected to cause undue technical difficulties and allowances have been made in the financial provisions to recognise the potential for changes.

'they [operators] should recognise, when provisioning, the potential uncertainties regarding the timing of Stage II and Stage III decommissioning.' **[126]**

As stated above, the provisions make an allowance for completing decommissioning earlier than planned.

'the Government also confirms its preliminary conclusion that there are a number of potentially feasible and acceptable decommissioning strategies for nuclear power stations available to the operator, including the safestore strategy' **[126]**

The definition of the Safestore strategy included in Cm 2919 **[121]** recognises that final site clearance for reactor sites could be deferred for a period of about 130 years. The technical work that has been done to date indicates that such a timescale is feasible, does have benefits and could be achieved safely. However, the programme for the revised Safestore strategy presented in this submission, as the preferred and planned strategy for the reactor sites, assumes that final site clearance is completed on timescales earlier than 130 years.

'To ensure that operators' decommissioning strategies remain soundly based as circumstances change, they will be reviewed quinquennially by HSE, who will consult the Environment Agencies.' **[126]**

This document is the second submission to HSE by Magnox Electric under the Quinquennial Review requirement.

Annex 3 Glossary

EPRI	Electric Power Research Institute (US)
EA	Environment Agency
HLW	High Level Waste
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IMC	Industry Management Committee
LLW	Low Level Waste
MAC	Miscellaneous Activated Components
Magnox	Magnesium alloy used as the canning material in fuel elements
MCI	Miscellaneous Contaminated Items
NEA	Nuclear Energy Agency (OECD)
NIA 65	The Nuclear Installations Act 1965 (as amended)
NII	HM Nuclear Installations Inspectorate
OECD	Organisation for Economic Co-operation and Development
OSPAR	The Oslo/Paris Conference of North Atlantic Environment Ministers
Phytoremediation	The use of green plants to remove pollutants from the environment or to render them harmless
RDU	Reactor Decommissioning Unit
RSA 93	The Radioactive Substances Act 1993
SEPA	Scottish Environment Protection Agency
UKCIP	UK Climate Impacts Programme
UK Nirex Ltd	Formerly Nirex (Nuclear Industry Radioactive Waste Executive)
UK National Inventory	Information on current stocks and predicted arisings of wastes including volumes, radioactivity content and physical and chemical form which is updated periodically.

APPENDIX 2

Extract from letter from British Nuclear Fuels plc to the NII, dated 19 January 2001

Re: Magnox Electric Quinquennial Review of Decommissioning and Waste Management Strategies

....the Magnox Electric quinquennial review document *{Appendix 1}* ... was sent to you under cover of my letter dated 28 April 2000 ... This document identified in Section 9 the financial provisions that Magnox Electric had set aside to cover its nuclear liabilities as at 31 March 1999.

....the financial provisions have been recalculated as at March 2000. As these revised provisions are based on the waste and decommissioning strategies presented in the submission document *{Appendix 1},* whereas the 31 March 1999 values are not, we would suggest that your review of our submission should consider the more recent values.

The 31 March 2000 values are :-

	£m
Fuel reprocessing and waste management	4,675
Decommissioning	4,395
Other (non-nuclear provisions)	65
	9,135

These values can be found in Note 18 on page 22 of the Magnox Electric plc Annual Report and Accounts, 31 March 2000. (reference 4)

APPENDIX 3

BNFL announces Magnox station lifetimes - 23 May 2000

Station	Licensed lifetime	Age at Cessation of Generation	Latest date for end of Generation
Calder Hall	50	50	2006 – 2008
Chapelcross	50	50	2008 – 2010
Bradwell	40	40	2002
Hinkley Point A	40	35	2000
Dungeness A	40	40	2006
Sizewell A	40	40	2006
Oldbury*	40	45	2013
Wylfa*	33	45	2016/2021

* Continuing to run Oldbury and Wylfa to these dates depends upon the development and use of Magrox fuel. Magrox is a fuel in which uranium is used in ceramic oxide rather than metal form. A decision on the use of Magrox fuel will be taken in around 2003. Oldbury and Wylfa will also need to undergo a Periodic Safety Review in order to secure operation to these dates.

Note: The decision not to progress the development of Magrox fuel was taken by BNFL in January 2001.

APPENDIX 4

Multi attribute decision analysis (MADA) - Background

The Royal Commission on Environmental Pollution, in their Twelfth Report, February 1988, addressed 'Best Practicable Environmental Options', Cm 310 (reference 20). The Commission noted that the term 'best practicable environmental option' (or 'BPEO') represented the best option *'taking account of the total pollution from a process and the technical possibilities for dealing with it'*. The BPEO, as envisaged, also involved the implementation of a systematic consultative and decision making process. The Twelfth Report provides a detailed exposition of the concept of BPEO, and of the principles that underline it, together with guidelines on it implications and its implementation. The Report provides a summary of the steps to be covered in selecting a BPEO, these are:

1. define the objective;
2. generate the options;
3. evaluate the options;
4. summarise and present the evaluation;
5. select the preferred option [BPEO];
6. review the preferred option; and
7. implement and monitor.

Throughout there is a need to maintain an auditable trail.

The Environmental Protection Act 1990 (EPA90) requires the regulatory body (originally HM Inspectorate of Pollution (HMIP), later to become the Environment Agency (EA) in England and Wales, and the Scottish Environment Protection Agency (SEPA)) to have regard to BPEO in setting conditions on Authorisations. In 1996 the regulator produced a guidance booklet entitled 'Best Practicable Environmental Option Assessments for IPC: A Summary' (reference 21) which defined the BPEO as - *"the option which, for a given objective, provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term as a result of releases of substances from an IPC process".* The guidance then expands on the seven steps defined in Cm 310.

APPENDIX 5

Magnox Station Lifetimes for Provisioning Purposes

Station	Decision on next PSR due	End of Generation / Closure date assumed for provisioning purposes	Start of final dismantling	Years after end of generation
Berkeley	-		2074	85
Hunterston A	-	1990	2081	91
Trawsfynydd	-	1993	2088	95
Hinkley Point A	-	2000	2095	95
Bradwell	2002	2002	2095	93
Dungeness A	2006	2006	2102	96
Sizewell A	2006	2006	2102	96
Oldbury	2008	2008 *	2109	101
Wylfa	2004	2009 *	2116	107
* conservative dates used for provisioning				

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