Nuclear Decommissioning Authority

Oxide Fuels

Credible Options

November 2011

Executive Summary

Background

After the NDA was formed it inherited a range of contracts covering reprocessing and storage of oxide spent fuels. Our strategy for oxide fuels is to honour our contractual obligations and complete the reprocessing contracts in THORP and place any remaining fuels into storage.[1]

THORP was expected to complete the reprocessing contracts by 2010. However, due to operational difficulties both in THORP and in downstream support plants this has not been possible. THORP is now expected to complete the reprocessing contracts in 2018.

Approach

In accordance with the commitment given in our 2011 Strategy, the NDA has been investigating whether the current strategy for managing our oxide fuels, compared to other credible alternatives, remains the most cost-effective.

This paper reports the key findings of this review of the underpinning for the strategy. It presents the Credible Options for oxide fuels and our assessment of them against a number of criteria. The details of this assessment are given in Section 3.

The options considered were;

- **Option 1**: Complete the reprocessing contracts in THORP — the current strategy for oxide fuels
- **Option 2**: Reprocess less than the contracted amount of spent fuel in THORP
- **Option 3**: Reprocess more than the contracted amount of spent fuel in THORP.

Key Findings

Our analysis has shown that the amount of fuel that should be reprocessed in THORP on economic grounds is comparable to the amount that is contracted to be reprocessed. This is due to a number of interacting factors which results in an alignment of economic and commercial drivers. Therefore, the delivery of the current strategy (Option 1), to complete the reprocessing contracts, remains the most viable and cost-effective option. Following the closure of THORP in 2018 we plan to place the remaining AGR fuel into interim storage pending conditioning and disposal to a Geological Disposal Facility (GDF). Future reviews and decisions will confirm how to manage it for the long-term.

[1] To complete the current reprocessing contracts some flexibility will be required around some very small amounts of the overseas fuels. They amount to about less than 0.1% of the THORP order book by mass.

We have also considered extending the reprocessing of fuel in THORP beyond the amount required by the contracts (Option 3). This includes AGR fuel and potential new business from domestic and overseas customers.

Delivering our strategy carries some performance risks. We will, therefore, continue to examine options to optimise the strategy and keep it cost-effective. This includes the option to reprocess less than the full contracted amount of spent fuel in THORP in case it is needed (Option 2).

Our analysis has shown reprocessing further AGR fuel beyond that needed to create space for interim storage is not a cost-effective means of managing it compared to Option 1.

The success of delivering our strategy depends on two key conditions;

a. Obtaining the required performance across our existing reprocessing assets
b. Securing an agreed means for the interim storage of the remaining AGR spent fuel.

We believe meeting these conditions is highly credible and our case to do so is well-advanced.

Way Forward

NDA's Strategy for Oxide Fuels

Our strategy for THORP and the future management of AGR spent fuel is subject to meeting the conditions (a) and (b) above. We will continue our work to underpin our strategy and expect to complete it by summer 2012, when it would be confirmed as our preferred strategic option.

THORP and the Long-term Potential for Reprocessing in the UK

Our strategy to close THORP following completion of the reprocessing contracts has potentially wider policy implications for spent fuel management in the UK.

The Government has, therefore, asked the NDA to use our work as the basis for providing advice to them about the wider, long-term potential for reprocessing in the UK. In section 8 we have set out our views on this, in the context of current Government policy and the currently foreseeable situation in the UK.

As well as feedback on our business decision about THORP and AGR fuel we are also therefore interested in receiving views on the long-term potential for reprocessing in the UK.

GLOSSARY

AGR	Advanced Gas Cooled Reactor. There are seven AGR power stations in the UK
BNFL	British Nuclear Fuels Ltd, the previous owner and operator of Sellafield Ltd prior to the formation of NDA
EDF Energy	The company that owns and operates the AGR power stations in the UK
GDF	Geological Disposal Facility, a facility for the disposal of intermediate and high level wastes including spent fuel.
HAL	Highly Active Liquor, an effluent from reprocessing spent fuel in THORP that is vitrified to form a disposable waste
HASTs	Highly Active Storage Tanks, highly engineered tanks used to store HAL prior to its vitrification
HLW	High Level Waste, being ILW but of such high radioactivity content as to be self-heat generating
ILW	Intermediate Level Waste
LLW	Low Level Waste
LWR	Light Water Reactor (comprising PWR (pressurised water reactor) and BWR (boiling water reactor designs)
MOX	Mixed Oxide Fuel, comprising plutonium and uranium oxides
NDA	The Nuclear Decommissioning Authority
NMP	Nuclear Management Partners, the operator contracted by the NDA to run Sellafield
OSPAR	Oslo Paris Convention on protecting the marine environment of the North East Atlantic
PWR	Pressurised Water Reactor. Sizewell B is a PWR
RWMD	Radioactive Waste Management Directorate. A division of the NDA responsible for developing a GDF for the disposal of intermediate and high level wastes including spent fuel
SED	Safety & Environmental Detriment, a numerical system developed by the NDA, the purpose of which is to quantify the hazard posed by a facility storing nuclear material. It was developed to help prioritise the funding of high hazard decommissioning and clean-up projects across our estate
SMP	The Sellafield MOX Plant, a plant intended to manufacture MOX fuel from the products of THORP reprocessing for overseas customers
SL	Sellafield Limited
SF	Spent Fuel
THORP	Thermal Oxide Reprocessing Plant – a chemical plant owned by NDA and operated by Sellafield Ltd for the reprocessing of oxide spent fuels from AGRs and LWRs
UKAEA	United Kingdom Atomic Energy Authority

1 INTRODUCTION

The NDA has an inventory of oxide spent fuel to manage from overseas and domestic customers. This includes managing the spent fuel from the UK's fleet of AGR power stations, owned and operated by EDFE. This section details the amounts of spent fuel contracted for management at Sellafield, about half of which is scheduled to be reprocessed in THORP.

1.1 Oxide fuel is used in Advanced Gas-Cooled Reactors (AGR) operated by EDF Energy in the UK, and in Light Water Reactors (LWR) operated by numerous utilities throughout the world. Oxide fuel is reprocessed in the Thermal Oxide Reprocessing Plant (THORP) at Sellafield which started operation in 1994.

1.2 Reprocessing of spent fuel in THORP provides uranium and plutonium products that can be potentially reused by our customers in new nuclear fuel, such as MOX. An alternative approach to reprocessing for managing AGR spent fuel is to store it in purpose built ponds or dry stores, pending a decision at some point in the future to either dispose of the fuel to a geological disposal facility (GDF) or to reprocess it.

1.3 After the NDA took over the UK's nuclear liabilities, it inherited from BNFL a range of spent fuel management contracts with domestic and overseas customers.

1.4 The NDA is contractually committed to receive and manage all spent fuel arising from the seven EDF Energy (EDFE) AGR power stations in England and Scotland. The contracts and ownership of AGR spent fuel reflect the many changes to the UK energy and nuclear industry that have occurred since the first AGRs were commissioned in mid- 1970s.

1.5 Based on current projections of the lifetime of the AGR fleet we estimate there remains about 6,200 teU of spent fuel for NDA to manage. About a third of this fuel is contracted with EDFE for reprocessing and the remaining two-thirds of this fuel is contracted for reprocessing or storage at our discretion. It should also be noted that, of the lifetime arisings of AGR fuel, about half is owned by EDFE and about half is owned by the NDA.[2,3]

[2] The split ownership of AGR spent fuel reflects the solvent restructuring of British Energy in late 2004. Fuel loaded into reactors prior to midnight on the 14 January 2005 is owned by EDFE and is referred to as 'historic' fuel; fuel loaded after this date is owned by NDA and is referred to as 'future' fuel.
[3] The NDA does not hold any contracts for, nor is it liable for the management of spent fuel from Sizewell B or from any potential new nuclear reactors.

1.6 If EDFE chooses to extend the lifetimes of its AGR fleet this will increase the amount of fuel we have to manage. The fuel arising from these potential station extensions is covered by the contracts between EDFE and NDA and would be owned by NDA. Under the terms of our contracts we are obliged to receive and manage all the AGR spent fuel coming from EDFE's AGR power stations.

1.7 Typically EDFE's AGR fleet discharges about 180 teU of spent fuel each year to Sellafield. Therefore, if EDFE extended its entire AGR fleet by 5-years we would have to manage an additional 900 teU of spent fuel.

1.8 The NDA also holds contracts to reprocess overseas-derived LWR fuel in THORP that has been received and is being stored at Sellafield. The contracts also cover the management of products and the return of appropriately conditioned wastes to customers. There remains about 400 teU of this fuel to reprocess. This means THORP has now completed over 90% of its order book for overseas fuel reprocessing.

1.9 There is also an inventory of oxide fuels which the NDA has inherited from the UKAEA. These fuels generally came from prototype reactors from the UK's historic nuclear energy development programmes. There is approximately 150 teU of this spent fuel and it is scheduled to be reprocessed in THORP.

1.10 A summary of the overseas- and UK-owned oxide spent fuel inventory for which the NDA holds contracts to manage is provided in Figure 1, overleaf. The diagram reflects the amounts of fuel committed by the contracts to be reprocessed, the "THORP order book", and the amounts which can be stored or reprocessed at the NDA's discretion.

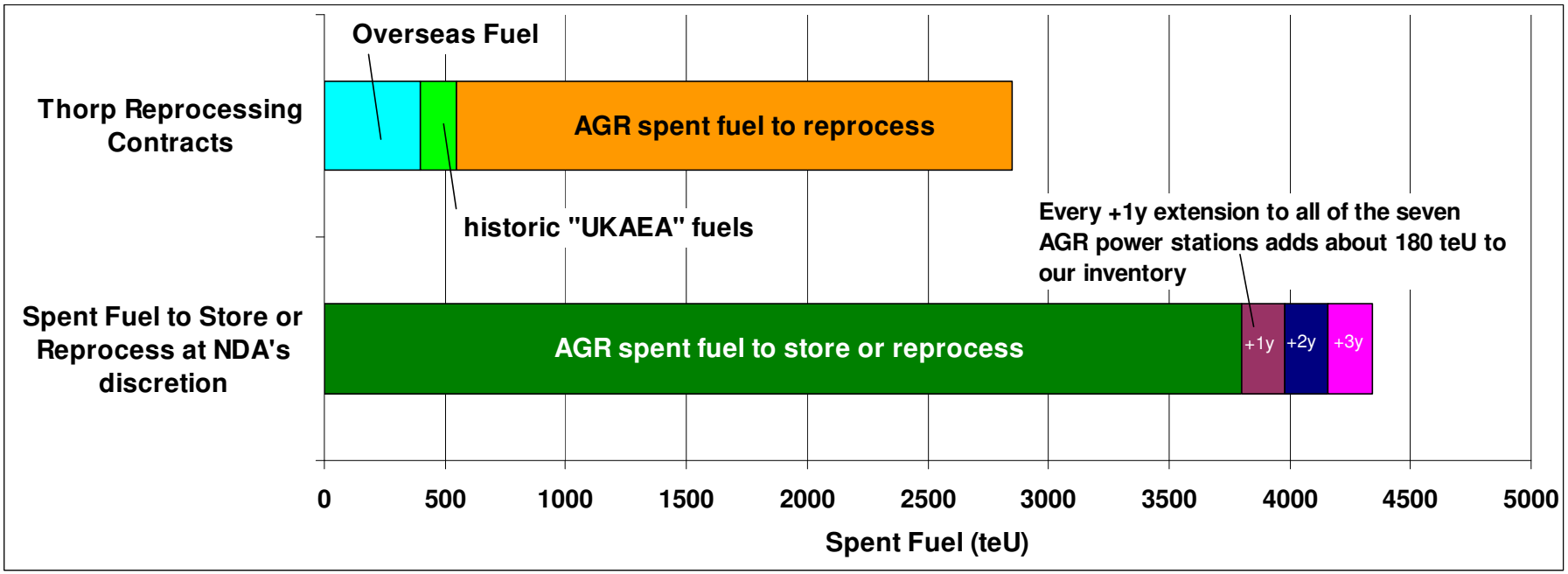

Figure 1 The NDA's oxide spent fuel inventory committed by our contracts to reprocessing and/or storage

2 THE CURRENT STRATEGY FOR OXIDE FUELS AND THE CASE FOR REVIEW

The NDA's strategy for managing its oxide spent fuels is to complete the reprocessing contracts in THORP and place any remaining fuel into storage. This section explains why the NDA is undertaking a study of its options for managing oxide fuels. It also explains the context of our study based on NDA's responsibilities under the Energy Act and since the decision to build THORP was made in the 1970s

THE CURRENT STRATEGY FOR OXIDE FUELS

2.1 In March 2011, following public consultation and Ministerial approval, we published our over-arching Strategy.[4] In this we explained that our current strategy for oxide spent fuels is to;

- Complete the reprocessing contracts in THORP as soon as practicable and;
- Place the remaining fuel, including any future arisings, into storage pending disposal to a GDF

2.2 Our strategy for oxide fuels reflects Government policy to complete the reprocessing contracts through THORP.[5] This Government direction was given to us through the Energy Act, 2004.

2.3 The delivery of our strategy for oxide fuels also ensures that we can meet our obligations to be able to regularly receive and manage spent fuel at Sellafield from EDFE's AGR power stations. The AGR power stations were built with cooling ponds of limited capacity to buffer store spent fuel arisings. For this reason it is essential that their ability to discharge fuel to Sellafield is maintained to sustain electricity generation.

[4] The Energy Act 2004 requires the Nuclear Decommissioning Authority (NDA) to review and publish its over-arching Strategy at least every five years. A copy of our Strategy can be seen on our website, http://www.nda.gov.uk/strategy/.
[5] ENERGY ACT 2004: Directions to the Nuclear Decommissioning Authority (the NDA) in respect of the Sellafield Nuclear Site http://www.nda.gov.uk/documents/upload/Directions-to-NDA-in-respect-of-Sellafield.pdf

THE CASE FOR A REVIEW OF THE OPTIONS FOR OXIDE FUELS

THE WINDSCALE INQUIRY AND THE DECISION TO BUILD THORP

2.4 In 1977 the proposal by British Nuclear Fuels (BNFL) to build THORP and reprocess AGR and overseas spent fuels was subject to a public inquiry, called the Windscale Inquiry, chaired by Justice Parker.[6]

2.5 Following a favourable report from the Windscale Inquiry, BNFL's proposal to build and operate THORP was approved. THORP was designed and built to reprocess oxide spent fuel for the following reasons;

- to recover the plutonium from AGR spent fuel so that it could be reused as MOX fuel in a commercial fast reactor programme
- because at the time there was insufficient confidence in the long-term wet or dry storage of the stainless steel clad AGR fuels and their subsequent disposal to a Geological Disposal Facility (GDF)
- to reprocess spent fuel from overseas customers under commercial contracts that would be profitable to the UK

2.6 However, since the Windscale Inquiry and the subsequent decision in 1978 to build THORP much has changed and the strategy has been reviewed by NDA a number of times, first with the publication of our 2006 Strategy and again with the publication of our 2011 Strategy. In the 2011 Strategy we undertook to carry out a study into the underpinning for this Strategy to ensure we have adopted the most cost-effective lifecycle management option.

CHANGES TO THE UK'S NUCLEAR INDUSTRY SINCE THE DECISION TO BUILD THORP

2.7 The UK has abandoned its fast reactor programme and there is no national policy to recover and reuse reprocessed plutonium or uranium. The current nuclear programme does not use plutonium-based fuels and the potential new UK nuclear new-build programme does not consider its use at this time. The Government's recent consultation on plutonium management described how a proposal to reuse separated plutonium in MOX fuel would be based on providing a cost-effective option for its management, rather than as a commercial operation in its own right. Further discussion on this is provided in section 8.[7]

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[6] The Windscale Inquiry, Justice Parker, Vol 1, 1978, HMSO, ISBN 0117513148.
[7] http://www.decc.gov.uk/en/content/cms/consultations/plutonium/plutonium.aspx

2.8 In the late 1970s it was uncertain whether AGR spent fuel could be stored for many decades. There was also concern about the continued build-up of spent fuel and plutonium in storage with little prospect of its final disposal.

2.9 Since this time, considerable knowledge and experience has been gained on the extended storage of AGR fuel, especially in ponds. Such is the extent of this work that the NDA believes that the technical and safety case for both storage and disposal of AGR spent fuel can be made. The case for this will be put by Sellafield Ltd and is subject to Regulatory approval. Although further and substantial work is still required in support of this, we believe any remaining uncertainties can be addressed. This is discussed in more detail in Section 4.

2.10 As well as the storage of spent fuel much further work has been undertaken on its disposal both in the UK and internationally. The Government has decided that, if spent fuel was to be disposed of, the best means of disposing it is to a Geological Disposal Facility (GDF). The higher activity wastes from reprocessing will also be disposed of to a GDF. In recognition of this, for planning purposes we use the "Baseline Inventory" provided in the Managing Radioactive Waste Safely White Paper as the basis for developing a geological disposal system specification and facility designs.[8]

2.11 This decision by Government was made after a series of studies and following the recommendations of CoRWM. The development and implementation of a facility for deep geological disposal of higher activity wastes is the responsibility of the Radioactive Waste Management Directorate (RWMD) of the NDA.

2.12 After the NDA was created in 2005 all of BNFL's contracts, assets and liabilities including those relating to THORP were transferred to the NDA. Our core objective is to ensure that the historic civil public sector nuclear legacy sites are decommissioned safely, securely, cost effectively and in ways that protect the environment. As part of this, we are required to operate existing commercial activities and meet current contracts, using revenues generated to offset spend on decommissioning.

2.13 Our objectives of nuclear clean-up and decommissioning are laid out in the Energy Act 2004 and are very different from those of BNFL's, the company that built THORP.

[8] A copy of the MRWS White paper is can be found at DECC's website see, http://mrws.decc.gov.uk/assets/decc/mrws/white-paper-final.pdf

RECENT EVENTS AND PERFORMANCE

2.14 After the NDA was formed in 2005 and took over BNFL's contracts THORP was originally expected to complete its order book in 2010. However, this has not been possible because of the cumulative effect of several failures at THORP and its supporting facilities, with the resulting loss of throughput. This has pushed back the estimate for completing reprocessing against our existing contracts to a significantly later date. It has also resulted in the need for additional infrastructure to support reprocessing operations to these later dates, as well as incurring the additional operational costs for THORP and supporting plants.

2.15 In 2011, the Sellafield Performance Plan was published which has a THORP end date of November 2018.[9] This is based on assumptions about reprocessing performance and the time it takes to prepare our facilities for the interim storage of the remaining AGR spent fuel. The plan also assumes additional infrastructure, replacement highly active storage tanks (replacement HASTs), that are required to handle the highly active wastes produced by reprocessing, at a capital cost of nearly £500M.

2.16 For all of the reasons cited above the NDA initiated a review of the options for managing its oxide fuels, the main purposes of which are to;

- Determine whether the current strategy, compared to other credible alternatives, remains the most cost-effective means of meeting our contractual commitments and obligations under the Energy Act
- Review and underpin our options for the future management of AGR fuel following a closure of THORP
- Inform future investment decisions on spent fuel management infrastructure against the strategy

THE WIDER CONTEXT OF OUR OPTIONS REVIEW OF OXIDE FUELS

2.17 We and Government recognise, however, that the closure of THORP has potentially wider policy implications for spent fuel management in the UK.

2.18 For over fifty years the UK has reprocessed spent fuel both as a means of managing it and as a means of supplying a commercial business service to both domestic and overseas energy companies. Therefore the closure of THORP signals a UK exit from reprocessing for the foreseeable future.

[9] The Sellafield Performance Plan was compiled by Sellafield Ltd under the guidance of Nuclear Management Partners (NMP), owners of the Site Licence Company.
http://www.sellafieldsites.com/news/2011-08-03/launch-of-the-sellafield-plan

2.19 There are a wide range of views amongst our stakeholders over the historic, current and future economic value of reprocessing to the UK and its nuclear industry.

2.20 The Government, therefore, has asked NDA to consider the potential wider impacts of its business decision on THORP on the potential for reprocessing in the UK and advise it of this. In section 8 we have set out our understanding of this in the context of current Government policy and the currently foreseeable situation in the UK.

2.21 In addition to inviting feedback on our business decision about THORP and AGR fuel, the NDA is also interested therefore in receiving views on the long-term potential for reprocessing in the UK.

3 DEVELOPMENT OF THE CREDIBLE OPTIONS

The key questions facing NDA are how much of the remaining fuels should be reprocessed in THORP and how any remaining fuels should be managed after its closure. This section explains how we developed the Credible Options for oxide spent fuels. It also highlights the effects of potential AGR station extensions by EDFE on our options to manage these fuels.

3.1 We consider that the driving strategic questions facing NDA about the management of *our* oxide spent fuels are;

- How much of the remaining oxide spent fuel, including any potential future arisings, should be reprocessed in THORP?
- How should we manage our remaining oxide fuels following a closure of THORP?

3.2 In the first instance, to develop our credible options we considered how much of the current and projected inventory could be reprocessed in THORP. We examined the likelihood of significant extensions to EDFE's AGR fleet and the potential impacts of this for reprocessing in THORP. We determined from this that if the AGR reactors were to receive significant lifetime extensions, say plus 5 years, then to reprocess all the AGR fuel would require operating THORP to the mid 2030s.

3.3 We concluded from this that it is highly unlikely that all the spent fuel coming from the AGR reactors can be reprocessed in THORP. Therefore, it is inevitable that the NDA will have to prepare at some point in the future to store thousands of tonnes of AGR spent fuel following a closure of THORP.

3.4 Given that we do not believe that THORP can manage all of our oxide fuels, the question facing NDA is largely one of strategic optimisation i.e. how much oxide fuel should we reprocess?

3.5 In this study we compared three options based on the amount of spent fuel reprocessed.

- **Option 1**: Complete the reprocessing contracts in THORP — the current strategy
- **Option 2**: Reprocess less than the contracted amount of spent fuel in THORP
- **Option 3**: Reprocess more than the contracted amount of spent fuel in THORP.

3.6 The amount of spent fuel to reprocess and the timing of THORP closure are strongly related. The costs and need to reprocess spent fuel are influenced by a number of interacting factors including THORP throughput, the ageing of our infrastructure, potential extensions to the AGR fleet, and our preparations for storage of the remaining spent fuels. This means we must also consider when would be the right time to close THORP.

3.7 We consider that the timing of the closure of THORP is affected by the availability and confidence in the alternative arrangements for storage and potentially disposal of our oxide fuels. If spent fuel is not reprocessed then it will be placed into storage with a view to disposing of it to a Geological Disposal Facility many years from now.[10] To underpin our comparison of options we have evaluated the lifecycle of spent fuel if it is reprocessed in THORP compared to it being stored and then disposed of.

3.8 The issues and decision over how the remaining oxide fuels are stored in the long-term and ultimately disposed are very important and will continue to receive strategic analysis from the NDA. However, the current decision facing

[10] These additional questions on long-term management of oxide fuels acknowledge that the NDA will be the owner of a greater part of any remaining oxide fuels, and that the management of spent nuclear fuels will span many decades and is an inter-generational issue. Placing the spent fuel into storage with a view to disposal would not preclude the option to reprocess or use an alternative conditioning technology at a later date. This is because the fuel would be maintained in a condition suitable for retrieval, inspection and recovery in compliance with IAEA guidelines and national regulatory requirements.

NDA is when to conclude THORP reprocessing and how to manage the remaining fuels in the period after its closure. This decision on THORP will then inform further spent fuel management and investment decisions on the NDA estate, such as the need for replacement HASTs or additional spent fuel storage facilities.

4 ASSESSMENT OF THE CREDIBLE OPTIONS

We have assessed each of our credible options against a set of criteria. The criteria we considered were wide-ranging covering Government policy, technical maturity and those from NDA's Value Framework (Cost, Income, Hazard, Safety, Environment & Socio-economics). This section provides the details of this assessment against each of the credible options.

4.1 We have undertaken an appraisal of each of the strategic options against a set of criteria we consider important in making a decision on oxide fuels. These criteria include the six attributes from NDA's Value Framework (Cost, Income, Hazard, Safety, Environment and Socio-economics).

4.2 Based on this we have undertaken an appraisal of the options against the following criteria;

A. Government Policy and contractual commitments
B. Cost, Income and cost uncertainty
C. Hazard, safety, security, environmental and socio-economic aspects included within NDA's Value Framework
D. Technical maturity, especially the viability of the interim storage and disposal of AGR spent fuel

We have also considered the options against;

- Our ability to manage AGR the lifetime arisings of fuel from EDFE's stations, see section 5; and
- Performance risks due to the age and condition of our infrastructure, see section 6

A. GOVERNMENT POLICY AND OUR CONTRACTUAL COMMITMENTS

4.3 The NDA was directed by the Energy Act 2004 to operate THORP to complete the reprocessing contracts for both overseas and domestic customers.[11] The overseas reprocessing contracts are also covered by inter-Governmental treaties agreeing to the reprocessing of fuel and return of products and wastes as applicable.[12]

4.4 If we were not to fulfil our contractual commitments for some fuels it would require Secretary of State approval and the agreement of an acceptable alternative option with the relevant customer.

4.5 In delivering our strategy for oxide fuels, if we determined that a more cost-effective option was available for managing particular fuels, we would prepare the case and a plan to implement the alternative option and submit this to the Secretary of State and our customer[s], if appropriate, for their approval.

4.6 Thus far, we have determined that to complete the current reprocessing contracts some flexibility will be required around some very small amounts of the overseas fuels. In the main, these 'leftovers' are experimental fuels and test materials from historical collaborative nuclear technology programmes with overseas companies and organisations. They amount to about less than 0.1% of the THORP order book by mass.

4.7 Government approval would also be required to take on new reprocessing contracts in THORP, if any such business was available. Our position on the prospects of new business in THORP is discussed in section 8.

B. COST, INCOME and COST UNCERTAINTY

4.8 We have assessed the lifecycle costs for managing all of our oxide fuels including the products and wastes from reprocessing compared to the direct disposal of spent fuel. We also included the costs for storage of spent fuels and wastes. This covered both wet and dry storage of spent fuel and the option to transfer fuel into long-term dry storage after a period of interim wet

[11] "The NDA shall operate THORP to complete existing reprocessing contracts, or any new contracts to which the Secretary of State has given her approval. The approval of the Secretary of State will be required for the following: any changes or variations to existing contracts that would change the physical quantity of fuel to be reprocessed under the contracts, and any changes or variations to existing contracts that would alter the economic case for the continued operation of THORP." See, ENERGY ACT 2004: Directions to the Nuclear Decommissioning Authority (the NDA) in respect of the Sellafield Nuclear Site http://www.nda.gov.uk/documents/upload/Directions-to-NDA-in-respect-of-Sellafield.pdf

[12] Government policy to complete the overseas reprocessing contracts through THORP was re-affirmed as recently as 2007 in the response to the Public Consultation on the Advance Allocation of some overseas-owned spent fuels.

storage. Our assessment included the capital build costs for potential new facilities that would support reprocessing operations and storage facilities for spent fuel and other wastes. The costs for operating these facilities were also included, as were the costs for disposing of spent fuel or wastes to a GDF.

4.9 In support of this work Sellafield Ltd conducted a year-long study that determined the infrastructure required to support THORP operating until as far as 2040. The study found that extended reprocessing in THORP beyond the contracted amount and into the next decade would require major, multi-billion pound investment across a wide-range of infrastructure at Sellafield. There would be numerous major capital build projects required to support THORP to this date.

4.10 We also included the revenue implications in this analysis including options for new spent fuel management services and managing additional spent fuel coming from any potential life extensions to EDFE's AGR fleet.[13]

4.11 The cost assessment of our options includes commercially sensitive information with overseas and domestic energy companies. The details of this cannot, therefore, be released.

4.12 The key findings of our cost study of the options was that there is "U-shaped" cost profile with the lowest cost close to our contract position and higher costs incurred for reprocessing less than or more than the contracted amount of spent fuel.

4.13 This means that based on our current understanding and assumptions delivering the contracts (Option1) is the most cost-effective option.[1] This option will make the best and most cost-effective use of our existing spent fuel management assets.

4.14 Over about the next seven years the costs to NDA to continue reprocessing spent fuel are comparable to the costs for storage and direct disposal. This is in the large part because the capital costs for the reprocessing infrastructure are already sunk. If these assets were not available it would be more cost-effective to cease reprocessing early.

4.15 If we exit reprocessing too early we will incur additional costs for;

- building additional storage capacity for AGR fuel
- managing fuels that are more susceptible to corrosion during storage

[13] As our cost assessment covers commercially sensitive information with overseas and domestic energy companies the details of it cannot be released.

- implementing alternative options for managing some fuels, for example, such as transferring the spent fuel to another reprocessor for reprocessing.

4.16 If we continue to reprocess AGR fuel beyond the amount needed to create sufficient space for interim storage (option 3) it would also not be cost-effective. If we were to run THORP beyond about 2020 we would have to gradually replace many of the secondary facilities that support its operations at great expense, although it is technically viable to do so. In NDA's view it is highly likely that making such investments would impact on the rate of risk and hazard reduction at Sellafield by diverting finite resources.

4.17 The outcome of our cost analysis has shown that completing the reprocessing contracts remains the most cost-effective strategy for our oxide fuels. In effect, when a number of interacting factors are taken into account, the amount of fuel that should be reprocessed in THORP on grounds of cost is comparable to the amount that is contracted to be reprocessed.

4.18 However, this is conditional on being able to complete the reprocessing contracts without the need for the replacement HASTs. If the costs for completing the reprocessing contracts were to rise – through the need for additional infrastructure or significant delays to the current programme – then it could be more cost-effective to reprocess less fuel than currently scheduled. Therefore, we will continue to monitor closely our reprocessing performance and the costs for completing the reprocessing contracts. We will continue to examine options to reprocess less fuel to ensure our strategy remains cost-effective.

C. NUCLEAR HAZARD, SAFETY, SECURITY and ENVIRONMENTAL ASPECTS

OVERVIEW

4.19 Reprocessing is preferred by some countries for managing spent oxide fuel, e.g. France and Japan, whereas "store-then-dispose" is preferred by others e.g. USA and Germany. Worldwide, the great majority of oxide fuel is stored wet in ponds. However, the dry storage of oxide fuels is becoming increasingly common with power station operators looking to expand capacity at operating nuclear power stations.

4.20 Our assessment noted that reprocessing and wet/dry storage options can be licensed for operation by national regulators and are therefore all

potentially acceptable. Whilst this is true, our appraisal did highlight some differences between the options which are discussed below.

NUCLEAR HAZARD (including Safety and Environmental Detriment)

4.21 Reprocessing of spent fuel produces highly active liquors (HAL) and separated plutonium. Once the HAL is vitrified into a HLW glass and the separated plutonium is made into new fuel their Safety and Environmental Detriment (SED) scores are comparable to those of spent fuel.

4.22 The SED scores of the storage of oxide spent fuels under pond or dry storage conditions are broadly comparable and very low. This is because the fuels are regarded as stable and unlikely to degrade even under credible fault conditions.

4.23 Some of our oxide fuels are more susceptible to corrosion during storage due to their sensitisation in the reactor if followed by sub-optimal storage conditions. We also have significant amounts of fuel debris and prototype fuels that have come from many years of experimental programmes. Our preference is to reprocess these fuels to simplify future storage arrangements. However, these differences have minimal impact on the SED rating and if THORP was inoperable we could still safely manage these fuels in either wet or dry storage.[14]

NON-NUCLEAR SAFETY

4.24 Safety as considered in NDA's value framework consists of worker dose and transport mileage. Of the options, doing additional reprocessing was the worst performing on the basis of high staffing levels resulting in greater worker dose uptake and transportation mileage.

[14] SED was developed to assist NDA and its site license companies in prioritising activities to reduced risk and hazard. It was never intended that it would be used to evaluate commercial nuclear fuel cycle options. In general, we have found it to be of limited value in discriminating between these options.

NUCLEAR SECURITY

4.25 Reprocessing produces separated plutonium which is securely stored at Sellafield. The overseas separated plutonium from THORP reprocessing will go into in to secure storage pending a decision from the owner on how to manage it. Neither early THORP closure or completing the contracts has any differential impact on the nature and number of spent fuel and waste transports as all existing products and wastes still have to be returned to customers in line with contractual obligations.

ENVIRONMENT

4.26 Consideration of environmental issues covers radiological and non-radiological impacts. Radiological discharges from THORP are regulated through Environmental Permits that require the operator to apply best practicable means to minimise wastes generated and discharges to the environment. To achieve this, the operator may install and operate abatement plants and/or choose to minimise at source. Therefore radiological discharges are considered to be accounted for within the cost analysis. However, this withstanding, the following observations can be made.

4.27 Completing the reprocessing contracts this decade is in-line with discharge authorisations (Option 1). Reprocessing more fuel than currently scheduled (Option 3) could potentially impact the UK's commitments under the OSPAR treaty. A preliminary analysis indicated that more reprocessing could challenge the alpha and tritium target levels under the UK Strategy for Radioactive Discharges, however, the calculated impact on radiation doses to critical groups was very small.

4.28 Non-radiological impacts are dominated by resource use (energy, concrete, steel) and carbon emissions. New capital build projects under each option would result in energy use and carbon emissions. As we believe the current strategy (Option 1) can be delivered without sanctioning further new capital assets, beyond those already planned-for, it is expected to result in the lowest lifecycle energy use and carbon emissions. However, this will in part depend on the comparative long-term energy use for pond versus dry storage. In the end, the better of these two methods may depend on the availability of a GDF. A previous NDA study found that avoided carbon emissions (mining/milling of U) are comparable to carbon emissions from reprocessing operations. Therefore energy use and carbon dioxide emissions

are not considered by us to be significant discriminators between the options.[15]

4.29 We also considered the lifecycle impacts of wastes from reprocessing versus storage. As an example, we noted that if we combined the wastes from reprocessing and the additional MOX spent fuel and compared them to the direct disposal of fuel then the size of a GDF would be broadly comparable. Therefore, we did not consider lifecycle impacts of the two options to be a key discriminator. This point is discussed in more detail in section 8.

SOCIO-ECONOMICS

4.30 Given the significant employment levels dependent on THORP closure, irrespective of date, will have socio-economic impacts in West Cumbria. As the current strategy is for THORP to close in 2018 the resulting workforce reductions are reflected in the manpower profiles published as part of the current Sellafield Performance Plan. A detailed socio economic impact assessment for West Cumbria, using those profiles as its baseline, is being undertaken under the auspices of Britain's Energy Coast. That study is due to be published later this year or early 2012

4.31 Closure of THORP earlier than 2018 would bring those workforce reductions forward, but the impact may be able to be mitigated, as with the current profiles, by the ongoing priority and acceleration being given to risk and high hazard reduction activity elsewhere on the site. Reprocessing additional fuel would maintain operational roles for a longer period and create shorter term construction jobs resulting from the capital build projects that would be required to keep THORP operating through the next decade. The impacts of this are difficult to quantify at this stage in the context of the other major construction projects that may come forward in the same time period and compete for labour.

TECHNICAL MATURITY

4.32 THORP and its associated plants have demonstrated that it is technically viable to reprocess oxide fuels as a means of managing them. It is a licensed operation under the UK's nuclear regulatory system across the entirety of the

[15] Spent fuel management: lifecycle model analysis, Sept 2007, A report for NDA prepared by ERM and IDM

process. Whilst continuing to reprocess AGR spent fuel into the next decade would require major investment, we consider that it is, evidentially, a technically mature and viable process.

4.33 We consider that the timing of the closure of THORP is affected by the availability and confidence in the alternative arrangements for the management of oxide fuels. If spent oxide fuel is not reprocessed then it will be placed into interim storage pending a future decision how to manage it in the long-term. Therefore, in the near-term the question facing NDA is whether there is sufficient confidence and justification in the interim storage and disposal of oxide fuels that we can cease investing in new infrastructure to support reprocessing.

4.34 By interim storage we mean the fuel will be placed into a storage regime in which we are confident it can be safely managed for the foreseeable future. At some point in the future a subsequent decision will be made on whether to continue with these interim storage arrangements or transition to a different storage regime. At the time this future decision is made it will, no doubt, be influenced by the availability of technology, the costs, regulatory requirements and the predicted timescales for a GDF.

4.35 Sellafield Ltd has undertaken options studies to select the best method to manage AGR fuel following the closure of THORP. These studies have been completed, in part, due to regulatory requirements to demonstrate what the “best available technique” is for managing AGR fuel for this interim period.[16]

4.36 The outcome of Sellafield’s assessments have concluded that wet storage in the THORP pond is the best available technique from both a technical and environmental standpoint. Pond storage in THORP was selected for a number of reasons. There is considerable operational experience of successfully managing AGR fuel in ponds, along with good technical underpinning and a sound understanding of its behaviour. Moreover, the THORP pond, which is a modern, seismically-qualified building, could be readily adapted to store thousands of tonnes of AGR fuel in high density storage containers. Pond storage was also considered to provide a flexible system to allow for retrieval, inspection and monitoring of fuel and would not foreclose future options given the uncertainties over the period of long-term storage required prior to disposal.

4.37 The NDA has conducted its own studies and commissioned independent reviews of Sellafield’s assessments. These reviews have supported the view

[16] For more information on “best available technique” see, http://www.rwbestpractice.co.uk/html%5CCode%20of%20Practice%20Issue%201%20_2010%2011%2008_.pdf

that interim pond storage of AGR fuel is the best available method for managing the remaining fuel following a closure of THORP.

4.38 Sellafield is continuing with its preparations to interim store AGR fuel in the THORP pond following completion of the reprocessing contracts. This requires the removal and disposal of redundant furniture and containers, called multi-element bottles (MEBs), used to store overseas fuel that has now been reprocessed. Once these have been removed the pond environment can be dosed with a corrosion inhibitor to make it caustic. A caustic environment has been used for over 20 years at Sellafield in the Fuel Handling Plant for storing AGR fuel and has proven a very effective corrosion inhibitor.

4.39 The closure of THORP will mean that AGR fuel received at Sellafield from the EDFE stations will be interim stored in the THORP pond pending disposal, rather than buffer stored pending reprocessing. As part of our preparations for the interim storage of AGR fuel, Sellafield Ltd will submit to the local planning authority a change of use application for the THORP pond to request the appropriate permissions to do so. We expect the application to be submitted around 2016 based on a THORP closure date of about 2018.

4.40 Our current plans assume that a GDF will be available from 2040 and will start to receive packaged AGR spent fuel from 2075. Given that it will take some years to package and then transfer all this fuel to the GDF for disposal once it is available, it is conceivable that we will have to store the AGR fuel for nearly one hundred years.[17]

4.41 We believe that our arrangements for the interim pond storage of AGR fuel are the best available option.[18] However, we do not assume that pond storage will remain the best option for such a long period, especially if the timescales for the availability of a GDF were to be extended. Therefore we will continue with our work on alternative options to wet storage, including dry storage and the early packaging of fuel for storage pending disposal. This will allow us to decide and underpin how the AGR fuel should be stored for the

[17] The dates shown are the assumptions adopted in our lifetime plans. However, the NDA has been asked by the Government to review the plans for a GDF and consider where there may be potential for accelerating progress. This could, potentially, result in a shorter period of interim storage of spent fuel.
[18] In 1977 the Windscale Inquiry considered whether pond storage methods could be “so adjusted and improved as to make increased pond storage life prudent”. The Inquiry concluded based on the evidence then available that there was insufficient experience to be confident that pond storage methods could be so adjusted. At the time BNFL “readily accepted” it could “install long-term storage facilities for AGR fuel but the developments would take many years”. In the 34 years since the Windscale Inquiry we believe that Sellafield Ltd has gained sufficient knowledge and experience on the storage and behaviour of AGR fuel to provide sufficient confidence in its interim storage. That is, we are assured that pond storage methods have now been so adjusted and improved to make increased pond life prudent until future decisions on long-term storage and disposal of AGR fuel are required. See para 8.19 and .20 of the Windscale Inquiry, Justice Parker, Vol 1, 1978, HMSO, ISBN 0117513148.

long-term and align this decision with the timescales and concepts for the geological disposal of spent fuels.

4.42 To support our study we also commissioned NDA's Radioactive Waste Management Directorate to undertake a disposability assessment of AGR fuel. The disposability assessment was undertaken and issued to NDA in 2010. The findings of the work concluded that AGR fuels should be suitable for geological disposal if appropriately packaged. Further work was recommended to optimise the disposal concept for AGR fuel and address some uncertainties associated with its disposal.

5 OUR ABILITY TO MANAGE THE LIFETIME ARISINGS OF AGR FUEL

EDFE owns and operates the UK's fleet of AGR power stations and is looking to extend the operating lives of these stations. The fuel discharged from these stations, if they are extended, would be owned by the NDA. This section explains how we have considered the impact of potential AGR stations extensions in the development of our strategy for oxide fuels.

5.1 EDFE owns and operates the UK's fleet of AGR power stations that provide about 15% of the UK's electricity generation. Over the past few years EDFE has continued with its rolling programme to extend the lifetimes of these stations. Last year five-year lifetime extensions were granted to its stations at Hartlepool and one of its stations at Heysham. The last of EDFE's AGR stations are currently scheduled to cease generating in 2023.

5.2 It would be prudent for us in our strategic planning to assume that EDFE will achieve further and significant extensions to the lifetimes of the AGR stations. Therefore, we must plan to maintain the assets and infrastructure across our estate that manage AGR fuel against further extensions to the lifetimes of the AGR stations.

5.3 We have assessed our capacity to store AGR fuel at Sellafield in the event that EDFE extends the lifetime of its stations. We have determined that if we largely complete our reprocessing contracts (Option 1) there is sufficient

capacity to interim store all the fuel from the AGR station in the THORP pond, even allowing for the longest credible extensions to the AGR fleet. If we cease reprocessing too early there may be insufficient space requiring us to build additional spent fuel storage capacity at Sellafield.

5.4 Following the cessation of electricity generation at an AGR power station it is estimated that it will take typically 3 to 4 years to remove all the fuel from the reactor cores. Fuel discharged from AGR reactors needs to be allowed to cool for about 5 years before it can be reprocessed in THORP. If EDFE was to extend the lifetimes of its two youngest AGR power stations by about 5 years beyond 2023 then THORP would probably have to operate to the mid to late 2030s in order to reprocess all the AGR fuel.

5.5 THORP was built at greater than the throughput capacity required for domestic needs so that it could provide reprocessing services to overseas customers. If THORP was used solely to reprocess AGR fuel then it is estimated that by the middle of next decade there would be insufficient fuel coming from the AGR stations to utilise its capacity. If we continued reprocessing only AGR fuel this will mean running THORP intermittently for periods when a sufficient stockpile of fuel had been accumulated.

5.6 In summary, the most important consequence of significant AGR station extensions is that it is very unlikely that all the AGR fuel can be reprocessed in THORP and it becomes increasingly less cost-effective to do so. Under these circumstances we do not consider it credible that the lifetime of THORP can be extended to reprocess all the AGR spent fuel.

5.7 The NDA is working closely with EDFE and Sellafield to understand the impacts of potential station extensions on our ability to receive and manage the lifetime arisings of AGR spent fuel at Sellafield. This work will inform future investment decisions on maintaining our assets for AGR spent fuel management. This work is of a commercially sensitive nature and cannot be shared.

6 PERFORMANCE RISKS

The cost-effective delivery of any strategy or project carries risk. Some of the assets that support oxide reprocessing at Sellafield have reduced operational throughputs as they are ageing. They will require careful management to ensure they are available to support operations over the next 7 years. This section explains how we have considered performance risks in the development of our strategy.

6.1 We have assessed the ability of our Sellafield assets to complete the reprocessing contracts in a timely and cost-effective manner. There are definite performance challenges, largely associated with the age and condition of our reprocessing assets at Sellafield. For example, the availability of evaporators to support reprocessing operations in THORP is limited, until a new evaporator can be built or the capability of the current evaporators is improved. In addition, the THORP pond must be prepared for the storage of AGR fuel. This requires the removal and disposal of redundant furniture and containers, called multi-element bottles (MEBs), used to store overseas fuel that has now been reprocessed.

6.2 THORP restarted operations in 2007 following the Feed Clarification Cell incident that forced its shutdown in 2005. Sellafield Ltd has assessed in detail the performance of the key parts of the infrastructure that support oxide fuels. Sellafield Ltd has published its “Performance Plan” of how it will deliver sustained performance and complete the reprocessing contracts in THORP by 2018.[19]

6.3 Risks remain with the sustained performance of THORP and support plants over the next 7 years. However reprocessing throughputs in the plant are now at the rates required to complete the reprocessing contracts in accordance with our current strategy (Option 1) and the Sellafield “Performance Plan”.

7 SUMMARY OF OUR ASSESSMENT AND OUR STRATEGIC POSITION

[19] The Sellafield Performance Plan, http://www.sellafieldsites.com/publications/sellafieldplan/

We have considered our options against a set of criteria and come to a view on what we believe is the best strategy for managing our oxide fuels. We refer to this as our strategic position. This section explains our strategic position and how and why we have come to this view. We would welcome feedback on this.

7.1 A summary of our assessment of the three Credible Options against our criteria is shown in Table 2 overleaf.

7.2 Our analysis shows that completing the reprocessing contracts (Option 1) is likely to be the most viable and cost-effective option. In doing so, we will have honoured our obligations to overseas customers, we will have time to prepare our facilities for the interim storage of AGR fuel, and we will have created sufficient space to receive and manage all the AGR fuel from EDFE's power stations. This strategy will also enable us to reprocess, whilst THORP is available, those spent fuels that are potentially more susceptible to corrosion in storage.

7.3 If we conclude reprocessing too early (Option 2) we may have to build additional storage capacity for AGR fuel and put in place additional arrangements to manage fuels more susceptible to corrosion during storage. We may also have to implement alternative arrangements for overseas fuel.

7.4 It is not cost-effective to reprocess more AGR fuel in THORP, beyond that needed to create space for interim storage (Option 3). If we were to run THORP beyond 2020 we would have to gradually replace many of the plants that support its operations at great expense, although it is technically viable to do so.

7.5 In addition, delivering this would potentially divert resources from our primary mission: risk and hazard reduction at Sellafield and nuclear decommissioning and clean-up. If we were to take on new overseas business in THORP, if any was available, this would potentially also impact on our ability to deliver clean-up and decommissioning. Further discussion on new business is given in section 8.

7.6 Our analysis has shown that, due to a number of interacting factors which we have considered, the amount of fuel that should be reprocessed in THORP on economic grounds is comparable to the amount that is contracted to be reprocessed (Option 1). This view is, however, conditional upon obtaining the required performance across our existing reprocessing assets and securing an agreed means for the interim storage of the remaining AGR spent fuel.

Our work on this with Sellafield Ltd is strongly indicating that securing both of these conditions is credible and our case to do so is well-advanced.

7.7 As the delivery of the strategy carries a number of performance risks we believe we should also continue to examine alternative options (Option 2) to complete reprocessing in advance of the order book.

7.8 The likelihood of significant lifetime extensions to EDFE's AGR fleet means that it is not credible that all the spent fuel coming from these reactors can be reprocessed in THORP. Therefore, it is inevitable that the NDA will have to prepare to store thousands of tonnes of AGR spent fuel for the foreseeable future.

7.9 Extending the reprocessing of AGR fuel beyond the amount contracted-for and that needed to create space for interim storage is not cost-effective (Option 3). Additionally, as our reprocessing infrastructure at Sellafield is ageing we consider this option would be less likely to be successfully delivered.

7.10 We have considered our options against a set of criteria and come to a view on what we believe is the best strategy for managing our oxide fuels. We refer to this as our strategic position.

7.11 Our strategic position is that the delivery of the current strategy, to complete the reprocessing contracts (Option 1), remains the most viable and cost-effective strategy. Following the closure of THORP in 2018 we plan to place the remaining AGR fuel, and any future arisings, into interim storage pending conditioning and disposal to a Geological Disposal Facility (GDF).

	THORP Options		
	Cease reprocessing early	**Complete the Contracts**	**Extend reprocessing in THORP**
	2	**1**	**3**
Policy and contracts	It is Government policy to complete the reprocessing contracts; any changes to contracts for THORP require Secretary of State approval	Some contractual adjustment may be required in respect of <0.1% of the Thorp order book by mass	New business, if available, would require a Public Consultation and Secretary of State approval
Hazard, safety, security, environmental & socio-economics	There are some fuels that would be better reprocessed than stored for the long-term, but we can still safely manage them if THORP is inoperable	Subject to regulatory approval of a safety case to store AGR fuel	Whilst there would be impacts on individual criteria reprocessing is a licensed operation and given sufficent planning and investment we would expect it to comply with all these critieria
Cost & cost uncertainty	Building additional storage capacity for AGR fuel and agreeing alternative options for overseas fuels could be costly	Cost-effective if existing assets can complete the mission - which we believe they can	Major investments would be required at Sellafield to run THORP in the next decade
Technical	There are some fuels that are more susceptible to corrosion during storage and would be better off being reprocessed, if THORP is available	We are confident we can store the remaining Oxide fuels, and subsequently dispose of them	Sellafield has demonstrated the technical viability of Oxide reprocessing
Our ability to manage AGR fuel	If we stop too early we will need to build additional storage capacity	There is sufficient capacity to manage AGR fuel even with lifetime extensions to the fleet	Reprocessing more than the contracted amount will leave more than sufficient capacity for the interim storage of AGR fuel
Performance risks	We would have to develop new plans for alternative options for our fuels. There is no guarantee these plans would hold less risk than the current plan.	There are risks but we have agreed a "performance plan" with NMP to deliver our current strategy	The infrastructure at Sellafield is ageing and unlikley to be cost-effective to extend. It would require many, new complex construction projects at Sellafield with no guarantee of success

Table 1 Summary of our assessment of THORP options against the criteria

8 THE WIDER CONTEXT OF THE NDA'S DECISION ON THORP AND THE POTENTIAL FOR REPROCESSING IN THE UK

The NDA's decision on THORP has potentially wider implications for the UK's nuclear industry and the future of reprocessing in the UK. In this section we discuss some of the arguments around reprocessing in the context of the future of nuclear power in the UK. We have considered whether the potential for reprocessing in the UK would have a material impact on the NDA's decision on THORP. We have also considered whether the NDA's decision on THORP has an impact on the potential for reprocessing in the UK.

8.1 The Government asked the NDA to consider the potential wider impacts of its business decision on THORP on the potential for reprocessing in the UK and provide advice along these lines.

8.2 This request from Government was not to consider the merits or otherwise of reprocessing in a potential future of nuclear power. Nor was it to consider the merits or otherwise of nuclear power. This would be too wide-ranging a question that extends far beyond the NDA's mission.

8.3 Rather, the request was for the NDA to reasonably consider whether;

- the potential for reprocessing in the UK has any significant impacts on the NDA's decision on THORP, and, *vice-versa*;
- our decision on THORP has any significant impacts on the potential for reprocessing in the UK

8.4 To do this we considered some of the arguments put forward for reprocessing spent fuel. Reprocessing of spent fuel could potentially be justified on a number of grounds including, for example;[20]

A if there is a requirement for separated plutonium for fuel in new reactors, whether fast or thermal

B if it is a cost-effective means of managing spent fuel and/or a profitable business for the service supplier

C if the quantities of wastes produced and the size of a GDF are much reduced per unit of electricity generated

D because storage and disposal of spent fuel is not technically viable

[20] We only considered a justification on civil grounds. The NDA and THORP have no role in the provision of nuclear materials for defence purposes.

8.5 As discussed in section 2, the UK has abandoned its fast reactor programme and there is no national policy to recover and reuse reprocessed plutonium or uranium. The UK has no plans for fast reactors and, at the earliest, we could not foresee fast reactors becoming commercially available in the UK before about 2060.[21]

8.6 These timescales strongly suggest there is time to plan to separate sufficient plutonium to fuel fast reactor cores. The remaining stocks of AGR spent fuel held in storage could still be reprocessed at a later date to provide plutonium for fast reactors. If we extended THORP operations and reprocessed all of the current lifetime arisings of AGR fuel it would add about 20 te of plutonium to the UK's anticipated 104 te stockpile.

8.7 The ability to undertake large-scale reprocessing of oxide fuels is an industrial strength and capability of the UK. If fast reactors were built in the future then the development of recycling processes for fast reactor spent fuel would be required to recover uranium and plutonium. However, given the differences between the nuclear fuels reprocessed in THORP and those that could be envisaged to be used in fast reactors it is questionable whether a THORP-type process would be used to reprocess spent fuels from fast reactors.

8.8 We could not credibly envisage that the life of THORP could be so extended until the projected date for fast reactors. Therefore, if there was a national strategic requirement to retain a reprocessing "skills" capability we would question whether this would be best maintained by operation of a production plant. Rather, the technical capability to do so might be best maintained by a research and development programme into advanced separations technologies.

8.9 None of the potential operators of new nuclear power stations has expressed an interest in the reprocessing and recycling of spent fuel from their reactors. Moreover, even if they had, given the estimates of when new reactors could potentially come on-line we would not expect bulk quantities of spent fuel from these new reactors to be available and suitable for reprocessing in THORP until the mid 2030s. By this time THORP and its associated plants would have been running for over forty years.

8.10 Based on this we consider that the timing of the closure of THORP has little material impact on any potential future requirement to supply plutonium

[21] A recent report on the potential expansion of nuclear energy in the UK by the National Nuclear Laboratory notes that, "PWR technology is likely to dominate and be the preferred reactor option over the next 60+ years in the UK and internationally." See, http://ripassetseu.s3.amazonaws.com/www.nnl.co.uk/_files/documents/sep_11/NNL__1315903177_Position_Paper_from_NNL_-_UK_N.pdf

for new reactors, if it became national policy to do so, or on the UK's ability to maintain a strategic industrial capability in this area.

8.11 Our economic analysis of spent fuel management options in the UK has shown that on a like-for-like basis storage followed by disposal of spent fuel is currently more cost-effective than reprocessing. In part this is because the anticipated costs of reprocessing and MOX fuel production in the UK have risen markedly. Additionally, the uranium price has been so low as to not economically support reprocessing.

8.12 The UK Government has recently consulted on options for managing the UK's stockpile of separated plutonium.[7] Government's preliminary policy view put out to consultation was that reusing plutonium in the form of MOX fuel offers the best prospect to deliver a solution for long-term plutonium management. However, the consultation paper explained that, the UK Government's current expectation is that, at current uranium prices, the value of the MOX fuel generated is significantly less than the costs of its manufacture. In other words, for the forseeable future, manufacture of MOX is primarily a route for consuming plutonium stocks rather than a commercial operation in its own right.

8.13 Taken together, our work on options for AGR fuel and the work we have completed for Government on options for plutonium have shown that the recycling of spent fuel in the UK in thermal reactors is unlikely to be commercially attractive, at least for the foreseeable future.

8.14 The UK has previously provided reprocessing services to overseas energy companies under commercial contracts. Of these countries which had previously contracted with the UK for reprocessing services, some have now adopted a 'wait and see' strategy, with their fuel going to interim storage pending disposal for the foreseeable future. Others have developed their own indigenous reprocessing facilities to manage their spent fuels. Some, especially in reaction to events at Fukushima, have proposed to phase out nuclear power altogether.

8.15 There is no evidence that overseas or domestic utilities are seeking to enter in to new contracts for meaningful amounts of new reprocessing in THORP, particularly on terms and timescales which would ensure profitability to the NDA. We maintain the position stated in our 2011 Strategy, that if approached by third parties for the provision of additional spent oxide fuel management services we would discuss this with UK Government. However, we consider that continuing to invest in new infrastructure to support THORP operating beyond the current contracts on the prospects of new business is not cost-effective.

8.16 Reprocessing separates out the products and wastes. However, based on our current understanding both glass and cement-based waste products from reprocessing and spent fuel are all disposable in the UK geological disposal facility reference concept, if appropriately packaged.

8.17 Based on work for us by RWMD, on a like-for-like basis, the GDF footprint for the disposal of 4,000 teU AGR spent fuel would be not more than 10% larger for direct disposal of the fuel rather than for disposal of its products and wastes.

8.18 Whilst there is a distinct reduction in the footprint of a GDF resulting from reprocessing, the difference is insufficient to make it an over-riding factor in our view. Therefore, we do not consider this to have a material impact on the timing of the closure of THORP.[22]

8.19 As discussed in section 4, we consider that the storage and disposal of AGR spent fuel to be technically viable. Separate assessments by RWMD have considered the disposability of spent fuels from a potential new nuclear build programme and concluded that they should be compatible with geological disposal.[23] Therefore, the closure of THORP does not impact on the viability of a programme of new nuclear power.

8.20 In summary, at the Government's request we have considered whether there are any interactions between THORP and the potential for reprocessing in the UK that would affect our business decision.

8.21 In the foreseeable future there is no perceived demand for THORP's reprocessing services beyond the current contracts. A new plant would be required to recycle the fuel from new build reactors, if the operators of these stations elected to reprocess their spent fuel. Therefore, our decision to close THORP following completion of the contracts is not influenced by any potential plans for reprocessing in the UK.

8.22 If, in the future, reprocessing was required to service fast reactors the timescales for this are very far removed from THORP's closure in 2018. The technology to reprocess fast reactor fuels is likely to be different and running a production plant is not considered the most appropriate means to maintain the UK's capability in this area, if it was required. Therefore, we do not consider that the timing of the closure of THORP significantly impacts the long-term potential for reprocessing in the UK. Moreover, we consider the UK

[22] This analysis is based on our current understanding of the disposal concepts for spent fuels and wastes. We recognise that future changes to these disposal concepts could change the relative benefits and detriments of direct disposal of spent fuel compared to reprocessing and recycle. We intend to publish the findings of this study.
[23] https://www.nda.gov.uk/news/disposability-assessment.cfm

has sufficient nuclear material to start a future programme of fast reactors without extending reprocessing in THORP beyond 2018.

9 WAY FORWARD

NDA'S STRATEGY FOR OXIDE FUELS

9.1 We will continue our work to evaluate and underpin our strategic position on oxide fuels including ongoing engagement with stakeholders. A key part of this will be determining whether the reprocessing contracts can be completed without additional new and costly infrastructure, and whether our proposals for the interim storage of AGR fuel are viable.

9.2 We expect to have underpinned our strategic position on oxide fuels by the summer of 2012 when our Preferred Option will then be confirmed as our strategy.

THE LONG-TERM POTENTIAL FOR REPROCESSING IN THE UK

9.3 Our strategy to close THORP following completion of the reprocessing contracts has potentially wider policy implications for spent fuel management in the UK.

9.4 The Government has, therefore, asked the NDA to use our work as the basis for providing advice to them about the wider, long-term potential for reprocessing in the UK. In section 8 we have set out our views on this, in the context of current Government policy and the currently foreseeable situation in the UK.

9.5 As well as feedback on our business decision about THORP and AGR fuel we are also, therefore, interested in receiving views on the long-term potential for reprocessing in the UK.