Nuclear Decommissioning Authority

Progress on approaches to the management of separated plutonium

Position Paper

January 2014

Nuclear Materials
Doc Ref: SMS/TS/B1-PLUT/002/A
Doc ID: 21100718

Progress on approaches to the management of separated plutonium
Position Paper
January 2014

Contents

Progress on approaches to the management of separated plutonium
Position Paper
January 2014

Executive Summary

On completion of reprocessing operations there will be around 140 tonnes of civil separated plutonium in the UK. The UK Government attaches a high priority to developing a policy which will see implementation of a lifecycle solution to put the vast majority of this plutonium beyond reach. This is because of the extensive ongoing security requirements to safely and securely store the material and international non-proliferation objectives to reduce plutonium stocks worldwide.

The Nuclear Decommissioning Authority (NDA), as owners of the majority of the material and the body responsible for its ongoing storage, have continued to support the UK Government and the Department of Energy and Climate Change (DECC) as it develops the UK policy on the management of separated plutonium in the UK.

This paper provides the key findings of recent work undertaken by NDA including:

- a review of the reuse as Mixed Oxide (MOX) option;
- a position on the alternative reuse proposals (in CANDU/PRISM reactors); and
- an assessment of the non-reuse options.

In summary, this work has resulted in NDA concluding that reuse remains the preferred option and, based on the information provided and against our definitions, there are three credible reuse options: - reuse as MOX in light water reactors, reuse in CANDU EC6 reactors and reuse in PRISM fast reactors. We note all the technologies being considered have pros and cons and that no “perfect” solution exists. It may be that a multi-track approach offers best value for money.

Currently, we believe there is insufficient understanding of the options to confidently move into implementation and consider that significant further work must be undertaken, focusing on technical and commercial risks and uncertainties, to enable DECC and UK Government to ultimately select and subsequently implement its preferred reuse option.

Regarding technical aspects, including licensing, all options require further understanding to be developed and to support this we intend to undertake technical studies over the next 1-2 years with the technology suppliers to establish a consistent level of understanding of risks and uncertainties for each option.

At this time we are seeing technology vendors leading development of the proposals although, commercially, there are many ways to implement all options. NDA will work with vendors, suppliers, utilities and Government to establish accessible options for funding, using risk profiles and implementation schedules established through the above work and develop proposals in parallel.

Recognising that we have three distinct technical solutions being proposed we plan to use a competitive process to secure the best outcome. Although NDA is developing the options for implementing a commercial procurement process, the form of this can only be defined once market positions are better understood. NDA will establish approaches to cover both a competitive and sole provider condition.

The exact timing of decision making will be established once the above work has progressed sufficiently. NDA will report on progress in due course.

Progress on approaches to the management of separated plutonium
Position Paper
January 2014

1 Background

At the end of the planned reprocessing programme around 140 tonnes of separated plutonium will be in storage in the UK.

Since its inception, the Nuclear Decommissioning Authority (NDA) has been supporting the UK Government's Department of Energy and Climate Change (DECC) as it develops its policy on the management of separated plutonium. We previously published our credible options studies which defined credible options as:

"those options which could potentially be accomplished, safely, while complying with the law, and using technology which is either available or capable of being developed within the foreseeable future, and which allow decisions to be made on a timescale that is commensurate with any strategic imperatives."

For plutonium, the timescale was regarded as around 25 years.

We articulated three Credible Options for plutonium:

- the current strategy of long-term storage (followed by disposal);
- immobilisation and direct disposal; and
- reuse as fuel, with conversion to Mixed Oxide (MOX) fuel for burning in current reactor designs as the reference.

We previously excluded options such as fast reactors or other next generation reactors as not credible, primarily since the market did not intend to deploy them for many decades.

In December 2011, informed by the Credible Options studies, the Government proposed a preliminary policy view to pursue reuse of plutonium as Mixed Oxide fuel, converting the vast majority of the UK civil separated plutonium into fuel for use in civil nuclear reactors. Any remaining plutonium whose condition is such that it could not be converted into MOX would be immobilised and treated as waste for disposal.

Government also pointed out that they were open to alternative proposals for plutonium management if they potentially offered better value for money to the taxpayer and would seek to gather more information on all options.

In addition Government concluded that overseas plutonium in the UK, which remains the responsibility of the owners, could be managed alongside UK plutonium, or title could be transferred to the UK, subject to acceptable commercial terms being agreed.

Given the conditionality of the Government's policy, the plan currently being enacted is that UK based stocks should be safely and securely stored, including consolidation of stocks at Sellafield.

Substantial further work has recently been undertaken by NDA in support of DECC focusing on further examination of reuse as MOX and assessment of alternative reuse proposals after NDA was approached by technology vendors.

2 Programme Outline

The aim of the programme is: **to plan, develop and implement a management solution for the separated civil plutonium in the UK through reuse, immobilisation and disposal until the stockpile has been reduced to zero and is put beyond reach.**

The NDA has been delivering the programme for managing plutonium since 2010 to support Government policy development, culminating in the published policy document in December 2011. It was recognised that the policy position was preliminary and several phases of work would need to be undertaken to better underpin, de-risk and define the preferred option prior to a firm decision being made to implement the policy. The phase of the programme recently completed has targeted key areas of technical and commercial risk and uncertainty, and considered the preferred option alongside potentially credible alternative reuse proposals.

Specifically in this phase NDA have continued to develop the following focus areas:

i. Examining in more detail the implementation of the preliminary preferred option of reuse as MOX in Light Water Reactors (LWR) in the UK, from a technical and commercial perspective.

ii. Calling for alternative proposals to reuse as MOX to be bought forward, assessing their credibility and establishing if they should be pursued further.

iii. Carrying out a review of non-reuse options.

iv. Developing the next steps including the approach to Justification[1].

Future phases of work will be developed as the programme progresses. It is noted that this is a long term programme with bulk reuse of plutonium likely to commence around 2030-2035 and concluding several decades after that.

[1] *Justification of Practices Involving Ionising Radiation*. A preliminary step in implementation required to demonstrate that the benefits of utilising such a practice outweigh any health detriment.

3 Summary of work

3.1 Implementation of reuse of MOX

NDA has made significant progress on understanding the technical and implementation aspects of MOX. The key findings are noted below.

The stockpile has been produced over many decades from a range of spent fuel types in a range of facilities. The composition is therefore variable with the majority of material well characterised and of good quality but with smaller portions contaminated or in the form of residues or MOX scraps.

A thorough analysis of the inventory against the product quality requirements of MOX fuel reaffirms that management of the full inventory as MOX is likely to be significantly more expensive than managing ~ 85-90% of the inventory. A multi-track approach will likely be needed, with the quantity being managed via each option, including as a waste, requiring optimisation.

Extensive engagement with third parties has led to a much improved understanding of the basis of cost and risk profile for the facilities required to deliver this option.

However, it is noted that whilst the US Department of Energy (DOE) are continuing to implement their plan for managing its surplus weapons grade plutonium via reuse as MOX, other options are currently being reviewed in parallel. This review has come about due to significant cost increases and schedule overruns at the US MOX Fuel Fabrication Facility and the fiscal climate. Although the US and UK programmes and contexts are very different, this development affects NDA confidence in the predictability of implementation and costs of reuse as MOX.

It is noted that the earliest commercial operation of new build reactors in the UK, which is critical path for MOX use, is now estimated to be 2023. The components of the high level programme previously published by DECC remain applicable although the schedule is not without risk.

A number of technical and licensing risks and uncertainties still exist and further analysis of technical issues should be undertaken to allow NDA to remain an intelligent customer for a potential procurement. Given the uncertainties associated with which reactors will ultimately be deployed in the UK, any application for Justification should retain the option to manage plutonium through all credible Light Water Reactor (LWR) types, at a minimum.

Due to the relative immaturity of the UK new build programme, at this stage, the appetite of developers to ultimately include MOX in their considerations remains uncertain.

Previous approaches by the MOX technology vendor (AREVA) have focused on sales of a MOX fabrication facility, based on proven experience gained over the last 20 years. Due to a key programme risk being identified as offtake for MOX, NDA, supported by AREVA, have begun to consider a more integrated approach, although

engaging with potential offtake partners as noted above is difficult, and progress is slow. In the short term, a window of opportunity may exist to factor in use of MOX, whilst developers establish their business cases for new reactors, agree commercial terms and develop licensing approaches.

To support this aspect, NDA has developed commercial and financial models to understand how new nuclear developers evaluate the financial aspects of a scheme, and the potential impact of MOX on this.

On the basis of this work, NDA consider that reuse as MOX remains a credible and technically mature option for the majority of plutonium and, given the current planned new build reactor types, remains implementable.

Based on the current nuclear new build programme, NDA consider the next 1-2 years are critical to establishing the options for implementation of MOX and for understanding the willingness and potential involvement of technology vendors, utilities and investors to realise the solution.

3.2 Alternative proposals to reuse as MOX

NDA approached the market in February 2012 and asked for any parties who believed they could offer credible alternatives to reuse as MOX to approach us. We received responses from two large commercial organisations, namely from Candu Energy (Candu) and General Electric Hitachi (GEH).

NDA placed low value contracts with both parties to consider scope associated with various criteria which would enable NDA to develop a view as to the credibility or otherwise of the proposals, noting the areas of uncertainty were different for Candu and GEH approaches.

A structured and thorough examination of these proposals, using the information provided by the organisations against credibility criteria outlined in detail in Appendices 1 and 2 and as noted above, has resulted in NDA concluding that:

- Reuse in Enhanced CANDU 6 (EC6) reactors remains a credible option; and
- Reuse in a GEH PRISM Fast Reactor should also be considered credible, although further investigation may change this view.

This position does not mean that all advanced or fast reactor systems are credible, noting that only the GEH PRISM system has been subject to detailed examination.

Individual position statements for the alternatives, along with the rationale, can be found in Appendices 1 and 2.

Both alternatives appear to have some benefits as well as disadvantages when compared to the reference LWR MOX option and NDA will continue to investigate both options with a focus on:

- developing further understanding regarding technical and implementation aspects of the proposals; and

- developing further understanding of the approaches and how the proposals might be commercialised.

Given the very early stages of development of the commercial proposals and uncertainties regarding the underpinning implementation costs at this time it is not possible to establish the cost to NDA of managing its plutonium through delivery of these alternatives with certainty.

We intend to retain the option to manage plutonium via CANDU and PRISM reactors in the next stage of our work including developing an application(s) for Justification, which is further discussed in section 3.4.

3.3 Review of non-reuse options

NDA also undertook a review of the non-reuse options of (a) long term storage followed by disposal and (b) immobilisation followed by disposal. In summary

- Long term storage followed by Disposal

  The long term storage option is being implemented by Sellafield Ltd in their lifetime plans. A review of the cost estimates has been undertaken using latest Sellafield Limited costs. The estimates showed some recent increases due to modified security arrangements and associated costs. Subsequent to storage, concluding after around a century, immobilisation followed by disposal is assumed.

- Immobilisation followed by Disposal using Hot Isostatic Pressing (HIP)

  A technical and flowsheet review has been undertaken by the National Nuclear Laboratory (NNL) supported by external peer reviewers which led to a reduced plutonium incorporation rate in the waste product. In addition a review of the capital and operating cost estimates has been undertaken by Sellafield Limited using data in the NNL study. This showed the estimates developed to be reasonable given the level of maturity of the technology.

Whilst this work has increased and refined our understanding of both these non-reuse options compared to the reuse option, the analysis and primary conclusions included in our previous Credible Options studies remain unchanged.

3.4 Justification approach

DECC launched a consultation on the approach to Justification of Practices for reuse of plutonium in May 2012. Their response to the consultation and the revised Guidance was published in May 2013.

DECC noted that “it is considered that generic guidance offers the most flexible and proportionate approach to justification” and reinforced that Justification considers the overall benefits and detriments of a proposal and is not an optioneering process.

The form of the application is up to the applicant:-

"The guidance advises that it is up to the applicant to determine whether they consider it most appropriate to proceed with technology specific applications or group a number of different technologies in a single application. In all cases, any application would need to include sufficient technical data, relating to the benefits and health detriment associated with the proposed practice, to allow an informed justification decision to be made."

This framework allows for the possibility of a generic application based on the high level benefits and disbenefits of reuse to be made rather than a detailed technology specific one. This enables NDA to develop its approach to Justification in tandem with its understanding of the options.

NDA will continue to engage with DECC as we develop our approach and application for Justification for reuse of plutonium.

4 Summary and outline of next steps

NDA has continued to support DECC as it develops its policy for managing separated plutonium.

NDA has undertaken work, supported by third party organisations, which has further developed our understanding of the MOX option, considered alternative reuse technologies, and reviewed the non-reuse options.

This work has resulted in NDA concluding that, based on the information provided and against our definitions, there are three credible reuse options: - reuse as MOX in light water reactors, reuse in CANDU EC6 reactors and reuse in PRISM fast reactors. NDA note all the technologies being considered have pros and cons and that no "perfect" solution exists and it may be that a multi-track approach may offer best value for money.

Currently, we believe there is insufficient understanding of the options to confidently move into implementation and consider that significant further work must be undertaken, focussing on technical and commercial risks and uncertainties, to enable DECC and UK Government to ultimately select and subsequently implement its preferred reuse option.

All options require further understanding to be developed regarding technical uncertainties and to support this we intend to undertake technical studies over the next 1-2 years with the technology suppliers to establish a consistent level of **understanding** of risks and uncertainties for each option. This does not mean that the **level** of risk for each of the options will be the same after this work.

Given there are many ways to commercially implement all options, NDA will work with vendors, suppliers, utilities and Government to establish accessible options for funding, using risk profiles established through the above work.

At this time we are seeing technology vendors leading development of the proposals, noting that the three options being promoted are all credible, and accordingly we plan to deliver a competitive process to secure the best outcome.

NDA is developing the options for implementing a commercial procurement process, should this be required, although the form of this can only be defined once market positions are better understood. NDA will establish approaches to cover both a competitive and sole provider market condition.

We also intend to work on regulatory and licencing aspects with the technology vendors and ONR/EA to define licencing needs and understand deployment risks such as fuel performance demonstration, noting this is a significant risk area for all options.

The DECC Justification guidance and process, allows progress to be made against all technology options in parallel. NDA will develop our Justification approach alongside refining our understanding of licencing aspects, with a view to subsequently making an application.

Further progress will be reported in due course.

Appendix 1 – NDA position on the application of CANDU to the management of separated plutonium

Background

In NDA's original Credible Options analysis on plutonium disposition we stated that the use of CANDU type reactors was technically credible but noted that at that time Atomic Energy of Canada Limited (AECL), who then owned the CANDU technology, did not intend to deploy them in the UK. NDA carried out significant work with AECL, gathered information on the technical basis and undertook a high level disposability assessment.

Supported by NDA's work, in December 2011, the Government set out that its preferred policy option for the lifecycle management of plutonium was re-use as MOX fuel in LWR reactors. Substantial further work has now been undertaken by NDA in support of DECC. This work has focussed on commercial and technical risk reduction activities and involved discussions and contracted scope with various parties about re-using the plutonium as MOX. However, alternative proposals offering better value for money or less risk to the taxpayer were not ruled out.

As part of the desire to gather more data on all options, NDA issued a request for parties to approach them if they believed they could develop and deliver a credible alternative proposal to reuse as MOX fuel. Candu Energy Inc. (Candu), as the exclusive licensee of CANDU technology, responded to this request and proposed a solution using the Enhanced CANDU 6 reactor (EC6). Candu indicated that they were now interested in re-entering the UK market, specifically to support the management of the UK plutonium, as they believed their solution could be efficiently applied to this mission and was deployable on the required timescales. We previously published our credible options studies which defined credible options as:

'those options which could potentially be accomplished, safely, while complying with the law, and using technology which is either available or capable of being developed within the foreseeable future, and which allow decisions to be made on a timescale that is commensurate with any strategic imperatives'.

For plutonium, the timescale was regarded as around 25 years.

Whilst noting that Candu are clearly a credible reactor vending organisation, in order to assess the credibility of the CANDU reactor for dealing with UK plutonium, NDA entered into a contractual relationship with Candu to contribute to the delivery of a feasibility study to generate information to be assessed against specified criteria. The key areas of focus were:

- Commercial implementation of CANDU in the UK including an overview of the business case;
- Licencability of CANDU, and associated facilities, and a review of the technical basis, maturity and implementation schedule; and
- Disposability assessment of spent CANDU MOX (CANMOX) fuel.

The Approach

The approach outlined in the Candu study was:

- fabrication of CANMOX fuel in the UK using dedicated pelleting and fuel fabrication facilities;
- irradiation of CANMOX fuel in EC6 type reactors in the UK; and
- storage of spent fuel pending disposal (in line with current new nuclear build assumptions).

Key Points

After a review of the submission and subsequent in depth discussions with Candu, NDA note that

- The study highlighted a number of potential benefits of utilising dedicated CANDU reactors to manage separated plutonium, notably a simplified CANMOX fuel manufacturing process, compared to LWR MOX, given the lower incorporation of plutonium in fuel, a track record of on-schedule, on-budget reactor construction, and the ability to utilise a wide range of the plutonium inventory which together would be expected to consequently reduce the overall costs of implementation of plutonium reuse.
- On the evidence provided, there is supply chain interest to be involved in the project from fabrication, civil engineering, technical consultancy and operations organisations. There are also relatively high levels of interest from third parties into a plutonium management mission, with some indicating they may be willing to provide equity. The relevant agencies have indicated export credit is available for the proportion of the project sourced overseas. Candu have indicated that a high degree of UK sourcing could be achieved and that they are willing to lead the effort to disposition plutonium and bring other parties together as required to deliver the outcomes.
- The estimates provided by Candu included capital and associated operations costs of fuel fabrication facilities, supported by work from GE-Hitachi Nuclear Energy Canada (GEH-C). These costs are lower than those for LWR MOX, attributed to a relatively simpler design of fuel fabrication facility. However, further due diligence must be undertaken in this area noting commercial scale production of CANMOX has not been undertaken. This information has been used to estimate the total cost to manage the stockpile but these estimates remain subject to uncertainty as specific commercial approaches have yet to be developed.
- On the information given Candu believe the project is essentially financeable using external funding mechanisms. Using such mechanisms to deliver any of the reuse options, including CANDU technology, may prove relatively expensive to NDA, taking account of market expectations on rate of investment returns in what investors consider to be a risky field.

- The technical readiness level of the systems is generally high, although some of the fuel fabrication systems have not been delivered at full industrial scale for plutonium fuels. There also remains uncertainty over the extent of the fuel performance demonstration programme that would be required noting the fuel performance library for CANMOX is not as extensive as for LWR MOX.

- This indicates that the proposal overall, if implemented would require some development work, related mostly to fuel performance and industrialisation of fuel fabrication. Whilst full scale industrial demonstration of all the individual elements of manufacturing and in reactor performance have been demonstrated for uranium fuels, the integrated system has not been demonstrated on a commercial scale for plutonium based fuels.

- Based on preliminary discussions with ONR, Candu are confident that a CANDU reactor burning CANMOX and a CANMOX fuel fabrication facility would be licencable in the UK, given overseas experience, similarities in UK and Canadian regulatory approaches and existing licencing work carried out in Canada and Europe on the CANDU reactor.

- Based on their worldwide experience, the overall implementation timetable to first irradiation is claimed by Candu to be in the range of 10-12 years, with the duration to disposition the stockpile through 2 reactors of 60 years. Options exist to reduce the disposition duration by deploying more reactors. NDA believe the implementation timetable to be ambitious considering the delivery performance norms currently seen in the UK and European nuclear landscape.

A high level assessment undertaken has indicated that CANMOX spent fuel disposability is expected to be comfortably bounded by the case made for LWR MOX, although this should be confirmed via a full Generic Disposability Assessment.

Assessment against Criteria

Our assessment of the proposal against the Criteria is that currently:

The schedule estimated by Candu to first irradiation of UK plutonium is potentially earlier than that of other credible reuse options and within the 25 year period defined in our credible options studies.

NDA has received cost information from Candu which has been used to estimate the total cost to manage the stockpile. This cost estimate remains subject to uncertainty as specific commercial approaches have yet to be finally established. To confidently establish the likely cost to manage the stockpile will require the level of definition of the potential commercial models to increase, including appropriate allocation of risk and value.

NDA note that the commercial structures by which the proposal could be implemented needs to be explored further and discussions need to take place to establish how Candu, the supply chain and utilities would be involved in realising the proposal, noting that on the evidence provided by Candu there are relatively high levels of market interest from utilities and third parties in a plutonium management mission, with some indicating they may be willing to provide equity. Candu have

focussed on this area to date, and have indicated that they have confidence that the required elements could be bought together to deliver a viable project.

There appears to be no fundamental impediments to achieving licencing of the scheme, although it is not possible to define the precise scope, cost and timescales to achieve this without further interaction between Candu and ONR. The technical maturity of certain areas means that some development work would need to be undertaken to confirm feasibility of a commercial scale implementation of the scheme.

NDA see no fundamental impediment why spent fuel arising from the operation of the scheme could not ultimately be disposed of in the Geological Disposal Facility (GDF), although a full disposability assessment has yet to be undertaken.

Summary

Given the assessment above, NDA consider that there is benefit in continuing to work with Candu to gain an improved understanding of implementation aspects, covering both technical and commercial areas.

Based on the information available at this time, reuse in CANDU reactors appears to remain a credible option against our criteria, but this assessment could change as additional evidence is gathered. Based on the potential benefits outlined above, NDA consider it is appropriate to include CANDU in the next stages of their work, in particular in developing an application for Justification, noting our preferred approach is to define a high level class or type of practice.

It is proposed that NDA continue to engage with Candu:

1. To develop further understanding of the implementation approach and understand how the proposal might be commercialised; and

2. To provide further information regarding technical aspects of the proposal, including the activities required to deliver licencing, gain confidence in CANMOX Fuel manufacturing, in reactor performance and spent fuel storage system, undertake a disposability assessment and support to Justification as required.

Subsequent to this next phase of work, envisaged to take place over the next 1-2 years or so, NDA will again consider its views on credibility.

Appendix 2 – NDA position on the application of PRISM to the management of separated plutonium

Background

In NDA's original Credible Option analysis on plutonium disposition we stated that fast reactors were not credible as the market did not intend to deploy them for many decades and therefore, since NDA was not prepared to take on the risks associated with developing and deploying a new technology, they were unlikely to be available in time to meet our policy objective since they would not be commercially available for several decades.

Supported by NDA's work, in December 2011, the Government set out that its preferred policy option for the lifecycle management of UK plutonium was reuse as MOX fuel. Substantial further work has been undertaken by NDA in support of DECC. This work has focussed on commercial and technical risk reduction activities and involved discussions and contracted scope with various parties about re-using the plutonium as MOX. However, alternative proposals offering better value for money or less risk to the taxpayer were not ruled out.

As part of the desire to gather more data on all options, NDA issued a request for parties to approach them if they believed they could develop and deliver a credible alternative proposal to reuse as MOX fuel. General Electric Hitachi (GEH) responded to this request noting GEH's interest in providing information to NDA on the use of PRISM technology, that their PRISM fast reactor is one of three reactors that GEH now offers to a world market (i.e. ABWR, ESBWR and PRISM) and that the reactor was deployable on the required timescales. We previously published our credible options studies which defined credible options as:

'those options which could potentially be accomplished, safely, while complying with the law, and using technology which is either available or capable of being developed within the foreseeable future, and which allow decisions to be made on a timescale that is commensurate with any strategic imperatives'.

For plutonium, the timescale was regarded as around 25 years.

Whilst noting that GEH are clearly a credible reactor vending organisation, in order to assess the credibility of PRISM, NDA entered into a contractual relationship with GEH to contribute to the delivery of a feasibility study to generate information to be assessed against specified criteria. The key areas of focus were:

- Licensability of PRISM, and associated facilities, verified by a third party, and a review of the technical basis and maturity;
- Commercial implementation of PRISM in the UK including an overview of the business case; and
- Generic Disposal Assessment of spent PRISM fuel to establish disposability.

The Approach

The approach outlined in the GEH study was:

- conversion of the separated Plutonium Oxide to a sodium bonded U/Pu/Zr metal fuel using Direct Electrolytic Reduction, Pyroprocessing and metal casting techniques;
- irradiation of this metal fuel in 2 C-PRISM type reactors, in a burn, rather than breed, mode via various irradiation schemes, such as "spiking"[2]; and
- storage of the spent fuel pending disposal (no recycle of spent fuel, in line with current UK new nuclear build assumptions).

Key Points

After a review of the submission and subsequent in depth discussions with GEH, NDA note that

- The study highlighted a number of potential benefits of utilising the PRISM reactor solution to manage separated plutonium, notably a reduced time to disposition the UK stockpile, given the higher incorporation of plutonium in fuel, a simplified fuel manufacturing process and reactor construction, and the ability to utilise the full inventory of plutonium which should consequently reduce the overall costs of implementation of plutonium reuse.

- An external assessment, by a suitably qualified and experienced organisation, using information within the submission, found "no fundamental impediment to UK licencability" of the facilities. Identification of the specific activities to achieve a successful licensing outcome was not part of the study scope since this would have required a significant level of interaction with ONR. However, using its own experience and industry norms, GEH estimated that licensing these first of a kind facilities would take around 6 years, similar to the period it took to licence Sizewell B.

- The technical readiness level[3] of the systems was generally claimed to be in the 6-7 region, although some of the fuel fabrication systems were considered to be less than this. NDA notes that the facilities required by the approach have not been industrially demonstrated, especially when considering changes in the regulatory context since the time when much of the technology basis was established. Consequently the proposal overall would require development work

[2] "spiking" is the use of the reactor to rapidly increase self protection by increasing the amount of radiation given off by a fuel element rather than for energy generation.

[3] Technology Readiness Level is a measure used to assess the maturity of evolving technologies during its development and in some cases during early operations, on a scale between 1 and 9. Further information can be found in "*EGG10-Technical-Baseline-and-Underpinning-Research-and-Development-Requirements-Rev5.pdf "at www.nda.gov.uk.*

to be undertaken, with the cost and time to complete this work still to be defined in detail.

- To allow high level comparison with other options, GEH provided estimates for the cost of facilities, and associated operations, to deliver plutonium disposition. This information has been used to estimate the total cost to manage the stockpile but these estimates remain subject to uncertainty as specific commercial approaches have yet to be developed.

- On the evidence provided, there is supply chain interest to be involved in the project from fabrication, civil engineering, technical consultancy and operations organisations. Given commercial approaches are in the very early stages of development, GEH did not seek to gain firm utility or third party commitments, although the US EXIM bank has indicated export credit is available for the project.

- The overall implementation timetable to first irradiation is claimed by GEH to be in the range of 14-18 years, with these estimates being supported by ABWR delivery results outside the UK. NDA believe this to be ambitious considering delivery performance norms currently seen in the UK and European nuclear landscape.

- A Generic Disposability Assessment carried out by the NDA's Radioactive Waste Management Division (RWMD) has indicated that, whilst challenging, a disposal safety case can probably be made for disposal of sodium bonded PRISM Spent Fuel derived from the irradiation of the plutonium stocks in the UK. In the event a disposability safety case cannot be made, alternative methods have been developed and costed by GEH for managing the spent fuel to remove the sodium to reduce the challenge.

Assessment against Criteria

Our assessment of the proposal against the criteria is that currently:

The schedule estimated by GEH to bulk irradiation of UK plutonium in a PRISM reactor is comparable to that of other credible options, and within the 25 year period defined in our credible options studies.

There appears to be no fundamental impediments to ultimately achieving licencing of the scheme, although it is not possible to define the precise scope, cost and timescales to achieve this without significant interaction between GEH and ONR. The technical maturity of certain areas means that some development work would need to be undertaken to confirm feasibility of a commercial scale implementation of the scheme.

NDA has received cost information from GEH which has been used to estimate the total cost to manage the stockpile. This cost estimate remains subject to uncertainty as specific commercial approaches have yet to be established. To confidently establish the likely cost to manage the stockpile will require the level of definition of the potential commercial models to increase, including appropriate allocation of risk and value between the private and public sectors. GEH have indicated that they

believe the technology risks to be low and consider a PRISM solution to manage UK plutonium can be implemented under commercial arrangements. NDA note that the commercial structures by which the proposal could be implemented need to be explored further and discussions need to take place to establish how GEH, the supply chain and utilities would be involved in realising the proposal.

RWMD see no fundamental impediment why spent fuel arising from the operation of the scheme could not ultimately be disposed of in a Geological Disposal Facility, although the fuel does represent some unique challenges.

Summary

Given the assessment above, NDA consider that there is benefit in continuing to work with GEH to gain an improved understanding of implementation, covering both technical and commercial aspects.

Based on the information available at this time, PRISM appears to be a credible option against our criteria, but this assessment could change as additional evidence is gathered. Based on the potential benefits outlined above, NDA consider it is appropriate to include PRISM in the next stages of their work, in particular in developing an application for Justification, noting the preferred approach is to define a very high level class or type of practice.

It is proposed that NDA continue to engage with GEH:

1. To develop further understanding of the implementation approach and understand how the proposal might be commercialised: and

2. To provide further information regarding technical aspects of the proposal, including the activities required to deliver licencing and support to Justification as required.

Subsequent to this next phase of work, envisaged to take place over the next 1-2 years or so, NDA will again consider its views on credibility**.**