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# NDA Plutonium Options: Comment by Nuclear Free Local Authorities (Scotland)

## 1.0 Introduction

The NDA is required to provide a lifecycle cost estimate for dealing with the UK's nuclear legacy, including separated civil plutonium. Current cost estimates do not include the cost of plutonium management throughout its lifetime. Plutonium stores cease to be accounted for after 2120, and no other management arrangements are in place, so, in accounting terms the plutonium and plutonium stores "disappear". Although the NDA has estimated the costs of 'disposing' of the plutonium, this has not been added to the national liabilities estimate because plutonium is currently regarded as a zero value asset. The NDA expects to present a list policy options for plutonium to Government by the end of December 2008.

Any strategy needs to address all types of plutonium that will ultimately be held in the UK civil stockpile. The three general classes of plutonium are Magnox derived plutonium (~83te), Thorp derived plutonium (~15te) and residues which contain around 3te of plutonium, amounting to around 101 tonnes in total.

The NDA sees three credible options for UK-owned plutonium: store indefinitely; immobilize and dispose and reuse and dispose. But it points out that the store option is not a lifecycle solution to plutonium management because at some point in the future it would either have to be disposed or reused.

## 1.1 Storage.

Many of the existing stores are ageing and reaching the end of their design life. As knowledge has increased over the past decades, more optimum methods for storing for the longer term have been developed. A new store is currently in the process of being built at Sellafield and is costing several hundred million pounds, but it does not have the capacity to take all the plutonium and so if we plan to store for the long term (post 2036) then additional capacity will need to be added to the new store. This is a cost that could be potentially avoided. Similar issues exist at Dounreay, but on a smaller scale.

There may be a requirement to treat or repackage some plutonium if it were to be stored for significant periods. Heat treatment and repackaging plants are likely to cost significantly more than a new store. The NDA stresses that all operations with plutonium are dose-intensive for operators, and best practice would be to minimise operation time for plutonium works. Recanning, can modification and can movement are also dose-intensive work unless very expensive remote equipment is back-fitted into facilities.

## 1.2 Immobilise and Dispose

The NDA uses the term "disposal" throughout which it defines as 'the emplacement of waste in a … disposal facility without intent to retrieve …" Clearly this emplacement in a facility does not get rid of the material.

If the intention is to emplace the plutonium in a geological repository built for nuclear waste, the plutonium will have to be in a suitable waste form which aids containment, and the fact that plutonium will be included in the waste inventory will have to be factored into the repository design. Immobilisation options include the following:-

**1.2.1 Low-spec MoX**: essentially MoX pellets, (i.e sintered uranium/plutonium), which are not ground to strict sizes, stored in cans. A new MoX "waste" plant would need to be designed, built, commissioned and operated if this option was selected for further development. There may be a question-mark over the proliferation resistance of this waste form.

**1.2.2 Cementation**: Ruled out by the BNFL Stakeholder Dialogue, but it has been decided to reconsider this. There may be proliferation resistance issues with this waste form too, but this might be got round by making the package size too big to steal.

**1.2.3 Hot Isostatic Pressing:** this technique turns the plutonium into ceramic blocks. The technique requires further R&D.

**1.2.4 Vitrification**: not the same process as the one used for High-Level Waste (HLW). It is being developed at Savannah River in the US.

**1.2.5 Immobilisation with HLW:** Since this would involve delaying waste vitrification, it is not recommended, although it has high proliferation resistance, at least for 2-300 years.

**1.3 Re-use and dispose.**

Three re-use options are described by the NDA: conversion to Inert Martix Fuel; conversion to MoX; and selling the plutonium to overseas customers for conversion to MoX.

**1.3.1 Inert Matrix Fuel** – NDA minded to reject this because it hasn't been fully developed yet.

**1.3.2 MoX Fuel** – likely to require a new MoX Plant. Running reactors on a 100% MoX core has yet to be demonstrated. Spent MoX requires longer term storage because it is hotter than conventional spent fuel. Reusing plutonium as MoX fuel results in a waste which is physically hotter and has a higher radioactivity than the separated plutonium from which it was derived, making emplacement in any king of geological facility more difficult.

**1.3.3 Sell the plutonium** – potential to transfer disposal liability to a third party. New transport assets would be required. The several hundred plutonium shipments likely to be required would be "unlikely to be favoured politically".

**2.0 Principles**

The NDA Plutonium Options paper suffers from the lack of description of any underlying principles which might be used to aid decision-making. As far as meeting the NDA's safety and environmental objectives, these might include the following:-

**(1) The Waste Minimization/Avoidance Principle**

**Definition:** The creation of radioactive waste (solid, liquid and gaseous) should be minimized. First and foremost this means we need to stop producing more nuclear waste. Since other principles argue that plutonium should be treated as a waste this means that the separation of yet more plutonium should end as soon as possible.

**(2) The Passively Safe Principle.**

**Definition:** Radioactive material in existing waste, including plutonium, should be immobilized in a stable chemical and physical form utilizing Best Available Technology (BAT), so that the need for maintenance and human intervention is minimized. Waste stores should be monitored and waste should be capable of being retrieved from storage for further remedial action or repackaging if necessary.[1]

**(3) The Reversibility Principle.**

**Definition:** Allied to the passively safe principle is the principle that any waste management technique needs to be reversible. Given the uncertain state of scientific knowledge of the way radionuclides behave in the environment and their impact on the health of humans and other biota, it is important to be able to retrieve radioactive waste to take account of any unexpected changes in conditions and prevent detrimental impacts on the environment. However, with regard to plutonium, the non-prolferation principle also needs to be taken into consideration.

**(4) The Concentrate and Contain Principle**

**Definition:** Where possible gaseous and liquid radioactivity should be trapped instead of being discharged from a nuclear facility, and then concentrated, immobilised, and stored as a solid waste. This is far preferable to releasing gaseous or liquid radioactive wastes into the environment – the so-called dilute and disperse approach. If possible, advantage should be taken of radioactive decay to reduce levels of radioactivity by keeping wastes in storage as an alternative to increasing or continuing discharges.

**(5) The Hazard Prioritisation Principle.**

**Definition:** The magnitude of the radioactive hazard should influence the timing of the implementation of passive storage and immobilisation. High Level Waste (HLW) in a liquid form represents one of the most significant radioactive waste hazards in the UK (if not the most hazardous) and should be placed in a passively safe state as soon as possible.[2]

**(6) Sustainable Development and Intergenerational Equity**

**Definition:** Development which meets the needs of the present without compromising the ability of future generations to meet their own needs and that of environmental protection.[3]

**(7) The Polluter Pays Principle**

**Definition:** Nuclear operators producing waste should pay for its management.

**(8) The Precautionary Principle**

**Definition:** Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[4]

**(9) The Proximity Principle**

**Definition:** Radioactive waste should, as far as is compatible with the safety of the management of such material, be managed on the site at which it was generated. With regard to fissile materials this is related to the non-proliferation principle. Transporting plutonium around, either as oxide or as MoX fuel under armed guard cannot guarantee security and also threatens civil liberties.

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[1] See for example: HSE Nuclear Safety Directorate (13/03/01) Guidance for Inspectors on the Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites. Appendix 4.

[2] HSE Nuclear Safety Directorate (13/03/01) Guidance for Inspectors on the Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites. Appendix 4.

[3] See http://www.sustainable-development.gov.uk/what_is_sd/what_is_sd.htm

[4] Nearly 180 countries met at the 'Earth Summit' in 1992 (UN Conference on Environment and Development) in Rio de Janeiro to discuss how to achieve sustainable development. The Summit agreed the Rio Declaration on Environment and Development (http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm)

**(10) The non-proliferation principle**

**Definition:** This means that fissile materials (plutonium and highly enriched uranium) should be immobilised in a form which would make their recovery for use in weapons virtually impossible. Stocks should, therefore, be declared wastes and all necessary steps should be taken to prevent their use in, or availability for use, in nuclear weapons. This should take into account not just diversion to nuclear weapons programmes by government, but also the threat of terrorism. Real security cannot be achieved by armed guards, but requires removal of the threat by ending the further separation of plutonium and the production of enriched uranium.

**(11) International Best Practice.**

**Definition:** The most effective processes (including clean technology) and long-term containment of existing nuclear waste should be used to prevent radioactive pollution of the environment. This should not be about end-of-pipe solutions, but should investigate whether the industry is using the right products and processes in the first place. Decisions on waste management should be based on an assessment of alternative options and should involve the public in their evaluation – this cannot be left to scientists and regulators alone.[5]

**3.0 Applying environmental principles to plutonium.**

**3.1 Limit the size of the stockpile by ending reprocessing as soon as possible.**

Plutonium should be considered a proliferation and security risk. The first objective of plutonium management policy should, therefore, be to **limit the size of the stockpile by ending reprocessing as soon as possible.** This can be done by:-

(a) **Implementing alternatives to Magnox spent fuel reprocessing as soon as possible** to limit the size of the plutonium inventory. The NDA can no longer claim there is no alternative to reprocessing spent Magnox fuel.[6]

(b) **Reducing to the bare minimum the quantity of British spent fuel reprocessed,** in keeping with the implementation of the 'concentrate and contain' principle.

(c) **End reprocessing of overseas customers' spent fuel.** As the Government and NDA have accepted that THORP's overseas customers will be able to receive the products from having their spent fuel reprocessed, without the reprocessing actually taking place, there is absolutely no reason why overseas customers' spent fuel needs to be actually reprocessing. Any plutonium returned to overseas customers should be in the form of an immobilized waste form.

(d) **The NDA should specifically rule out future reprocessing as running counter to its plutonium management objectives.** The 2008 Energy White Paper states that the UK Government has concluded that any new nuclear power stations should proceed on the basis that spent fuel will not be reprocessed and the plans for, and financing of, waste management should proceed on this basis. The White Paper also stated that the Government is not currently expecting proposals to reprocess spent fuel from new nuclear power stations.[7] However, the possibility of such proposals being brought forward in the future is left open. Government officials have said that reprocessing spent fuel from new reactors has not been

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[5] RCEP (1998) The Twenty First Report, Setting Environmental Standards. (http://www.rcep.org.uk/studies/standards/s-chap9.htm#top ),
[6] BNFL World March 2003, "A Life Beyond Closure".
[7] "Meeting the Energy Challenge: A White Paper on Nuclear Power" BERR, Jan 2008 (See page 114)
See also: RobEdwards.com 23rd May 2007 http://www.robedwards.com/2007/05/uk_signals_aban.html
Independent on Sunday 13th Jan 2008
http://www.independent.co.uk/environment/green-living/sellafield-cleanup-will-cost-16334bn-769990.html

ruled out.[8] Sellafield trade unions have already started campaigning for a new reprocessing plant so that spent nuclear fuel from new reactors can be reprocessed, and new reprocessing contracts from abroad can be sought.[9] Prime Minister Gordon Brown was recently reported to have discussed with the Japanese Prime Minister the possibility of new Japanese reprocessing contracts for Sellafield to 'revive the UK's declining reprocessing industry'.[10]

### 3.2 SMP2?

The NDA Option paper argues that the plutonium stockpile potentially has a very large energy value to the UK which may prove to be a national asset. The Sellafield MoX Plant, built at a cost of £490m, has been nothing short of an economic disaster. It has not produced more than 2.6 tonnes of MoX in any one year, and yet needs to be producing over 37 tonnes per year in order to break even. Future decommissioning costs will be around £92m. Even if SMP manages to improve its output to 10 tonnes of MoX per year, the plant is liable to make a loss of £2.3bn.[11] Jackson estimates that Britain has a 77 tonne stockpile of MoX-useable plutonium which could be converted into 1,540 tonnes of MoX which could provide a 30% fuel loading for three PWRs for 60 years. But this would require construction of another MoX fuel fabrication plant.

The economic efficiency of implementing such a plan, when carbon savings could be much more effectively saved by spending the money on energy efficiency and renewables must be seriously open to question. Such a scenario would also involve armed convoys transporting MoX fuel along the UK's motorway system, with the attendant safety and security risks as well as the threat to civil liberties. In addition, the use of MoX fuel is likely to compromise reactor safety and magnify the risk of cancer fatalities from a severe accident compared with low-enriched uranium fuel, and is more hazardous to plant workers than all-uranium fuel because of plutonium's radiotoxicity.[12] In addition spent MoX fuel would be a much more hazardous waste form to deal with than conventional spent fuel. Because it would be hotter it would have a greater volume requirement if it were placed in a geologic repository than conventional spent fuel, at least during the first hundred years or so,[13] and irradiated MoX fuel has considerably more radiotoxic content than conventional spent fuel.[14]

For all these reasons, using the plutonium stockpile as MoX fuel should be rejected.

### 3.3 Selling the plutonium.

The NDA Options paper says this option is "unlikely to be favoured politically". This hardly begins to cover the serious problems likely to be engendered by carrying out such a proposal. The policy would raise severe proliferation and security risks. Even if the plutonium were sold to overseas customers incorporated into fresh MOX fuel, which the IAEA classifies as a direct use material, it could be separated by straightforward chemical means and be made into nuclear weapons. A country that possesses plutonium oxide or MOX fuel must be considered to possess the essential material for manufacturing nuclear weapons. The NDA sale of plutonium oxide or MoX fuel could directly contribute to nuclear proliferation, for example in East Asia. Anything which would legitimize plutonium commerce must be rejected. In addition to posing a threat of proliferation at the state level,

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[8] Nuclear Fuel, 18th June 2007
[9] GMB 18th Jan 2008 http://www.gmb.org.uk/Templates/Internal.asp?NodeID=96494
[10] Telegraph 23rd June 2008
http://www.telegraph.co.uk/money/main.jhtml?xml=/money/2008/06/23/cnjap123.xml
[11] Nukenomics by Ian Jackson, NEI, 2008.
[12] Public Health Consequences of Substituting Mixed Oxide for Uranium Fuel in Light Water Reactors, by Dr Ed Lyman, Nuclear Control Institute, 21st Jan 1999. http://www.nci.org/k-m/moxsum.htm
[13] French Experts Warn of New Problems with Disposing of Spent MOX Fuel, by Ann MacLachlan, *NuclearFuel*, July 10, 2000, p. 1.
[14] U.S. Office of Technology Assessment, *Managing the Nation's Commercial High-Level Radioactive Waste*, March 1985, p. 72; J. Malherbe et al., "Influence of High Burn Up on the High Level Waste Reprocessing Waste Management," in Proceedings of the International Topical Meeting, *High Level Radioactive Waste Management*, Volume 2, Las Vegas, Nevada, April 8-12, 1990, p. 1395.

MOX-fuel and plutonium commerce also poses a risk of theft or diversion by criminal organizations or terrorist groups. A study presented to the International Atomic Energy Agency (IAEA) has documented hundreds of instances of smuggling of nuclear materials, ten percent of which involved weapons-grade plutonium or uranium, and identified 130 terrorist groups capable of making a nuclear bomb.[15]

### 3.4 Immobilisation Options

Several authors have concluded over the years that blending plutonium with high-level waste as it is being vitrified is probably the best options for dealing with it.[16] Unfortunately, because of the length of time it would take, this would delay the vitrification of the extremely hazardous liquid high-level waste, which would run counter to the principle of hazard prioritization. Barker and Sadnicki recommended that the Government should look at other methods of immobilizing plutonium.[17] They estimate that the cost of immobilization could be 25% less than for a reactor-based disposition programme.

The NDA options paper says there could be a question-mark over the proliferation resistance of the low-spec MoX option. However, the MoX could be stored along with spent fuel to improve its proliferation resistance.

The other immobilization options mentioned in the NDA options paper should be investigated further and tested against the environmental principles above, and other criteria such as cost, dose levels to the work force and so on.

### Conclusions

By applying a set of environmental principles to the problem of what to do with the UK's surplus of around 100 tonnes of plutonium, we conclude that:-

(1) The creation of further plutonium stocks should be stopped as quickly as possible.
(2) Converting the existing stockpile of UK plutonium to MoX fuel would require the construction of a new MoX fuel fabrication plant. This would not be an economic use of resources and there are many other more efficient climate abatement options.
(3) The use of MoX fuel fails to meet non-proliferation objectives; involves unacceptable safety and security risks, and is a threat to civil liberties. Spent MoX fuel would be a much more hazardous waste form to deal with than conventional spent fuel.
(4) Selling plutonium to overseas customers, either in the form of MoX or plutonium oxide also fails to meet non-proliferation objectives. In addition to posing a threat of proliferation at the state level, MOX-fuel and plutonium commerce also poses a risk of theft or diversion by criminal organizations or terrorist groups. Anything which would legitimise plutonium commerce must be rejected.
(5) All immobilization options mentioned in the NDA options paper should be investigated further and tested against environmental principles, including in particular proliferation resistance, and other criteria such as cost, dose levels to the work force and so on.

[15] 130 Terrorist Groups Capable of Nuclear Attack says UN, by Rob Edwards, Sunday Herald, 13th May 2001. http://www.robedwards.com/2001/05/130_terrorist_g.html
[16] See for example Disposition of Separated Plutonium by Frans Berkhout et al, Science and Global Security, Volume 3, Issue 3 &4, March 1993.
[17] The Disposition of Civil Plutonium in the UK, by Fred Barker and Mike Sadnicki, April 2001.