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Options for dealing with UK Plutonium Stockpiles

Introduction

A poor prognosis for the Sellafield MoX (Mixed plutonium and uranium oxide fuel) Plant (SMP) by its owners the Nuclear Decommissioning Authority (NDA) has once again highlighted the question about what to do with the UK's embarrassing stockpile of 100 tonnes of weapons useable plutonium. This plutonium has been separated from spent nuclear waste fuel produced in the UK's nuclear reactors. Bizarrely, the failure of SMP, at a cost to the taxpayer of £2bn, and the continuing pointlessness of extracting plutonium from spent fuel at Sellafield, has led some to suggest building a replacement MoX fuel plant.

The NDA is required to provide a lifecycle cost estimate for dealing with the UK's nuclear legacy, including separated civil plutonium, but current estimates do not include the cost of plutonium management after 2120. Although the NDA has estimated the costs of 'disposing' of the plutonium, this has not been added to the national liabilities estimate. Consequently it needs to present a series of policy options for plutonium to Government to resolve this problem.

The NDA ran a consultation between August and October 2008 on what it saw as three credible options for UK-owned plutonium: store indefinitely; immobilize and dispose and reuse and dispose. (1) But it pointed 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.

The NDA published a revised Plutonium Credible Options report in January 2009. It says it will continue to work with the Government to gain an understanding of the policy frameworks with respect to energy, climate change and security of nuclear material and ensure they are reflected in future optioneering and decision making. Further work will be undertaken to assess the financial implications of the differing radioactive waste management polices in England and Scotland.

In the meantime it recommends implementing a default strategy which involves budgeting for the cost of continuing to store plutonium until 2120 (or the end date of the Sellafield site) and then 'disposing' of it (in other words emplacing the plutonium in a suitable form in a deep geological facility). This will allow a complete lifecycle to be defined, while the

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ultimate plutonium management strategy is developed. When this default strategy is implemented the NDA's liability estimate will increase to include the cost of disposal. (2)

So, whilst the NDA has sidestepped making a decision about whether or not to use plutonium to fuel new UK reactors, or sell it to another country to fuel their reactors, the subject is still very much on the agenda, and it's clear re-use is what some in the industry and the trade unions at Sellafield would favour. (3)

A new MoX Plant for Sellafield?

SMP was built between 1994 and 1997 at an original cost of £470m, but has been dogged with problems ever since. There were five public consultation exercises and a number of legal challenges, before the first plutonium dioxide powder was introduced into the plant in April 2002. Designed to manufacture 120 tonnes of MoX fuel per year for foreign customers, its production capacity has been reduced to around 40t/yr. Even that reduced target is clearly beyond its capability – it has only produced 9.45 tonnes in its seven year life. (4)

The £470m plant was assessed by government-appointed consultants – Arthur D. Little (ADL) in 2001 to have a net positive value of £216m, but only after writing off the construction costs, and this was partly based on winning Japanese business, which failed to materialise. (5) After 10 years SMP has still not got the all-clear for full operation and the bill is believed to have soared to around £2 billion due to delays in discharging contracts. (6)

Strictly speaking, SMP's problems are irrelevant to the question of how to deal with the UK's stockpile of plutonium. It was designed to manufacture MoX fuel for foreign customers only. However, the fact it may be forced to close has raised the profile of the re-use option for UK plutonium. With unemployment becoming an increasing worry, the potential job losses if SMP closes will boost the argument in favour of building a replacement. The NDA's Plutonium Credible Options report rules out using SMP to manufacture MoX using UK plutonium for new reactors in this country. The NDA says it does not believe that SMP provides either the capacity or longevity to be used for the UK's plutonium stockpile and the recycle options which have been considered assumed that plutonium is either sold direct or that MoX is fabricated in a new plant. (7)

The Guardian has confirmed that 'well placed industry sources' are saying there is little chance the plant will stay open. This will come as little surprise to observers who have watched SMP's wretched performance since it opened in 2002 – with perhaps the only surprise being that the plant has survived this long. (8) The NDA's latest in-house review of SMP is due to go before the Board of Directors in March 2009 and then to the Government.

Local MP Jamie Reed is pressing the case for a new MoX plant to be built at Sellafield, to deal with the UK's 100 tonne plutonium stockpile, and to secure the jobs of 1,000 staff who either work at SMP or have jobs linked to it elsewhere on the Sellafield site. He says a new plant could also create up to 5,000 construction jobs. Areva, which is part of the consortium now running Sellafield, has already been reported to be talking to the NDA about a new MoX plant. (9)

Plutonium Inventory

The UK plutonium stockpile will grow to around 100 tonnes at the end of the currently planned reprocessing operations. This will be the largest civil plutonium stockpile anywhere in the world.

Plutonium separation originally began for the purpose of building nuclear weapons. Later because uranium resources were known to be limited, fast reactors, fuelled by plutonium, were thought to be the way forward. These reactors can theoretically, at the same time as generating electricity, convert non-fissile (the useless portion) uranium into more fissile plutonium. However, fast reactors have been a disaster world-wide.

A string of problems have all come together to stop the development and construction of commercial scale fast reactors. One major difficulty is that they use liquid metal as a coolant – usually liquid sodium, which explodes on contact with air. Currently, only one commercial fast reactor is operating—the Beloyarsk BN-600 in Russia. India is only intermittently operating its Fast Breeder Test Reactor (FBTR) at Kalpakkam. The UK has closed down its Prototype Fast Reactor at Dounreay. The French closed down their Superphénix Fast Reactor in 1996 after it had achieved an average capacity factor of less than 7% over eleven years' of operation. Japan's fast reactor has been shut since a leak of liquid sodium coolant in 1995. (10)

In the absence of fast reactors, several countries, such as Germany, France and Switzerland, opted to use their plutonium stockpiles in conventional reactors. However this route for making use of the plutonium stockpile was problematic in the UK because of the type of reactors built here. In the absence of the capability to use plutonium in either conventional or fast reactors separated plutonium has accumulated.

It should, of course, be noted that separation of plutonium from spent nuclear waste fuel – known as reprocessing – is completely unnecessary. Only around 5 – 10-% of the world's spent fuel arisings are submitted for reprocessing, the rest is stored. (11)

Current Position

The NDA currently assumes that plutonium has a zero value. The material is currently stored at Dounreay (2 tonnes) and Sellafield (100 tonnes). But the Dounreay plan only shows plutonium being stored until 2075, and the Sellafield plan shows it being stored until 2120. No costs for on-going storage are budgeted for after those dates. (12) Clearly this is not a credible strategy so the NDA has been looking at options for its future management.

Under the Energy Act the NDA needs to make sure that all work to clean up its sites is included in the lifetime plans. A number of other drivers have pushed the NDA to consider options for plutonium management. These include: international pressure to reduce stockpiles; the need to ensure any geological repository can accommodate whichever option is chosen; increased contamination of plutonium by americium the longer it is stored, making recycling options more expensive; the need to consider recycling in line with developing UK energy and climate policies.

Credible Options

In developing the options the NDA assumes there will be no reprocessing beyond the completion of that currently planned at Sellafield. It also assumes fast reactors or speculative reactor technologies do not meet the definition of 'credible' at the moment as they are likely to take more than 25 years to deploy, and no MOD material is included in the inventory.

Broadly speaking the NDA defines three credible options for managing the UK stockpile:

(1) Dispose as soon as practicable;
(2) Recycle prior to disposal;
(3) Store prior to disposal. (13)

(It should be noted the NDA uses the word 'disposal' here to refer to placing the plutonium in an underground geological repository leaving open the possibility that it could eventually be returned to the surface by being transported by groundwater, for example. It does not mean "to get rid of.")

Disposal as waste

The NDA says all options ultimately result in disposal, and so the planned Geological Disposal Facility (GDF) needs to be designed to accommodate plutonium. However this first option would require plutonium to be 'immobilised' through encapsulation, and then stored until a repository is available. The NDA says it is working on gaining a greater understanding of the implications of disposing of plutonium in a geological disposal facility.

Many of the technologies which could be used to achieve the encapsulation are not fully developed and more work needs to be done to establish how much plutonium could be incorporated into different waste forms. The amount of plutonium that is included in each waste package has a very significant impact on the cost. The difference between the highest and lowest incorporation rates that might be possible can alter the cost by billions. The suitability of different wastes will also need to be assessed from a security perspective particularly in the light of a terrorist threat.

Risks include the possibility the repository cannot accept plutonium waste forms; that the public refuses to accept disposal of plutonium in the repository or the possibility that disposal is uneconomic.

Recycling

Within the recycle option there are a number of possible sub-options. The plutonium could be sold to another country, for example. A contract to convert the plutonium into MoX fuel could be awarded to a company in another country, or a MoX fuel fabrication facilty could be built in the UK. Once converted into fuel, the MoX could be sold abroad or used in reactors in this country.

The NDA looks at recycling the plutonium as MoX fuel which is fabricated in the UK and then shipped to either Europe or Canada or selling plutonium oxide powder. It also looks at leasing plutonium to a third party with spent fuel being returned to the UK.

The NDA says it has not specifically analysed the option of using MoX in UK reactors (whether fabricated here in the UK or abroad) as it would require a change to the Government's stance on licensing reactors for MoX fuels. Should it become an option in the future, this would be very similar to the options currently analysed but without the need for, or cost of international sea transport.

To refine this option the NDA will undertake 'a market engagement exercise' to gauge the level of interest in recycling plutonium. If the option of recycling proves viable then discussions will take place with Government to determine the type of commercial arrangement which they would find acceptable.

Aside from the possible risk that there is no market for plutonium or MoX, or that future policy prevents the transport abroad of plutonium or MoX, there is also the risk that the geological repository cannot be designed to accept spent MoX fuel.

Storage

Whatever decision is taken some plutonium will remain in storage for at least 30 to 50 years. The NDA says storage can never take the material to a defined end state, so it can only ever be a temporary measure until a decision is taken about whether plutonium is classified as an asset or a waste.

The storage strategy risks the possibility that it becomes unacceptable from a security point of view, or the cost of storing plutonium in a secure condition may become too high.

Options

The options which have been assessed so far are:

1. Storage until 2120
2. Dispose in a cement composite
3. Dispose in a glass composite
4. Dispose in a ceramic composite
5. Dispose as low specification MoX assemblies using a new plant
6. Dispose as low specification MoX in cans, modifying the Sellafield MOX plant
7. Sell or lease as MoX for use in a CANDU reactor
8. Sell or lease as MoX for use in a LWR reactor
9. Sell as separated plutonium.

The NDA's analysis shows that the probability of generating a positive cash flow from any of these options is small.

The NDA recommends continuing to plan to store plutonium until 2120 (Sellafield closure date), but this reference strategy should now also include what it calls 'deferred encapsulation' i.e. encapsulation for disposal in 2120. Implementing this reference

strategy will allow a complete lifecycle to be defined, while the ultimate plutonium management strategy is developed. When the reference strategy is implemented the NDA's liability estimate will increase to include the cost of encapsulation and disposal.

In the meantime further research work will be carried out particularly relating to disposal and the potential market appetite for recycling in order to inform the ultimate strategy.

Interestingly the NDA says the deferred encapsulation for disposal reference strategy cannot be applied to the 2 tonnes of plutonium at Dounreay because that would not be in line with current Scottish Government policy on radioactive waste. (14)

Conclusions

NFLA's submission on the NDA's plutonium options consultation paper concluded that by applying a set of environmental principles to the problem of what to do with the UK's plutonium stockpile it can been seen 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 legitimize 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.

In its response to stakeholder comments on the plutonium options consultation paper, the NDA highlights comments raised on policy issues which it says are a matter for Government – specifically how plutonium fits within a wider energy or climate change policy. It says it has asked the Government for policy guidance on this. So, whilst the NDA has sidestepped making a decision on using plutonium to fuel new UK reactors, the subject is still very much on the agenda, and this is clearly what some in the industry and the trade unions at Sellafield would favour. (15)

The idea of using the UK plutonium stockpile in purpose-built reactors first came up in a presentation made by Bill Wilkinson of BNFL speaking in Brussels in 2000. He suggested building one or two AP1000 reactors which, unlike most other conventional reactors, could probably use 100% MOX fuel, but would also be inherently more dangerous. (16)

Wilkinson estimated that two new 1200-megawatt reactors would take 25 years to convert 90 tonnes of plutonium into radioactive spent fuel. Wilkinson claimed that because the

reactors would also generate power, they would save more than £1 billion compared with developing a technology to 'immobilise' the plutonium as a waste form. However, a study carried out by Mike Sadnicki and Fred Barker disputed this and concluding that the cheapest option, would be to use the Sellafield MOX Plant (SMP) to fabricate what the authors call "low-spec" or 'dirty" MoX fuel which would not be appropriate for loading into reactors. That material could be placed in a waste facility. (17)

West Cumbria's MP, Jamie Reed wants the Government to classify the 100-tonne plutonium stockpile as an asset as part of "a nuclear renaissance". He says it could power three new reactors for years to come, and that its energy potential is equivalent to more than 800 million barrels of oil. (18) Figures from the National Nuclear Laboratory, formerly part of British Nuclear Fuels, suggest that recycling plutonium and uranium would save more than £2billion on disposal costs. Burning it would avoid the creation of 0.5 billion tonnes of carbon dioxide. Reclassifying the stockpile as an asset, it says, would generate £20 billion of inward investment, without the need for government funding. (19)

In May 2008, the NDA shipped a cargo of highly dangerous plutonium dioxide under armed escort to France, simply because it wanted to replace plutonium used in orders for mixed oxide (MoX) fuel that had to be produced in European facilities when Sellafield was forced to sub-contract the orders from the Sellafield MOX Plant (SMP) because of the plant's failure to produce the goods on time. This may be the first of many plutonium-swap shipments as a number of SMP orders have had to be sub-contracted to France and Belgium. (20)

Shipping plutonium dioxide around the globe has serious implications for nuclear-weapons proliferation. MoX fuel shipments are not much better because the plutonium in it can easily be separated by straightforward chemistry from the uranium dioxide and used to fabricate nuclear weapons. A number of ways of doing this are described in detail in the open literature. (21)

Starting down the road of using plutonium as a fuel, whether at Sellafield or elsewhere, would be a step on the road to a plutonium economy which would bring with it much greater risks of nuclear proliferation, create terrorist targets and ultimately threaten civil liberties. As the plutonium-MoX economy grows, and transports proliferate, the risk of plutonium finding its way to a terrorist group or a clandestine state programme dramatically increases. A new generation of plutonium powered nuclear reactors would also increase the number of targets for a nuclear terrorist attack. (22)

The nuclear industry's vision is clear: a new MoX fuel fabrication plant at Sellafield with several new reactors capable of using MoX as fuel. Ultimately the industry hopes this will convince us that ordinary spent fuel should be reprocessed to separate plutonium to fuel fast reactors, and so we will also need to build a new reprocessing plant at Sellafield. This scenario will almost certainly never come to fruition because of technical, economic and other obstacles. But, in the meantime, promoting the plutonium economy as an option for the UK threatens to open a Pandora's Box around the globe.

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