The UK Government's Consultation on the Management of the UK's Plutonium Stock (URN 12D/075 – 28th May 2012).

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The Consultation asks four questions. We are directly answering here only the first: 'Do respondents agree with the Government's view that it is sensible to issue generic guidance for the reuse of plutonium?' Our answer to that question makes the other three questions, in our view, redundant - at least for now. However we provide other arguments about plutonium disposition that will remain relevant to future decisions.

Our answer to the Government's first question is that it is premature for Government to consider issuing such generic guidance. While Government is still formally committed to the idea that non-reuse options may be implemented for the Pu stock, this move towards generic guidance for reuse alone gives a message that implementation of the reuse option is now officially regarded as the only serious way forward on Government's own suggested 25 year timescale.

We regard this slippage towards endorsement of a single option as undesirable: it involves a premature closing down of serious consideration of immobilisation/direct disposal options, with the resulting risk that the reuse option will prove more costly and potentially more hazardous than some potential immobilisation options. This risk has been enhanced by recent events – notably, the UK experience with the Sellafield MOX facility and the extraordinary cost escalation in construction of the USA MOX facility.

We consider that there are no clear reasons to discriminate in favour of the MOX option on technical, economic or timescale grounds at this time, and that the escalating commitment to MOX as the single way forward is unwise and potentially costly.

The arguments used in earlier Government documentation[1] in favour of LWR MOX and against immobilisation options are that:

- LWR MOX is technically proven and all immobilisation alternatives are either unproven or ruled out on other grounds (e.g. the high costs of cementation and disposal at low concentrations of plutonium).
- The overall cost of the LWR MOX route is potentially lower than immobilisation, though this potentially lower cost is dependent on the 'sale value' of the MOX. Government asserts that the costs of developing MOX and the immobilisation options are otherwise of the same order.[2]

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[1] DECC *Management of the UK's Plutonium Stocks – a consultation on the long-term management of UK owned separated plutonium* February 2011, and DECC *Management of the UK's Plutonium Stocks – a consultation response on the long-term management of UK-owned separated civil plutonium* 1 December 2011

[2] "…our best current estimates show that costs of procuring and operating the necessary facilities for the reuse option, including disposal, are comparable with the estimated costs of procuring and operating the necessary facilities for the immobilisation option, including disposal.

The basis of this statement is unreviewable, however, because all economic and cost data, other than unhelpful single numbers for total costs, have been redacted from relevant documents.

- LWR MOX is the only acceptable option likely to become reliably available within a timespan that Government regards as acceptable.

None of these arguments is as conclusively in favour of MOX as Government suggests.

With regard to which immobilisation options are worth considering, we suggest that the best choice at this point would appear to be ceramic-based immobilisation. One variant of this approach, "Dispose as ceramic using Hot Isostatic Press" (HIP), with a plutonium loading of 10%, was included in the NDA *Credible Options Analysis (Gate A)* of 2010. It was described as " being developed by the National Nuclear Laboratory at Sellafield for the immobilisation of plutonium containing residues."[3]

In the brief (and heavily redacted) economic, environmental and socio-economic analyses in the *Credible Options Analysis*, it was found for HIP that:

- "The disposal strategies generally carry less uncertainty than the reuse strategies, with the exception of option 2 (cement)" (p. 38);
- The processing plant would be less complex than a MOX plant (p. 43);
- Fewer jobs would be created (p. 44) – which presumably translates into lower costs in one important area.

These advantages make intuitive sense because:

1. Three orders of magnitude fewer plutonium-containing objects would be produced in an immobilisation facility. A MOX pellet contains about a gram of plutonium while a ceramic immobilisation form would be expected to contain on the order of a kilogram.

2. Quality control requirements would be much less stringent for an immobilisation waste form because, unlike MOX, it would not be required to sustain very high power densities and temperatures, and to contain a high concentration of fission products. The Sellafield MOX plant failed to meet these stringent quality requirements for a decade before being abandoned.

An additional advantage of a ceramic waste form is that it can be engineered to be much more insoluble in a geological environment than MOX.[4]

While these costs will continue to move and develop over time, the current estimates for the discounted costs of each of these options is around £3bn. For reuse these costs should be reduced by sales of the resulting MOX fuel, although the quantum cannot be predicted with accuracy at this time and would ultimately have to be negotiated with the reactor operators." DECC, op. cit. 1 Dec. 2011, pp. 14-15.

[3] NDA , *Plutonium: Credible Options Analysis (Gate A)* of 2010, pp. 34

[4] See e.g., Sergey V. Yudintsev, et al, "Actinide host phases as radioactive waste forms" in *Structural Chemistry of Inorganic Actinide Compounds*, edited by S.V. Krivovichev, et al, Elsevier, 2007, p. 457; and R.C. Ewing and W.J. Weber, "Actinide Waste Forms and Radiation Effects" in

The main objection to the HIP option in the *Credible Options Analysis* was that "This option is technically immature for large scale bulk plutonium" (p. 52).

Below, we critique in turn the three arguments being made in favour of LWR MOX:

- Only LWR MOX is technically proven;
- The overall cost of LWR MOX will probably be lower than for immobilisation; and
- Only MOX will be available for implementation in a timescale of 25 years.[5]

Argument 1: Only LWR MOX is technically proven

It is true that, at present, ceramic forms of immobilisation are less proven than LWR MOX. As indicated above, however, there are reasons to expect that they should be less costly and a commitment to further R&D in this area would reduce the uncertainties.

Argument 2: The overall cost of LWR MOX will probably be lower than for immobilisation

Given that Government has redacted all relevant cost and economic information on which this judgment is based, there is no way in which this claim can be independently evaluated. However if we start by accepting, for present purposes, that the costs of MOX and immobilisation might be similar - with the sale value of MOX the compensating factor that could tip the balance in favour of MOX - we have the following cautionary comments:

First, there is the question of construction costs. While it is the case that AREVA has built and run a MOX plant in France that has achieved design throughputs, its economic status is not publicly available. In the UK, as is well known, the technical and economic performance of the Sellafield MOX Plant (SMP) was frankly disastrous.

The third relevant example is the MOX plant currently under construction in the USA, in which AREVA has the lead technical role. This project has experienced extraordinary cost increases and delays. The estimated construction cost that was provided to Congress as a basis for authorizing the project in 2002 was $1 billion. According to an audit report by the US Department of Energy Inspector General, NNSA (the responsible agency within the Department of Energy) 'reported that it had a high degree of confidence in its 2002 estimate because the MOX technology was well-established and based on proven processes used in Europe since the 1960s, and that it expected modifications to the technology to be relatively minor.' [6]

The Chemistry of the Actinides and Transactinide Elements, vol. 6, edited by L.R. Morss, et al, Springer, 2010, p. 3813.

[5] DECC op. cit. 1December 2011, op. cit. p. 13

[6] U.S. Department of Energy, Office of Inspector General, Office of Audit Services, *Status of the Mixed Oxide Fuel Fabrication Facility,* DOE/IG-0713 December 2005, p. 2.

As of early 2012, however, the expected start of operations of the U.S. MOX plant had slipped 11 years and its estimated construction cost had grown to $6 billion. An additional $7 billion was projected for its operating cost over the 13 years that it would take to dispose of the 34 tons of excess weapons plutonium covered by the bilateral U.S.-Russian agreement.[7]

It is not at all clear, therefore, that a new MOX plant in the UK would necessarily experience controllable costs or excellent technical performance. A new immobilisation plant might not be immune to all these risks either, but its less demanding technical requirements would make them smaller.

Second, there is the issue of the value of MOX. The Government sets considerable store by the expectation that the MOX produced by a new plant might have a sale value of c. £1 billion (discounted at an unspecified rate and with no indication of the underlying assumptions). Government also suggests that it will undertake 'detailed commercial discussions on the market for MOX'.[8]

If there were such a thing as a 'market' for MOX, however, such 'commercial discussions' would be unnecessary. There *is* a market for LWR fuel, with prices widely available in the absence of commercial discussions. The need for such discussions in the case of MOX results from the fact that in the absence of a 'commercial' market for MOX, its 'price' has to be set in bilateral negotiation between Government and a potential user, as Government itself acknowledges. Given the disadvantages and extra costs associated with MOX use - including the reduced reactor control margins and therefore the need for regulatory approval to use MOX instead of uranium fuel, concerns about fuel performance and public opposition - this 'price' will always involve a substantial discount relative to uranium fuel.

The U.S. has 71 pressurised water reactors but, even after offering deep discounts, the US Department of Energy (DOE) in 2000 found only one private utility (Duke) willing to use MOX fuel. That utility changed its mind in 2008 after poor performance of test MOX fuel made by AREVA and the delay in the completion of the MOX fuel fabrication plant by more than ten years. Currently, the US DOE is negotiating over MOX use with the Tennessee Valley Authority (TVA), a government-owned utility. Since three of TVA's six operating reactors are boiling water reactors, a deal with TVA would face the DOE with the additional costs and delays that will result from redesigning the US MOX plant to produce BWR as well as PWR fuel.[9]

The value of the MOX may therefore in practice be extremely low, especially in the UK position where at present only one company - EDF - is seriously considering going ahead with new reactor construction in the UK, and is under no obligation to use MOX. It is worth noting here that in its responses to the previous Government consultation on plutonium management, the Nuclear Industry Association pointedly referred to the new generation of putative

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[7] U.S. Department of Energy, *Congressional Budget Request*, *FY 2013* Vol. 1, p. 461.

[8] DECC op. cit. December 2011, p. 29.

[9] U.S. Government Accountability Office, *DOE Needs to Address Uncertainties with and Strengthen Independent Safety Oversight of Its Plutonium Disposition Program,* GAO-10-378, 2010, pp. 22-25.

reactors in the UK as 'uranium fuelled'[10] and warned against the possibility that MOX issues might delay progress. EDF in its response to the same consultation did not speak of using MOX itself but emphasized the 'technical, industrial, economic, planning and licensing factors that will need to be addressed',[11] in addition to gaining stakeholder support, if MOX use is to be implemented. This reinforces the view that the value of any MOX produced may be very low.

Argument 3: Only MOX will be available for implementation over a 25 year period

The fact that environmental, safety, social and stakeholder issues are much greater for MOX than for immobilisation suggests that the time to implementation might be much longer for MOX than officially expected. Immobilisation could be carried out at a single site (presumably Sellafield) and major stakeholder issues would be confined to this single location. There also would be no need for 'commercial' negotiation with utilities of the kind outlined above. Further, MOX would need to be transported to a range of different sites across England and possibly Wales, raising significant stakeholder issues associated with plutonium movement along transport routes and at reactor sites. As EDF argued in relation to MOX use, 'it is important that the UK takes the time needed to do this work' and that it 'be conducted in an open and measured way.'[12]

All this suggests that the timescale for availability of the MOX route might be longer than Government expects, while the immobilisation option might be ready as soon or sooner, if the necessary R&D work were put in hand in the next few years. Government itself argues that HIP technology might be mature in 10 years' time.[13]

Conclusion

The overall argument we make is not that the fuel MOX route be closed down – it is rather an argument in favour of diversity and the avoidance of prematurely closing down immobilisation options. We also contend that it would be deeply disturbing if decisions to spend billions of pounds of public money on any one of these options were to be taken in the complete absence – as now – of publication of any meaningful cost or economic data.

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[10] *Nuclear Industry Association response to DECC Consultation* available online together with DECC op. cit., December 2011first page (not numbered)

[11] *EDF Energy's Response to your questions,* available online together with DECC op. cit., December 2011second page (not numbered).

[12] *EDF Energy's response to your questions,* op. cit. December 2011, second page (not numbered).

[13] DECC op. cit. February 2011, op. cit. p. 31.