Plutonium Disposition: What are We Trying to Accomplish?

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We need an alternative to MOX

- Projected life-cycle cost of >$30B
  - ~$1M per kilogram!
  - Unlikely to be supported in Congress over period needed
  - Should not be supported by Congress
  - MOX program does not deliver security benefits worth taking >$30 billion from other priorities

- Circumstances in Russia have radically changed
  - Importance of Russian effort reduced

- But do we have alternatives that:
  - Are significantly less expensive?
  - Would probably work?
  - Could achieve a substantial portion of the disposition effort's objectives?
The committee’s statement of task

- SOT focuses on the technical issues related to WIPP
  - Capacity, waste acceptance, etc.
  - Specific bar on recommendations going beyond technical issues
  - Framed as “to support U.S. commitments under the PMDA”
- But:
  - All options involve non-technical policy considerations
  - Continuing with the PMDA may or may not serve U.S. interests
  - Technical issues with dilute and dispose go way beyond WIPP
    - Was always framed as “dilute and dispose” not “the WIPP option”
    - Might need boreholes, next repository
    - Issues related to speed, cost of dilution, facility capacity
    - Issues related to how much protection dilution and storage offer against theft and use by non-state adversaries, or recovery and use by the host state (and could this protection be increased)
- Suggestion: explore basis for waste acceptance, security limits on plutonium concentration in the cans – could make a big difference

Plutonium disposition:
3 main goals, 2 subsidiary goals

Main goals:
- Reduce the risk of nuclear theft and terrorism
  - Original source of the “clear and present danger” urgency
- Support deep, transparent, and irreversible arms reductions
  - Was also a key early motivation
- Reduce the burdens of indefinite storage
  - Cost, safety, political issues

Subsidiary goals:
- Provide jobs
- Address the politics of plutonium management

Once subsidiary goals are now major drivers

The energy content of the plutonium should not be a major driver
  - Tiny on the scale of world energy needs, large only in number of bombs that could be made from it
The NAS study: key criteria for choice

Security objectives:
- Prevent access by unauthorized parties
- Reduce risk of reincorporation into existing arsenals
- Support arms control and nonproliferation agreements and institutions

Context of 1994:
- “Loose nukes” beginning to be a major concern
- Further disintegration of the Soviet successor states seemed possible
- Positive U.S.-Russian relations, optimism about deep nuclear arms reductions, far-reaching verification and transparency

The NAS study: key criteria for choice (cont.)

- Goal: achieve the “spent fuel standard”
  - Put excess weapons plutonium in a form that poses no more security risk than plutonium in commercial spent nuclear fuel
  - Standard relates to both ease of theft and use by non-state adversaries and ease of recovery and use by host state

- While:
  - Maintaining, to the extent practical, the “stored weapon standard” — security and accounting comparable to those for nuclear weapons — until spent fuel standard reached
  - Ensuring compliance with ES&H standards and no significant addition to risks to human health from nuclear energy
  - Minimizing time (considered a key security criterion in 1994)
  - Minimizing cost
The NAS study: recommended paths

- Regime of declarations, monitoring, and reductions in stocks of all nuclear weapons, plutonium, and HEU
- Storage of plutonium under high security and international monitoring
  - Ultimately seek “stored weapon standard” for all separated plutonium and HEU worldwide
- Pursue two long-term disposition tracks in parallel:
  - MOX in existing reactors (no new reactors needed)
  - Immobilization with high-level waste
  - Either might fail – each could be a backup to the other

First two very important recommendations largely forgotten today

Plutonium disposition is not a top priority for reducing the risk of nuclear theft

- Nuclear theft risks are not closely linked to size of stocks – building with 2 tons poses the same risk as building with 100 tons
  - Both security levels and reducing number of sites and buildings are more important than total size of stock
- Disposition applies to some of the most secure plutonium in all of Russia and the United States
- Removing Pu from secure vaults, processing it in bulk, transporting it, can increase risk – need MPC&A investment to minimize the short-term bump needed for long-term benefit

Source: DTRA
Plutonium disposition could offer significant support for arms reductions

- Plutonium disposition – physically transforming plutonium into forms that would be difficult and expensive to recover for use in weapons – sends a message that arms reductions will not be reversed
  - Getting rid of the huge world stockpiles of plutonium is likely to be essential to very deep reductions, pursuit of zero nuclear weapons
  - In nearer term, helps fulfill Article VI obligations, strengthen political support for nonproliferation measures
- But plutonium disposition only has substantial benefits in these respects if plutonium stocks are reduced enough that they would no longer support Cold War arsenals
  - Disposition of 34 tons only has significant benefit as 1st step to much more
  - Disposition without substantial commitment to, or progress on, deep reductions may have little benefit

The burdens of continued storage are modest

- Net marginal cost of storing the excess plutonium in addition to the other plutonium that will be stored in any case is small
- Net marginal ES&H burden of continued storage is also small
- Political difficulty of continued storage is substantial
  - South Carolina was promised plutonium would be processed (with resulting jobs) and then leave – not be stored there indefinitely

Source: Savannah River Nuclear Solutions
Dilute and dispose options could largely meet U.S. security objectives

- Reducing risks of theft
  - Key priority is achieving high standards of security and accounting – for all stocks of nuclear weapons and weapons-useable nuclear material
  - Plutonium immobilized in can-in-canister form; immobilized and disposed in WIPP; or placed in deep boreholes would pose very low risks of theft

- Supporting nuclear arms reductions
  - Key priority is deeper reductions in stockpiles of weapons and materials available for weapons – otherwise disposition has little effect
  - For excess, key near-term step is placement under international monitoring
  - Immobilization in can-in-canister, with disposal to WIPP, or in deep borehole would go a significant distance to making reversal of arms reductions more difficult

- Reducing burdens of long-term storage
  - Any of these options likely to address this objective

- Providing jobs, managing politics
  - Provides some jobs, but fewer, at lower cost – and helps move Pu out

Meeting 100% of the spent fuel standard is not essential

- Spent fuel standard is a desirable goal, if it can be achieved at reasonable cost
  - Intended to address both “loose nukes” and rearmament concerns
  - Different properties relevant to non-state adversaries and the host state

- Government should take a risk-informed approach to thinking through the spent fuel standard
  - If material resulting from a disposition option is modestly more attractive than plutonium in commercial spent fuel, would this:
    - Noticeably increase the overall risk of nuclear theft, in the context of other stocks that might be stolen?
    - Noticeably decrease the overall political support disposition offers for deep nuclear arms reductions, in the context of other issues such reductions face, and other relevant stocks?

- Seen in this light, currently discussed options for dilute and dispose followed by disposal to WIPP, to boreholes, or to a later repository seem unlikely to noticeably increase risks
Context: The near-total collapse of U.S.-
Russian nuclear cooperation

- Spring 2014: U.S. cuts off nuclear energy R&D cooperation
  - Part of sanctions over Russia’s seizure of Crimea, intervention in E. Ukraine
  - Commercial sales continued; R&D agreement, 123 agreement still in place
- Late 2014: Russia cuts off almost all nuclear security cooperation
  - Russia had long had growing concerns about “unequal” nature of this cooperation -- framed Russia as “weak” country needing U.S. help to manage its nuclear stocks, allowed U.S. visits to sensitive sites
  - Some non-Rostom, non-MoD cooperation continued, at small scale
  - 2016: Russia suspends PMDA, suspends or withdraws from other accords
- World’s two largest nuclear complexes are essentially not speaking to each other – except for New START verification
  - Personal lab-to-lab contacts almost completely cut off
  - Congress has imposed difficult-to-certify “waiver” requirements for any further spending on aid to Russia for nuclear security
  - Technical people on both sides eager to work together
  - Russia willing to resume if work includes both nuclear energy and security

The impact of a U.S. shift to immobilization on the Russian program is uncertain

- Early Russian view was permissive:
  - “If you want to flush gold down the toilet, that’s your problem”
- Later Russian view (reflected in PMDA) was restrictive:
  - U.S. and Russia should both use as fuel in reactors, not immobilize
  - Immobilization seen as “just another form of storage,” U.S. could recover the material, would give the United States an advantage
  - BUT, PMDA permits “other methods that may be agreed by the Parties”
  - Recent Putin comments: Russia unlikely to agree to U.S. immobilization
- Logically, no strong reason for Russia to oppose immobilization
  - PMDA now supports Russia’s preferred nuclear energy approach
  - Given remaining stock, specific approach to disposition of 34 tons is not strategically significant
  - Dilute and dispose material would be difficult and expensive to recover
- PMDA in current form cannot be implemented in any case – timelines cannot be met, U.S. funding for Russian program unlikely
The Russian argument that immobilization is just another form of storage is wrong

- True, isotopics are not changed
  - U.S. could, in principle, recover plutonium from the immobilized forms
  - Could be changed if U.S. mixed W-Pu with R-Pu from elsewhere

- But recovering plutonium would be difficult, take a long time
  - Would require building major new chemical facility for plutonium processing – billions of dollars, many years
  - Question for panel: how difficult to recover from proposed D&D form?

- United States would have to be crazy to spend billions to put plutonium into a form it would cost billions more to get it back from if it had any intention of ever recovering it

Source: DOE/NNSA

The benefit to U.S. security of the Russian disposition program is real but modest

- With or without PMDA, Russia will fuel the BN-800 with plutonium
- With PMDA implementation:
  - BN-800 would use W-Pu, not R-Pu
  - Disposition spent fuel will not be reprocessed until disposition is complete
  - BN-800 breeding ratio will be slightly less than 1, rather than slightly more than 1 (tiny change in annual plutonium production)
  - There will be verification of the use of the W-Pu as fuel
  - The United States would provide significant funding for the MOX plant (unless agreement amended)
- Modifying the PMDA to permit disposal might be possible IF U.S.-Russian relations improved

Source: Rosatom
In short: cheaper options may well be able to achieve key disposition objectives

- Immobilization options *might* be billions of dollars cheaper
  - DOE doing studies to confirm
- Immobilization options have a good chance of meeting the security objectives of plutonium disposition
- May be able to get Russian agreement to use immobilization rather than MOX under the PMDA
  - If not, the PMDA's security benefits, while real, are not enormous
- Achieving 100% of spent fuel standard may not be needed to meet main objectives

Some recommendations for next steps

- Focus first on high standards of security and accounting:
  - Try to work with Russia to insure that MOX plant, other processing and transport involved, uses world-class security and accounting
  - Can demonstrate how excellent MPC&A can be consistent with economic production
- Focus second on international monitoring:
  - Even for the plutonium already declared excess, most will not enter disposition process or the monitoring currently planned for decades
  - Should revive idea of putting excess material under IAEA monitoring soon – even while it is still in classified form (Trilateral Initiative techniques can protect classified data)
  - U.S. should announce (before 2020 NPT Review) that it will permit (and finance) IAEA monitoring of all or most of its excess material – challenge Russia to take similar steps
- Pursue deep reductions in weapons and materials
  - Disposition makes a major contribution only has one part of an overall deep reductions package
Some recommendations for next steps (II)

- Pursue alternatives to MOX
  - Move forward with dilute and dispose
  - Pursue R&D, design on other immobilization options as backups
  - May make sense to implement can-in-canister for some of the excess stock, WIPP disposal for another portion

- Seek an understanding with Russia
  - Ideally: keep PMDA in place, but allow dilute and dispose or other disposal options
  - May only be possible if political relations improve, nuclear cooperation restarts in other areas
  - Seek arrangements for high security throughout the disposition process

- Design options to be expandable
  - Because disposition only makes major contribution to security if applied to much larger stocks of material

For further reading...

  http://fissilematerials.org/library/gfmr07.pdf

- Bunn, “Disposition of Excess Plutonium: Rethinking Security Objectives and Technological Approaches”
  http://belfercenter.hks.harvard.edu/files/bunn_testimony_july262006.pdf
Another option that should be considered: plutonium swaps

- France is the only country with an effective program turning plutonium into MOX
- United States could offer France 40 tons of plutonium and $4B to take it off our hands
  - If they say yes: probably the cheapest disposition option
  - If they say no: we put the lie to the idea that plutonium is wonderfully valuable material
  - Would require major effort to ensure security during transport, processing
  - Would require license amendments for facilities to handle W-Pu
  - France already has >80t of separated plutonium already; substituting 40 tons of W-Pu for the R-Pu that would otherwise be used would cause the R-Pu stock to increase by a similar amount
  - In effect, would shift 40 tons of W-Pu not under safeguards to 40 tons of R-Pu under Euratom safeguards to ensure peaceful use – some significant benefit from an arms reduction perspective
  - Option has not been seriously explored to date

The dilute and dispose option

- Dilute with “Stardust”
  - VERY simple process – mixing powder in gloveboxes
  - Already being done for EM plutonium
  - Material composition classified
  - Store in drums pending disposal
- Disposal in WIPP or other location:
  - WIPP MIGHT be able to hold all currently declared excess plutonium – but it might not
  - Reason Obama team never called it “the WIPP option” – always “dilute and dispose”
  - A key question is: how much plutonium could safely be put in each drum? (Panel should challenge assumptions.)
  - Some consideration of disposal in boreholes at DOE sites
  - U.S. will ultimately need an additional repository in any case
Other immobilization options

- Can-in-canister:
  - Originally chosen immobilization approach
  - Would there be enough HLW remaining by the time disposition began on a large scale?
  - How much is “enough” HLW?

- Miscellaneous others:
  - Could they be done without major new facilities?
  - Could R-Pu be mixed in?
  - Could materials and facilities at Hanford play a role?

Would any of these options resolve any of the concerns with dilute and disposal? How much would they cost? With what confidence?

Source: DOE/NNSA