



HARVARD Kennedy School
BELFER CENTER
FOR SCIENCE AND INTERNATIONAL AFFAIRS

Plutonium Disposition: What are We Trying to Accomplish?

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Disposal of Surplus Plutonium in WIPP: Data-Gathering
Session for National Academies study

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belfercenter.org/managingtheatom

We need an alternative to MOX

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- ❑ 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?



Source: Shaw Group

The committee's statement of task

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- ❑ 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

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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

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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.)

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- ❑ 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

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- ❑ 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

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- ❑ 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

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- ❑ 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

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- ❑ 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

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- ❑ Reducing risks of theft
 - Key priority is achieving high standards of security and accounting – for *all* stocks of nuclear weapons and weapons-usable 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

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- ❑ 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

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- ❑ 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

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- ❑ 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

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- ❑ True, isotopes 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

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- ❑ 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

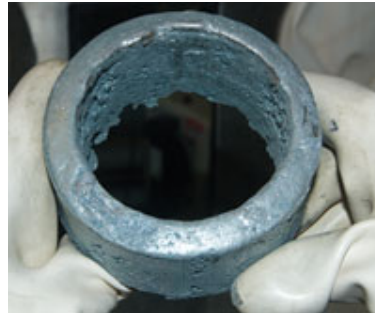


Source: Rosatom

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

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- ❑ 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



Source: Los Alamos

Some recommendations for next steps

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- ❑ 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)

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- ❑ 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...

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- ❑ Bunn and Diakov, "Disposition of Excess Plutonium" in *Global Fissile Materials Report 2007*:
<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

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- ❑ 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

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- ❑ 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

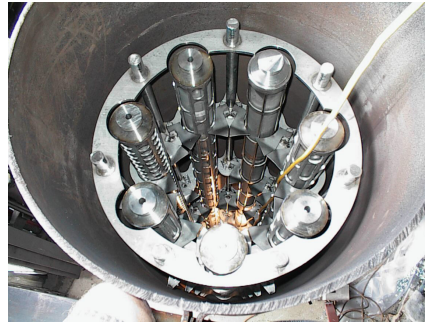
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❑ Can-in-canister:

- 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?



Source: DOE/NNSA

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