HARVARD Kennedy School
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FOR SCIENCE AND INTERNATIONAL AFFAIRS

Plutonium Disposition: What are We Trying to Accomplish?

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Plutonium Disposition Alternatives Workshop

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belfercenter.org/managingtheatom

We need an alternative to MOX

- Projected life-cycle cost of $28B
  - ~$700,000 per kilogram!
  - Unlikely to be supported in Congress over period needed
  - Should not be supported by Congress
  - *MOX program as currently structured does not deliver security benefits worth taking $28 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

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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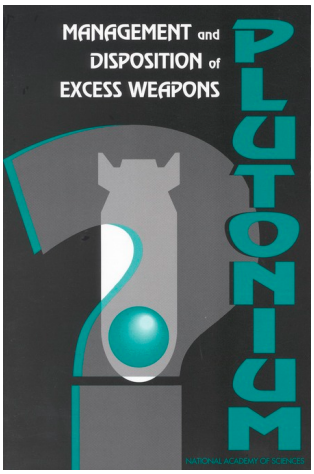
Security objectives:

- 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 major concern
- Further disintegration of 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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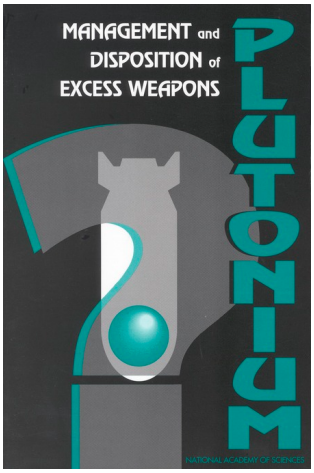
- Goal: achieve the "spent fuel standard"
  - Put excess weapons plutonium in a form that poses no *more* security risk than plutonium in commercial spent nuclear fuel
  - Standard relates to both ease of theft and use by non-state adversaries and ease of recovery by host state
- While:
  - Maintaining, 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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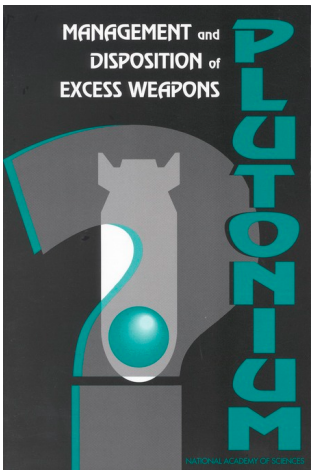
- Regime of declarations, monitoring, and reductions in stocks of all nuclear weapons, plutonium, and HEU
- Storage of plutonium under high security and international monitoring
  - Ultimately seek "stored weapon standard" for *all* separated plutonium and HEU worldwide
- Pursue two long-term disposition 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 major recommendations largely forgotten today – may be more important



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 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, 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

Are there realistic immobilization options?

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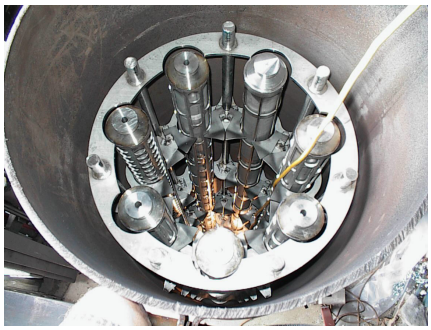
- Can-in-canister:
  - Would there be enough HLW remaining by the time disposition began on a large scale?
  - How much is "enough" HLW?
- Immobilization to WIPP:
  - Could WIPP accommodate all the excess plutonium? Would legislation be needed?
  - Would the WIPP disposal forms meet the spent fuel standard? How much does it matter?
- Immobilization to deep boreholes:
  - Could this get approval, licenses, in a reasonable time?

How much would any of these options cost? With what confidence?



Source: DOE/NNSA

Immobilization 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 immobilization to WIPP, to boreholes, or with the limited fission products remaining at SRS seem unlikely to noticeably increase risks

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"
  - Will Russia now agree to U.S. immobilization?
- Logically, no strong reason for Russia to oppose immobilization
  - PMDA now supports nuclear energy approach Russia wants to pursue anyway
  - Given remaining stock, specific approach to disposition of 34 tons is not strategically significant
  - In preliminary discussions, Russian officials "understanding" of problems the U.S. is encountering with MOX
  - *But,* a U.S. view of the logic may not drive the outcome

The Russian argument that immobilization is just another form of storage is wrong

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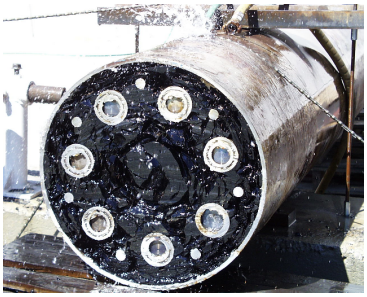
- True, isotopics are not changed
  - U.S. *could,* in principle, recover plutonium from the immobilized forms
- But recovering plutonium would be difficult, take a long time
  - Would require building major new chemical facility for plutonium processing – billions of dollars, many years
  - No large-scale facility capable of separating ceramic forms has ever been built
- 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 build BN-800, fuel it with plutonium
- With PMDA:
  - BN-800 will 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 will provide significant funding for the MOX plant
- Collapse of agreement *could* also affect other cooperation

Source: Encyclopedia of Safety

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Another option that should be considered: plutonium transfers

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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 in the U.S. to 40 tons of R-Pu under Euratom safeguards to ensure peaceful use in France – some significant benefit from an arms reduction perspective
  - Option has not been seriously explored to date

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

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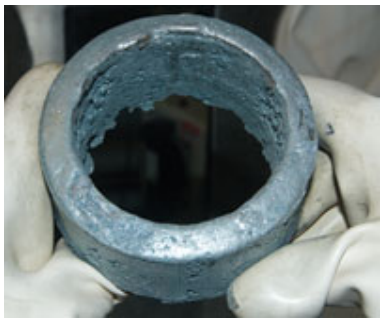
- Immobilization options *might* be billions of dollars cheaper
  - R&D, design likely necessary to confirm
- Immobilization options have a good chance of meeting the security objectives of plutonium disposition
- May be able to get Russian agreement to use immobilization rather than MOX under the PMDA
  - If not, the PMDA's security benefits, while real, are not enormous
- Achieving 100% of spent fuel standard may not be needed to meet 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 2015 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
  - Consider swaps approach
  - Pursue R&D, design on immobilization options – probably more than one, to have a backup
  - 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 the immobilization or swap option the United States chooses
  - Seek arrangements for high security throughout the disposition process
- Design options to be expandable
  - Because disposition only makes major contribution 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