

THE U.S. SURPLUS PLUTONIUM DILEMMA: LESSONS FOR JAPAN

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SEPARATED PLUTONIUM: “A CLEAR AND PRESENT DANGER”

- All uranium fueled reactors produce plutonium
- Plutonium contained in spent fuel is protected by intrinsic barriers to its separation and use in weapons
 - Dilution (1 percent)
 - Size and weight
 - Radiation barrier
- Separated plutonium poses a “clear and present danger”
 - Risk of rapid conversion by States for use in nuclear weapons
 - Risk of theft by terrorists for use in improvised nuclear devices
- Separated plutonium must be safeguarded and protected much more intensively than spent fuel
 - “Category I” versus “Category III”

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THE U.S. SURPLUS PLUTONIUM PROBLEM

- At the end of the Cold War, the U.S. and Russia were each left with thousands of bombs' worth of excess separated plutonium
- In 2000, the two countries signed a Plutonium Management and Disposition Agreement (PMDA), which committed both sides to convert 34 tonnes of Pu into a form less accessible for weapon use
 - U.S.: 26 tonnes to be turned into MOX (pluthermal) fuel and irradiated in light-water reactors; 8 tonnes to be "immobilized" with high-level radioactive waste
 - Russia: 34 tonnes as MOX in LWRs and the BN-600 fast reactor
- Initial rationale
 - Help to lock in bilateral nuclear arms reductions
 - Reduce threat of theft by sub-national groups
 - Reduce plutonium storage costs

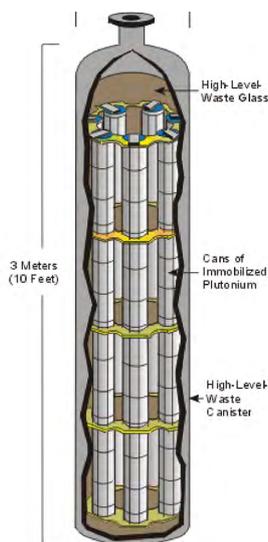
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SPENT FUEL STANDARD

- "Spent fuel standard" concept for excess plutonium disposition
 - To render separated plutonium "roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel": U.S. National Academy of Sciences, 1994
- Chief attributes:
 - Mass and bulk of disposition item
 - Plutonium chemical dilution
 - "self-protecting" radiation barrier (e.g. cesium-137)
 - Plutonium isotopic composition (not ranked as a significant factor, as nearly all plutonium isotopes are weapon-usable)

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PLUTONIUM “CAN-IN-CANISTER” IMMOBILIZATION



ALL-MOX DISPOSITION

- In 2002, the U.S. cancelled the immobilization program and focused exclusively on MOX
 - Claimed that the country could not afford to pursue both options
 - Although immobilization was projected to be cheaper, Russia apparently would not accept immobilization of all U.S. plutonium because the method did not change the isotopic composition to reactor-grade, even though this had no meaningful impact on the weapon-usability of the material by either nation
- DOE began building the Mixed Oxide Fuel Fabrication Facility (MFFF) at the Savannah River Site in the state of South Carolina in 2007
- In 2010, the PMDA was amended
 - U.S.: irradiation as MOX fuel in light-water reactors
 - Russia: irradiation in BN-600 and BN-800 fast reactors

PROBLEMS WITH MOX

- MOX is worse than doing nothing because it significantly increases
 - Diversion and theft risks
 - Environmental and public health risks
 - Cost
- Total cost estimate for the MOX project has skyrocketed from US \$5 billion in 2002 to US \$30-50 billion today (on the order of \$1 million/kg Pu or \$50,000/kg MOX (25 times the cost of LEU fuel)
- US \$5 billion has already been spent, but the plant is only about 30% complete; won't operate before 2048
- No utility has committed to using MOX fuel, even with the promise of generous subsidies

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SECURITY ISSUES

- Because the U.S. MOX program was getting so expensive, the contractors received exemptions from the Nuclear Regulatory Commission from important security regulations
 - MOX fuel with Pu content < 20% was exempted from Category I security requirements at reactor based on the false notion that it is an unattractive target for terrorists to steal
 - The MOX fuel fabrication plant was exempted from requirements that if material is subject to an alleged theft it must be *physically* located within a short period of time: review of computer records judged adequate

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PU DISPOSITION ALTERNATIVES

- Given its massive cost escalation and delays, the Obama administration tried to cancel the MOX project and replace it with “dilute and dispose:”
 - Mixture with chemically inert materials and burial in the Waste Isolation Pilot Plant (WIPP) in New Mexico
 - Also the option proposed for disposal of 331 kg of Japanese plutonium from the Fast Critical Assembly
 - Cheaper and faster than MOX
- Other options also exist
 - Immobilization with vitrified (“glassified”) high-level waste and disposal in a mined repository (originally Yucca Mountain)
 - Immobilization without a radiation barrier and disposal in deep borehole

DILUTION AND DISPOSAL

- WIPP: an operating geologic repository for DOE transuranic (TRU) waste near Carlsbad, New Mexico
- Projected cost to dilute and dispose of 34 MT of Pu in WIPP is around \$15 billion --- 2-3 times less than MOX
- WIPP operated successfully until it was shut down in February 2014 after a waste drum overheated and released plutonium into the repository
- Limited operations resumed earlier this year
 - Residual contamination remains a problem

DILUTION AND DISPOSAL: THE OBSTACLES



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PLUTONIUM DISPOSAL CONFIGURATION

- Disposal container: 208-liter drum containing a stainless steel inner container
- Inner container contains plutonium oxide diluted to below 10 weight-percent
- Criticality considerations limit the amount of plutonium in each container to less than 380 grams of Pu-239
- Each container contains well below the amount of material needed for a nuclear bomb
 - Compare to fresh MOX fuel assemblies, diluted to near 10% but each containing several bombs' worth of plutonium

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STARDUST

- Dilute and dispose does not meet the “spent fuel standard” because it does not use a radiation barrier. The concept gives more credit to dilution and other mechanical and chemical barriers to separation
- Current concept dilutes Pu with a special material called “stardust” in order to effectively reduce the attractiveness of the material for producing weapons
 - “A mixture of cementing, gelling, thickening and foaming agents” that makes it “more difficult and complex to recover, concentrate and purify the plutonium”
- The US DOE claims that the additional time and resources needed to recover diluted Pu is comparable to the spent fuel standard
- Many different “stardust” compositions
- The compositions of stardust are classified as “official use only” by the US – could Japan

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OTHER OPTIONS

- Alternative options are available for further reducing Pu accessibility in WIPP drums
 - Dilution below 1% in cement grout
 - Immobilization in refractory materials (ceramic)

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THE RUSSIA QUESTION

- In October 2016, Russia suspended its implementation of the PMDA
 - It asserted that the U.S. was not upholding its end of the deal because the Obama administration wanted to change its disposition approach from MOX to dilute-and-dispose, which Russia claims is reversible because it doesn't change the isotopics
 - It imposed a number of conditions for its resumption of the agreement, none of which is directly relevant to plutonium disposition
- Position of Trump administration not known

JAPAN'S CONTRIBUTION

- If Russia insists on isotopic dilution to > 10 percent Pu-240, Japan could have an important role to play
- The U.S. could import Japanese plutonium stored in Europe or Japan for blending with weapons-grade plutonium prior to dilution; The U.S. could pay Japan billions of US dollars for this material and it would still cost less than continuing with the MOX program
- To increase the isotopic fraction of 34 tonnes of weapons-grade plutonium to > 0.1, a minimum of about 10 tonnes of reactor-grade Pu would be needed
- WIPP, or a combination of WIPP and immobilization, could likely accommodate the additional Pu from Japan
- The U.S. should commit to placing any Japanese plutonium received for this purpose under IAEA safeguards

DILUTE AND DISPOSE IN JAPAN?

- Japanese law prohibits geologic disposal of plutonium
- However, dilute-and-dispose canisters are considered “transuranic waste” in the U.S., allowing their disposal in WIPP; Japan could make the same determination
- Japan needs a geologic repository for transuranic waste—could also be a disposal site for diluted plutonium waste

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CONCLUSIONS

- Disposal of excess plutonium in WIPP has been proven
- Assuming WIPP resumes operations within several years, it could be used for disposing the entire U.S. inventory in an affordable manner
- Near-term burial of plutonium in a repository is more secure than indefinite above-ground storage of highly irradiated disposition forms
- This strategy might also provide a disposition path for a large fraction of Japan’s own surplus plutonium

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