# Nonproliferation and Nuclear Security Issues at the Back End of the Fuel Cycle

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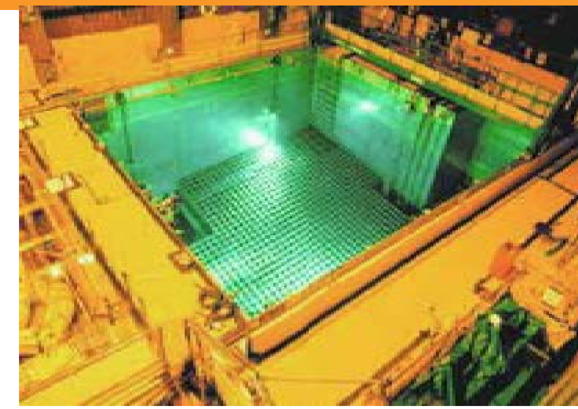
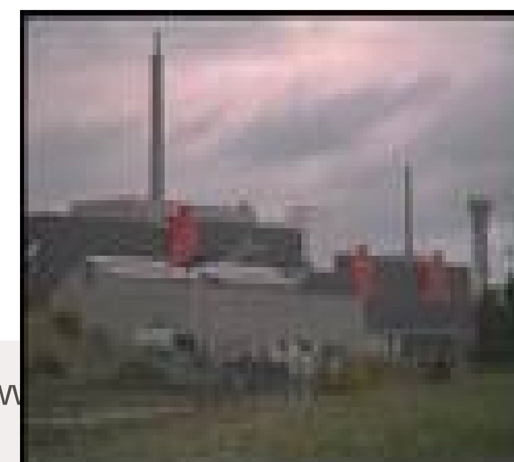


# OUTLINE

- Proliferation and security risks
  - Reprocessing
  - Disposal
- How to ensure nonproliferation & nuclear security for direct disposal of SNF on a long-term basis?

# Issue is Plutonium

- 8.5kg = enough to make a nuclear weapon (or less)
- This amount is roughly what is produced in the core of a large nuclear power reactor
- In SNF, it is relatively secure, diluted with 100x as much uranium and mixed with highly radioactive fission products. The gamma radiation barrier is lethal for about 100 years
- Without radiation barrier, main danger is inhalation.
- So, it matters what form plutonium takes.

# Bottom line:

- **Direct disposal generally viewed by nonproliferation community as most proliferation-resistant approach to spent fuel**
  - Plutonium remains in fuel, with radiation barriers
  - Efforts to “divert” would be costly, take time
- **But, risks increase over time (>100 years) because radiation barriers (“self-protection”) decrease**
  - “Plutonium mine”

# What are proliferation risks?

- **In general, that material/equipment/facilities will be used for non-peaceful/explosive purposes**
  - Diversion of declared material at declared facilities
  - Use of declared facilities to produce undeclared material
  - Undeclared facilities, activities

# Nuclear security risks at back end

- **IAEA (Pub 1481 Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities):**
  - Risk of unauthorized removal with the intent to construct a nuclear explosive device;
  - Risk of unauthorized removal which could lead to subsequent dispersal;
  - Risk of sabotage.
- **Concern is terrorist access to material, or sabotage of facilities. At back end, transport a particular concern.**

# How to assess?

- **Sophisticated methodologies available, but in general, look at:**
  - Material attractiveness – how much effort is needed to make it weapons-usable (or into an effective RDD)? Can that effort be detected? This will be different for states vs. terrorists
  - Ease of monitoring – Can a diversion be detected in a timely fashion? Are we counting flows of material or discrete items?

# Spent fuel pathways

| DIRECT DISPOSAL | REPROCESSING | MIX (PARTIAL REPROCESSING) |
|---|---|---|
| At reactor | At reactor | At reactor |
| Away-from-reactor | ? | Away-from-reactor |
| Centralized, interim storage | ? | Centralized, interim storage |
| | Reprocessing | Reprocessing |
| | Fuel Fabrication (MOX) | Fuel Fabrication (MOX) |
| Repository for SNF | Repository for MOX SNF & HLW | Repository for SNF, MOX SNF & HLW |

# Proliferation/security risks of materials, facilities

| | Materials | Proliferation + security risks |
|---|---|---|
| At reactor | Irradiated fuel bundles | Self-protection = lesser risk of diversion, unauthorized removal, undeclared activities. Risk of sabotage mixed |
| Away-from-reactor/ Interim Storage | Irradiated fuel in dry casks | Self-protection = lesser risk of diversion, unauthorized removal, undeclared activities. Lesser risk of sabotage |
| Reprocessing | In-process material<br>Separated plutonium | Risks of diversion, misuse of declared facilities, undeclared facilities, unauthorized removal, sabotage |
| Fuel Fabrication (MOX) | Separated plutonium<br>Fabricated fuel | Risks of diversion, misuse of declared facilities, undeclared facilities, unauthorized removal, sabotage |
| Repository for SNF | Self-protecting irradiated fuel bundles | Self-protection declines after 100 years. A repository for just HLW has nuclear security risks but no proliferation risks. |

# Proliferation risks of back-end choices

- **Reprocessing & fuel fabrication facilities pose risks of bulk-handling facilities**
  - Misuse of facility (material unaccounted for)
  - Diversion of material
  - Diversion to an unsafeguarded facility
- **SNF storage and direct disposal easier (bundle counting) but direct disposal of spent fuel in a repository has other risks**
  - Radiation barrier declines over time, making a repository a "plutonium mine"

# Decay of spent PWR fuel over time (Source: IPFM, "Managing Spent Fuel from Nuclear Power Reactors: Experience and Lessons from Around the World," September 2011)

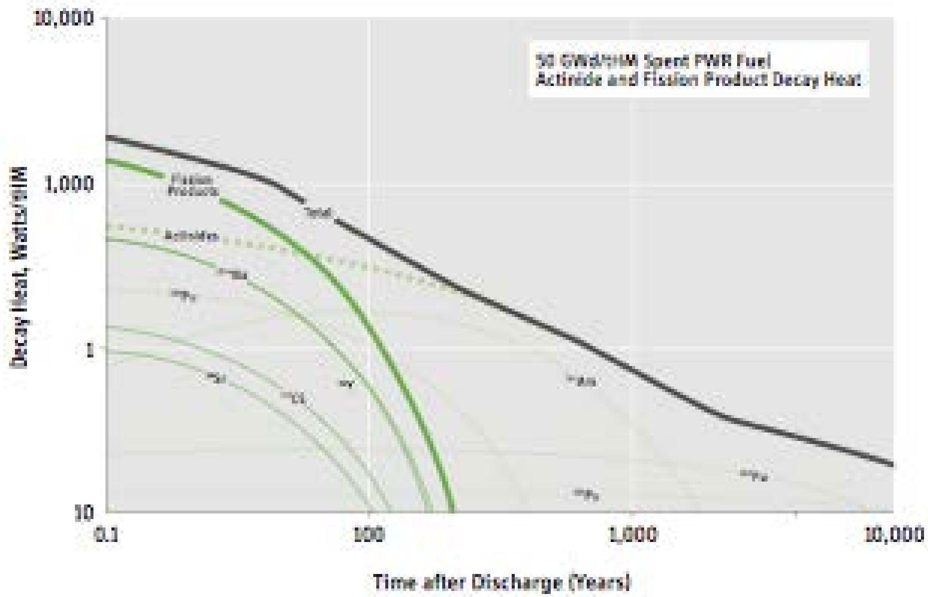



**Figure 1.7:** Contributions to the decay heat generated by spent PWR fuel irradiated to 50 GWd/tHM. *Source: Roald Wigeland.*

# Other recycling considerations

- “Burner” vs. Breeder Fast Reactors
- Current concept is to burn up transuranics as fuel (which produce most heat after 100 years)
- Advantages: Improve proliferation resistance (marginally) by not fully separating Pu from fission products. Full recycle could reduce risk of repository as a Pu mine
- Disadvantages: TIME & MONEY

# Political challenges of the back end

- **No international consensus on a few relevant issues**
  - How long is “long-term” storage – 50, 100 years?
  - What is “waste” – is SNF asset or liability?
  - What are costs?
- **Huge political hurdles for repositories**
  - Siting is biggest
  - Questions about retrievability; monitoring; phased management

# Ensuring nonproliferation & security for direct disposal in the long-term

- **No geological repository for commercial SNF has yet opened**
- **Main challenge for nonproliferation and security will be how to prevent access after several hundred years (will we forget how to make nuclear weapons by then?)**
  - Would multilateral/multinational or international management/ownership be helpful?
- **But this challenge pales in comparison to getting a few repositories open**

# Contact information

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