Used Nuclear Fuel Management
Storage and Recycling

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Commercial Nuclear Power in the U.S.

- 104 commercial power reactors nationwide
- Nuclear power provides ~20% of U.S. electricity generation
  - Worldwide: ~14%
- First commercial U.S. power reactor operational in 1957 (Shippingport, Pa.)
- As of Sept. 2011, one reactor under construction in U.S. (Watts Bar 2)
  - Worldwide: 65 units under construction
Commercial Nuclear Power in the U.S.

- All 104 U.S. plants use Light Water Reactor (LWR) technology
  - Heat generated from fission of uranium atoms creates steam and drives a turbine
  - “Light water” refers to normal water being used to carry heat from fission and “moderate” (slow) neutron radiation to allow large-scale fission to occur

- One major benefit of nuclear power is the large amount of energy generated by a relatively small quantity of uranium fuel
Pressurized Water Reactor
Nuclear Fuel Assemblies

- Ceramic uranium dioxide (UO₂) fuel pellets stacked into zirconium fuel rods 12 ft. in length
- Fuel rods are bundled into square-shaped fuel assemblies held together by structural grids and top/bottom members
- Overall length of fuel assembly = ~160 in.
- Overall weight of fuel assembly = ~1,500 lbs.
- Number of fuel assemblies per reactor = ~200
Nuclear Fuel Assembly
Used Nuclear Fuel Assemblies

- Each fuel assembly is used for about 5 years
- Once used in reactor, become highly radioactive
  - Fission of uranium creates radioactive “fission products”
  - Fuel assembly structure becomes “activated”
- When removed from reactor, must be handled underwater
  - Continued generation of heat must be removed
  - Water is superb radiation shielding medium
Used Fuel Pools

- The original on-site primary method for used fuel storage (interim)
- Steel-lined concrete pools with stainless steel storage cells
  - Very deep (at least 40 ft.) to ensure radiation shielding during storage and movement of assemblies
  - Neutron absorbing chemicals added to help prevent inadvertent fission chain reaction
  - Active cooling system to remove decay heat
Used Fuel Pools (cont’d)

- No plants designed with intent to store used fuel on-site indefinitely
- Finite storage space in each used fuel pool
  - Limited by size of concrete structure and storage cells
- Storage capacity reached in pools at most U.S. reactors
- Some storage space remains open to retain ability to refuel reactors and facilitate maintenance activities
On-Site Dry Cask Storage

- Used fuel must be removed from pools to enable uninterrupted plant operation.
- Technology developed in 1980s to allow used fuel storage in sealed, dry containers with passive cooling (i.e., no moving parts).
- Used fuel is transferred into metal canisters underwater (in pool), then canister is placed into concrete overpack.
- Dry cask system (canister and overpack) is placed at on-site Independent Spent Fuel Storage Installation (ISFSI).
On-Site Dry Cask Storage (cont’d)
Going Forward: Centralized Interim Storage

- Federal government remains obligated to take title of used fuel inventory
- Centralized Interim Storage (CIS) can facilitate removal of used fuel from reactor locations in near term
  - Decommissioned reactor sites of principal interest
- Large, secure, isolated complex solely charged with storing used fuel in dry cask storage systems
- Essentially a very large ISFSI – same technology, licensing criteria, etc.
- Could be opened by end of decade
Going Forward: Deep Geologic Storage

- Ultimate disposition strategy for used nuclear fuel
- Isolation in deep, inert geologic repositories
  - Design life: more than 10,000 years
- Used fuel is stored in repository in dry cask systems (possibly systems already in use)
- Repository may be designed to facilitate ready retrieval of used fuel for recycling (reprocessing)
- One deep geologic repository for used fuel under construction: Onkalo in Finland
Multiple geologic repositories in operation for storage of non-fuel radioactive wastes:

- DOE Waste Isolation Pilot Plant (WIPP) in Eddy County, New Mexico
  - Transuranic wastes (Pu, U, Am, Np, etc.) from DOE activities (weapons complex)
- Schacht Asse II and Morsleben (Germany)
- Forsmark (Sweden)
- Ancient “Operating Experience”
Yucca Mountain, Nev.
Used Fuel Recycling (Reprocessing)

- Recovery of fissile material (U, Pu) from used nuclear fuel for reinsertion into fuel cycle
  - Example: PUREX process (left)
- Can further extract other materials (e.g., transuranics) to reduce radiotoxicity of final waste products
  - Geologic storage is still needed
- Use of advanced reactor designs with reprocessing techniques could significantly reduce toxicity of wastes
- Cost of recycling currently more than “once-through” fuel cycles
  - Difference varies on depth/complexity of recycling method and cost of uranium
Conclusion

- Used fuel storage is proven, safe, and effective both domestically and internationally.
- Expanding on-site storage of used fuel in dry cask systems is effective in isolating wastes from the environment.
- Moving fuel to a centralized interim storage facility (using same proven dry cask technologies) is the optimal near-term success path for used fuel management.
- Ultimate isolation in deep geologic storage facilities will be necessary with or without recycling.
Questions?