Scenario Definitions & Analysis Phases

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Analysis Phases

- **Phase 1:** Characteristics of U.S. spent fuel inventory as of December 2009
- **Phase 2:** Spent fuel discharged through 2100
- **Phase 3:** Impact of repository disposal
- **Phase 4:** Steady state reprocessing and fabrication of PWR MOX and recycled UOX fuel
- **Phase 5:** Impact of reprocessing combined with repository disposal

Phase 1: Characteristics of U.S. Spent Fuel Inventory as of December 2009

- Assumptions
  - Nuclear power plant characteristics and wet/dry storage inventories as of December 2009 (provided)
  - PWR assemblies contain initial uranium mass of 0.43 MTU, initial ^{235}U enrichment of 3.43% and have a burn-up of 39 GWd/MT
  - BWR assemblies contain initial uranium mass of 0.18 MTU, initial ^{235}U enrichment of 2.39% and have a burn-up of 32 GWd/MT

Phase 1: Characteristics of U.S. Spent Fuel Inventory as of December 2009 (cont'd)

- Output Measures
  - Total mass of spent fuel at beginning of 2010
  - Total mass of ^{234}U, ^{235}U, ^{236}U and ^{238}U in spent fuel at beginning of 2010
  - Total mass of ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu in spent fuel at beginning of 2010
  - Mass of fission products and minor actinides, either total or by isotope, in spent fuel at beginning of 2010

Phase 2: Spent Fuel Discharged Through 2100

- Assumptions
  - Those previously stated
  - Nuclear power plant operation starts on Jan. 1 of first year of commercial operation and plant operates for 60 years
  - Sufficient new plants come on-line to maintain current generation capacity of 100.3 Giga-watts (electrical)
  - Plant capacity factor of 90% (100% of design thermal power for 90% of the time each year)
  - From 2010 through end of plant life:
    - PWR fuel assemblies discharged have an initial ^{235}U enrichment of 4.4% and a burn-up of 55 GWd/MT
    - BWR fuel assemblies discharged have an initial ^{235}U enrichment of 4.35% and a burn-up of 55 GWd/MT
  - No reprocessing or repository available before 2100

Phase 2: Spent Fuel Discharged Through 2100 (cont'd)

- Output Measures
  - Total number of PWR and BWR assemblies discharged
  - Total mass of ^{234}U, ^{235}U, ^{236}U and ^{238}U discharged
  - Total mass of ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu discharged
  - Mass of fission products and minor actinides discharged, either total or by isotope

Phase 3: Impact of Repository Disposal

- Assumptions
  - Previous spent fuel discharge assumptions
  - No reprocessing available before 2100
  - Repository starts in operation in 2040 and begins at full capacity of:
    - Scenario 1 – 1,500 MT/year
    - Scenario 2 – 3,000 MT/year
  - Spent fuel must be at least 10 years old for repository disposal and fuel selection starts with oldest fuel first

Phase 3: Impact of Repository Disposal (cont'd)

- Output Measures
  - Total mass of PWR spent fuel disposed of each year through 2100 for each scenario
  - Total mass of BWR spent fuel disposed of each year through 2100 for each scenario

Phase 4: Steady State Reprocessing and Fabrication of PWR MOX and Recycled UOX Fuel

- Assumptions – Part 1
  - A sufficient quantity of PWR spent fuel exists with the following characteristics for a reprocessing facility to operate at full capacity
    - Fabricated using new uranium
    - Initial enrichment – 4.4%
    - Burn up – 55 GWd/MT
  - Only PWR fuel of this type is reprocessed
  - All other spent fuel is stored
  - There is an unlimited amount of natural uranium, natural uranium enrichment capacity, and new uranium UOX assembly fabrication capacity
  - All operations are at steady state:
    - Nuclear power plants – no new or replacement units starting up
    - Reprocessing facility – operating at full capacity
    - MOX fuel fabrication facility – sufficient capacity to recycle all separated plutonium
    - Recycled UOX fuel fabrication facility – sufficient capacity to recycle all re-enriched separated uranium

Phase 4: Steady State Reprocessing and Fabrication of PWR MOX and Recycled UOX Fuel (cont'd)

- Assumptions – Part 2
  - PWR MOX assemblies are fabricated from separated plutonium and fresh uranium tails (^{235}U assay in tails mass is 0.2%). MOX assemblies are limited to a maximum total plutonium content of 14%. No BWR MOX assemblies are fabricated.
  - PWR recycled UOX assemblies are fabricated from enriched recycled uranium (no blending of highly enriched uranium with the separated uranium). There is no limit on the maximum ^{235}U assay in the recycled UOX assemblies to offset the loss of reactivity because of ^{236}U content. No BWR recycled UOX assemblies are fabricated.
  - Six scenarios considered:
    - Reprocessing capacity of 1,500 MT/yr and all fuel 5 years old
    - Reprocessing capacity of 1,500 MT/yr and all fuel 25 years old
    - Reprocessing capacity of 1,500 MT/yr and all fuel 50 years old
    - Reprocessing capacity of 3,000 MT/yr and all fuel 5 years old
    - Reprocessing capacity of 3,000 MT/yr and all fuel 25 years old
    - Reprocessing capacity of 3,000 MT/yr and all fuel 50 years old

Phase 4: Steady State Reprocessing and Fabrication of PWR MOX and Recycled UOX Fuel (cont'd)

- Output Measures
  - Mass of fission products and minor actinides separated by reprocessing, either total or by isotope
  - Percent reduction in total natural uranium demand
  - Either total number or mass, and isotopic composition, of assemblies fabricated:
    - New uranium PWR assemblies
    - New uranium BWR assemblies
    - PWR recycled UOX assemblies – all equivalent to 4.4% natural ^{235}U enrichment
    - PWR MOX assemblies (including Pu quality and Pu percent)
  - Mass of uranium tails generated:
    - New uranium tails
    - Recycled uranium tails

Phase 5: Impact of Reprocessing Combined with Repository Disposal

- Assumptions – Part 1
  - Previous spent fuel discharge assumptions
  - Reprocessing facility starts operation in 2030 and begins at full capacity of:
    - Scenario 1 – 1,500 MT/yr
    - Scenario 2 – 3,000 MT/yr
  - Fuel must be at least 5 years old for reprocessing and fuel selection will start with youngest fuel first
  - Only PWR fuel fabricated from new uranium is reprocessed and none is disposed of in repository. All other spent fuel is disposed of in repository.
  - PWR MOX assemblies are fabricated from separated plutonium and fresh uranium tails (^{235}U assay in tails mass is 0.2%). MOX assemblies are limited to a maximum total plutonium content of 14%. No BWR MOX assemblies are fabricated.

Phase 5: Impact of Reprocessing Combined with Repository Disposal (cont'd)

- Assumptions – Part 2
  - PWR recycled UOX assemblies are fabricated from enriched recycled uranium (no blending of highly enriched uranium with the separated uranium). There is no limit on the maximum ^{235}U assay in the recycled UOX assemblies to offset the loss of reactivity because of ^{236}U content. No BWR recycled UOX assemblies are fabricated.
  - There is an unlimited amount of natural uranium, natural uranium enrichment capacity, and new uranium UOX assembly fabrication capacity
  - Repository starts operation in 2040 and begins at full capacity of 1,500 MT/yr of spent fuel. High level waste containing fission products and minor actinides is disposed of in the same repository and in the same year that separation takes place, but with no limit on disposal capacity.
  - Spent fuel must be at least 10 years old for repository disposal

Phase 5: Impact of Reprocessing Combined with Repository Disposal (cont'd)

- Output Measures
  - Total mass of PWR and BWR spent fuel disposed of in repository
  - Mass of fission products and minor actinides, either total or by isotope, disposed of in repository
  - Total mass of PWR spent fuel reprocessed
  - Percent reduction in natural uranium demand
  - Either total number or mass, and isotopic composition, of assemblies fabricated:
    - New uranium PWR assemblies
    - New uranium BWR assemblies
    - PWR recycled UOX assemblies (including ^{235}U assay)
    - PWR MOX assemblies (including Pu quality, Pu percent)
  - Mass of uranium tails generated:
    - New uranium tails
    - Recycled uranium tails