The Nuclear Fuel Cycle

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Uranium Milling



- Ore is crushed
- Uranium is separated



• U₃O₈ "yellow cake" produced



Uranium Conversion (to UF₆ gas)

- Impurities removed
- Uranium combined with fluorine
- UF₆ gas produced

 Gaseous form facilitates enrichment





U Enrichment

- Natural U is > 99% ²³⁸U and only ~ 0.7% ²³⁵U
- Separation of ²³⁵UF₆ and ²³⁸UF₆ based on (very small) mass difference
 Uranium enriched





Centrifugation

■UF₆ enriched from 0.7% ²³⁵U to 3%-5% ²³⁵U



Fuel Fabrication

Enriched UF₆ gas converted to uranium oxide (UO₂) solid



Uranium Oxide Ceramic Fuel Pellets



Fuel rods filled with ceramic pellets are grouped into fuel assemblies



Fuel Fabrication



A pressurized water reactor fuel assembly



Reactors



Diablo Canyon nuclear power plant in the U.S.





- Cause new fissions to occur
- •Be absorbed to form unstable, radioactive nuclide

Fuel Consumption in the Reactor

- Fuel is in reactor for 4 6 years
- U consumed, fission products and transuranics (mostly Pu) produced



Radioactive Decay Equations



Sources of radiation

Units of Dose and Exposure

- <u>Roentgen (R)</u> unit of exposure ionization of air by *x* or gamma rays
- <u>**RAD (Radiation Absorbed Dose)</u>** energy deposited in material (Gray (Gy) is international unit)</u>
- <u>rem</u> (Roengten Equivalent Man)
 - unit of dose equivalent
 - Seivert (Sv) is international unit

Units of Radioactivity

<u>Activity</u> - a rate; the number of emissions (of radiation) per unit time.

dps - disintegrations per second Bequerel = 1 dps Curie = 37,000,000,000 dps Picocurie = 0.037 dps or 2.2 dpm

- Used fuel first stored in pool at least 5 years
 - \circ Cooling and shielding
- Older fuel can move to dry casks
 - o Air cools
 - $\circ\,$ Steel and concrete shields

Fuel recycle/reprocessing

Fuel recycle/reprocessing

Geologic Repository

- The choice of countries worldwide
- U.S. has studied Yucca Mt., Nevada as potential location

The Three C's of Used Nuclear Fuel

Compact....

Suppose

- You live for 80 years
- All electricity is nuclear
- Your share of used nuclear fuel

The Three C's of Used Nuclear Fuel

Compact.... Contained....

- Solid fuel pellet, inside...
- Metal fuel rod, inside...
- Steel canister, inside...
- Storage or shipping cask

The Three C's of Used Nuclear Fuel

Compact.... Contained.... Cared for....

- Carefully tracked
- Decades of safe handling experience
- Easy to detect and monitor
- Paid for in Nuclear Waste Fee

The End . . .

