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Fuel Cycle Strategy Impacts

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Fuel Cycle Strategy Impacts

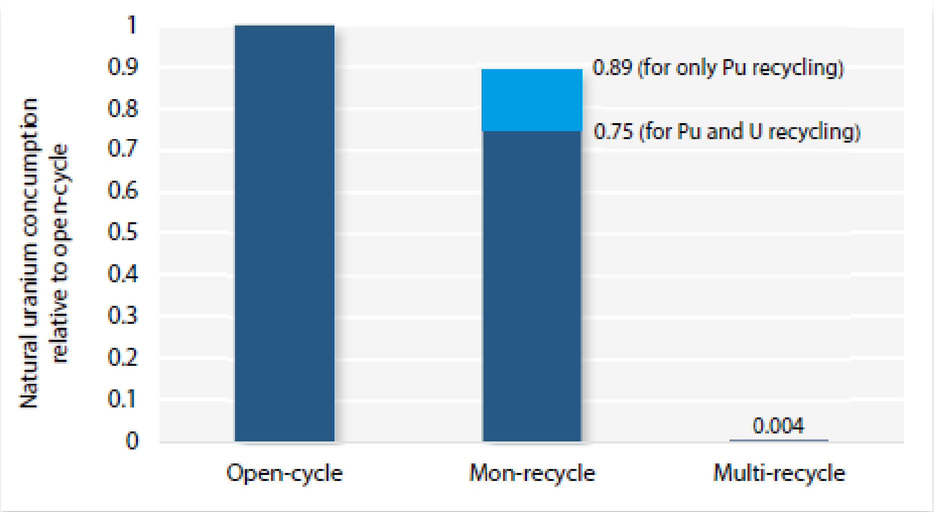
Resource Utilization and Waste Characteristics

Idaho National Laboratory

Uranium Mining Needs

- **At current usage, known uranium reserves are sufficient for 130 years**
  - Exploration to discover additional reserves will be minimal until uranium prices recover from their current low value
- **The open-cycle takes ~8 MT Uranium to make 1 MT of fuel**
  - 8 MT U_{nat} @ 0.72% U_{235} yields 1 MT LEU @ 4.3% U_{235} +7 MT DU @ 0.21% U_{235}
- **Mono-recycle recovers fissile content from SNF**
  - ~1.2% Pu + ~1% U_{235}
  - Reduces U_{nat} needs by 25%
- **Multi-recycle uses fast reactors to make fissile from fertile**
  - Can use waste DU instead of mining
  - Existing DU would last ~3,000 years before need to resume mining

Figure 4. Natural uranium consumption relative to open-cycle

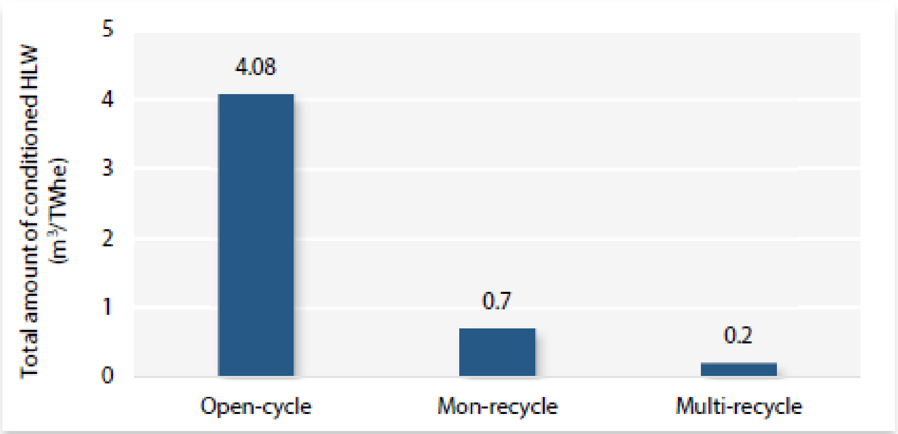


Source: NEA, 2006; Zohuri and McDaniel, 2018.

High Level Waste Production

- **In open-cycle, SNF is disposed**
  - Includes ~94% residual uranium, 5% fission products, 1% transuranics (TRU)
- **In mono-cycle, most of U is low level waste, some TRU is destroyed**
  - Reenrichment of recovered U -> over 85% becomes DU, rest recycled into fuel
  - Most remaining fissile in U and Pu consumed during 2nd cycle
  - All fission products and 2nd cycle SNF is disposed
- **In multi-recycle, only minor actinides (MA) and fission products disposed**
  - Optional recycle of MA further reduces waste

Figure 6. **High-level radioactive waste volume for the fuel cycle options**

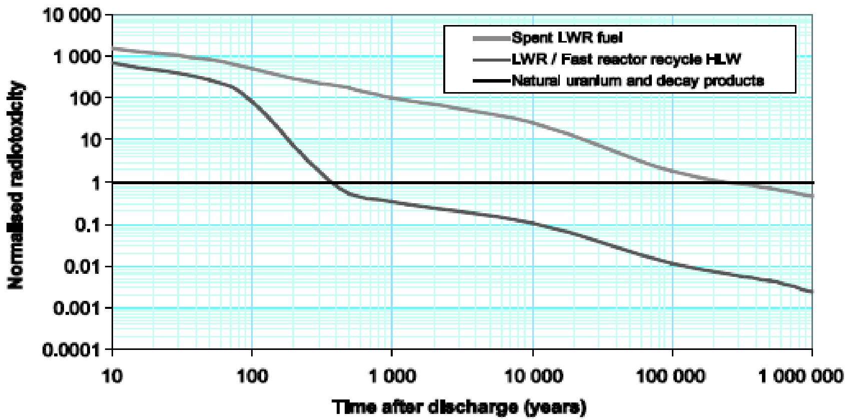


Source: *Advanced Nuclear Fuel Cycles and Radioactive Waste Management* (NEA, 2006).

High Level Waste Radiotoxicity, Decay Heat

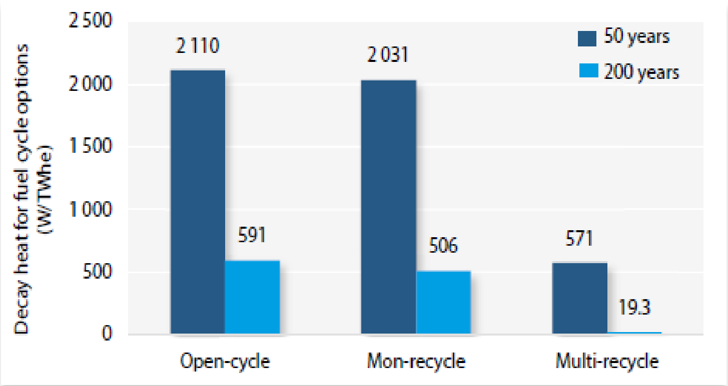
- **Radiotoxicity sources in spent Light Water Reactor (LWR) fuel**
  - Primarily fission products for first ~30 years - until most decay away
  - Primarily transuranics for up to 250,000 years - until most decay away
  - Long-term from remaining uranium – due to buildup of decay products (radon)
- **In multi-recycle with minor actinide recycle option . . .**
  - Only trace amounts of uranium and transuranics disposed
  - Remaining radiotoxicity and decay heat only from fission products

Figure 7. Ingestion radiotoxicity for spent light-water reactor fuel and processing waste where actinides are recovered for recycling



Source: *Potential Benefits and Impacts of Advanced Nuclear Fuel Cycles with Actinide Partitioning and Transmutation* (NEA, 2011).

Figure 5. Decay heat at 50 years and 200 years for fuel cycle options



Source: *Advanced Nuclear Fuel Cycles and Radioactive Waste Management* (NEA, 2006).