U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Fuel Cycle Research and Development

Waste Management Implications of Fuel Cycle Alternatives

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Blue Ribbon Commission Subcommittee meeting on Reactor and Fuel Cycle Technology

Washington, DC

October 12, 2010

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The DOE-NE Fuel Cycle R&D Program is examining a broad range of fuel cycle options

Advanced Fuel Cycle Initiative with GNEP

- Incremental improvement of existing technologies
- Driven by better utilization of Yucca Mountain repository
- Focused on near-term technology deployment

Fuel Cycle Research and Development

- Transformational breakthroughs
- Unconstrained range of storage and disposal options
- Long-term, goal-oriented, science-based approach

Encouraging creativity to discover new options and new technologies

Radioactive Waste Characteristics

- **Both decay heat and radiotoxicity are important factors in radioactive waste handling, storage, and disposal.**
  - Decay heat can damage, and impair the ability of the waste form, the waste packaging, and the storage/disposal site to effectively isolate the waste from the environment
  - Radiotoxicity represents the hazard contained in the waste that must be isolated.
    - *Calculation of dose requires specific waste form, packaging, and disposal site information*
  - Radiation requires shielding during radioactive waste handling and storage, and can damage and impair the ability of the waste form and packaging to contain the waste
  - Radioactive contaminated wastes that result from operating and maintaining nuclear facilities are generated in all phases of a nuclear fuel cycle
    - *These waste streams are much larger, but have much lower concentrations of radioactive isotopes, compared to the used fuel meat and activated/contaminated fuel assembly and core materials*
- **The importance of each of these factors depends on the choice of repository**
- **Volume of material to be disposed can also be important, however should be considered together with decay heat and radiotoxicity**

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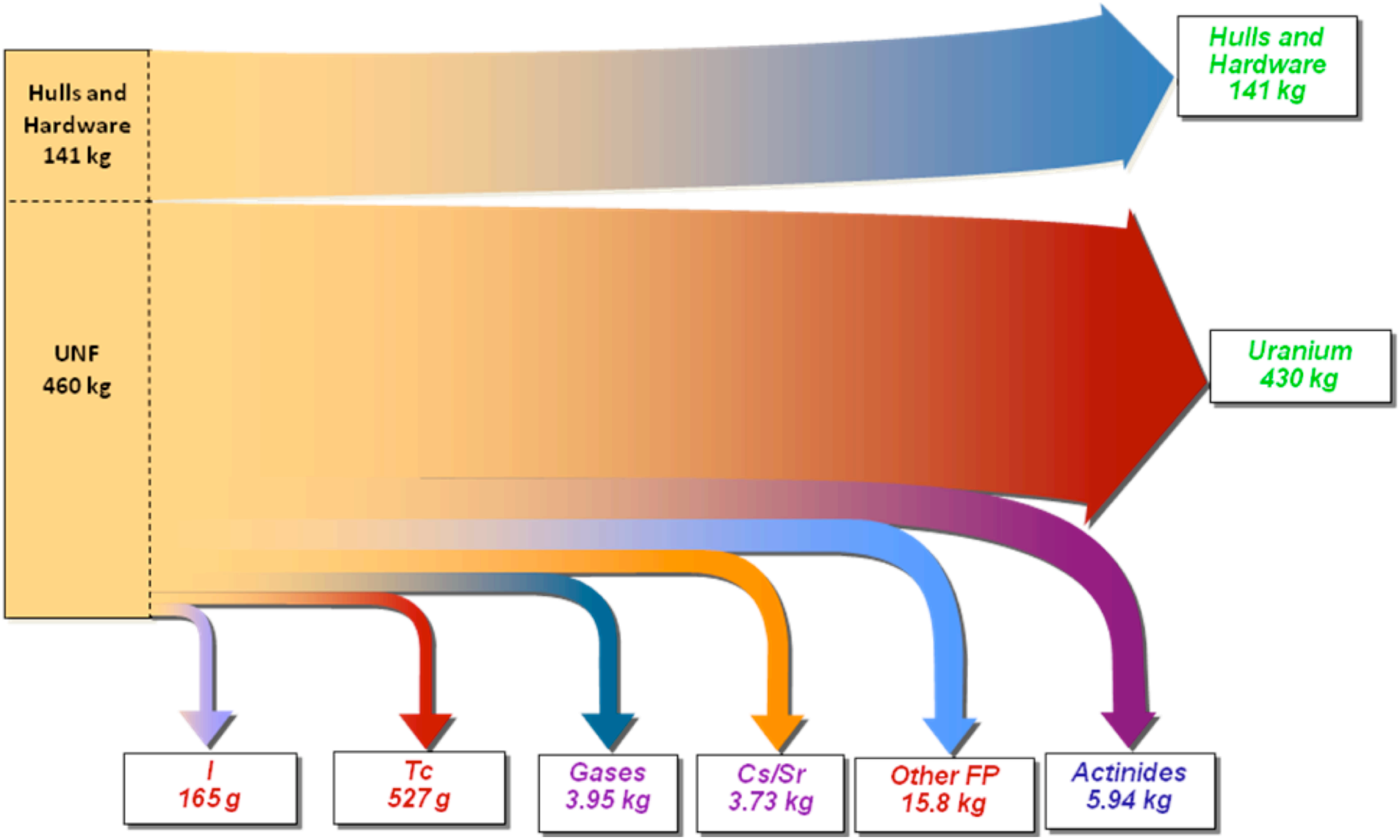
CONSTITUENTS OF A TYPICAL LIGHT WATER REACTOR FUEL ASSEMBLY AFTER IRRADIATION (51 GWD/T BURNUP)



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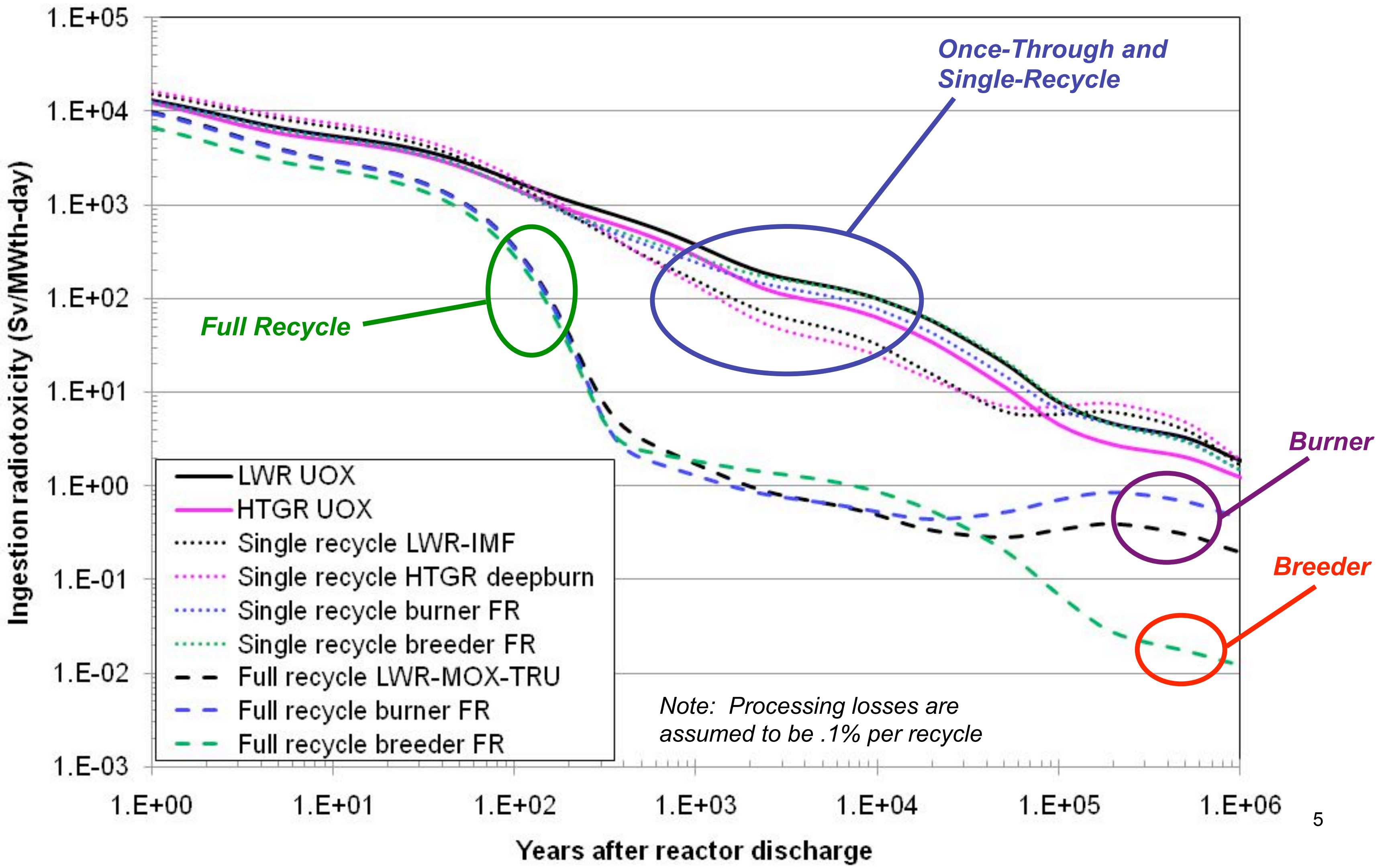
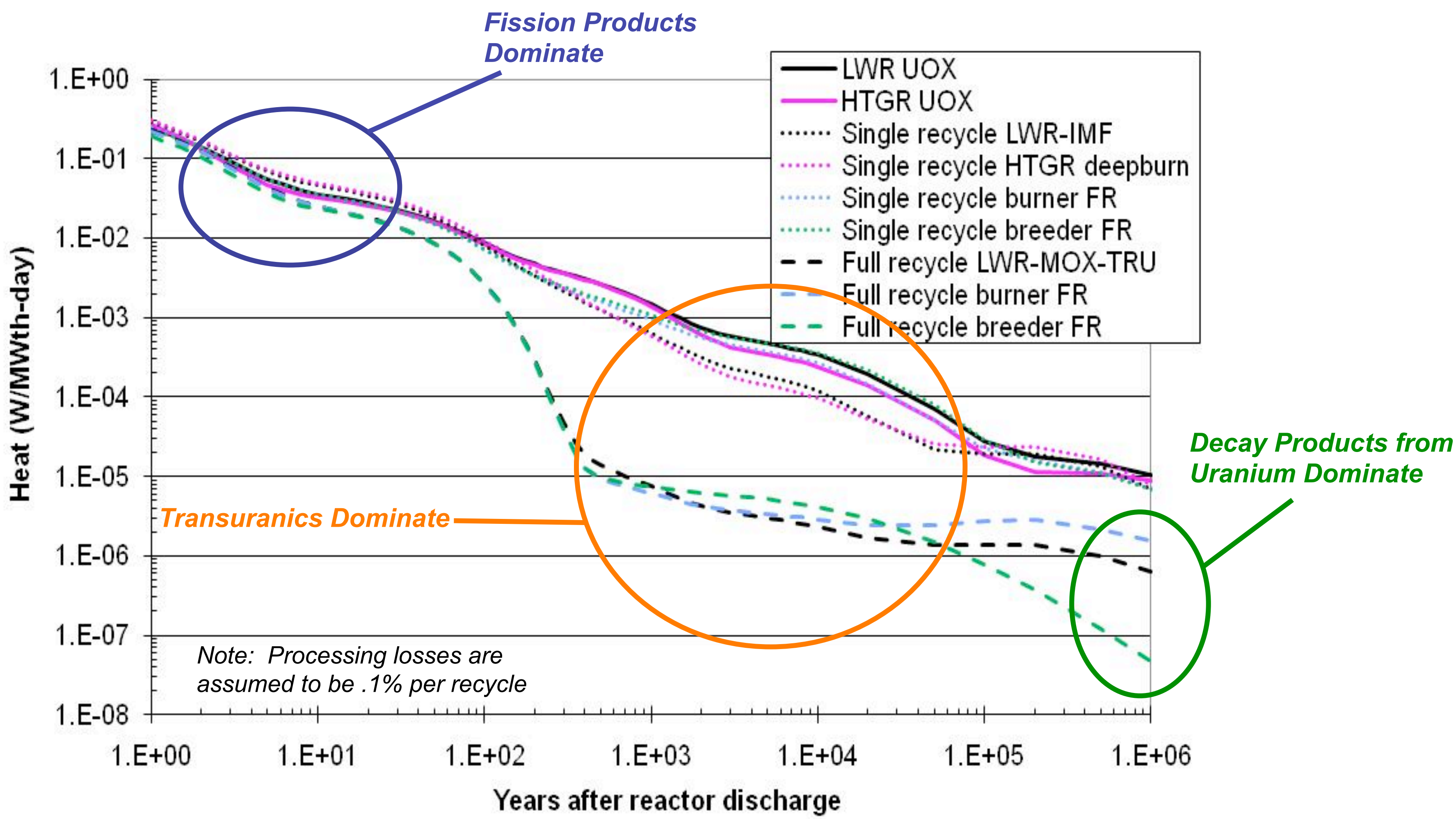
Radiotoxicity of waste as function of time after reactor discharge



Long-term decay heat of waste as function of time after reactor discharge

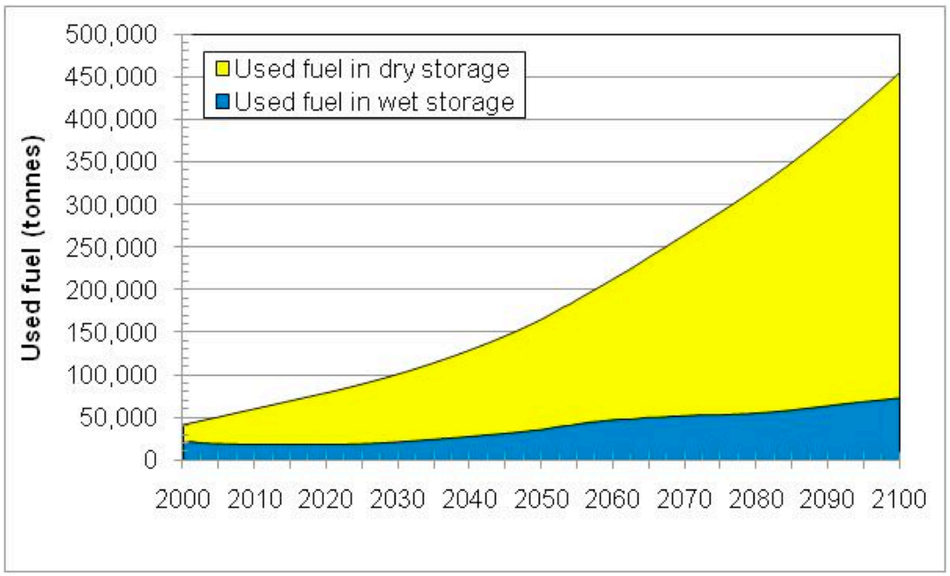


Projections for nuclear waste generation depend on assumptions in the scenario analysis – *Example Scenario*

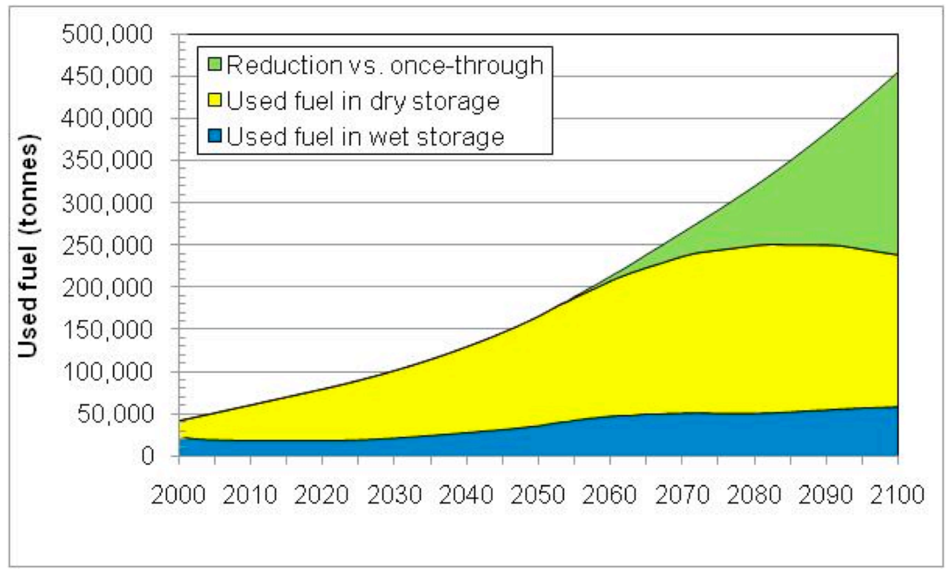
- **First new LWR in 2020**
- **Nuclear grows to 212 GWe installed capacity in 2050**
- **From 2050 to 2100, nuclear share of total electricity is kept constant**
- **1st separations plant operational in 2050 at 800 tonnes/year**
- **Additional 1600 tonnes/year is added each 10 years through 2090 (for a total of 7200 tonnes/year)**
- **Fast reactors are built when separated material is available for startup; remainder of nuclear energy demand is met by new LWRs**
  - The transuranic conversion ratio for the FRs is 0.5
- **After removal from reactor, used LWR fuel is kept in wet storage for 10 years, then moved to dry storage until it is recycled**

Example scenario: used fuel in storage is decreased by almost 50% by 2100

Once-Through



Continuous Recycle in Fast Reactors

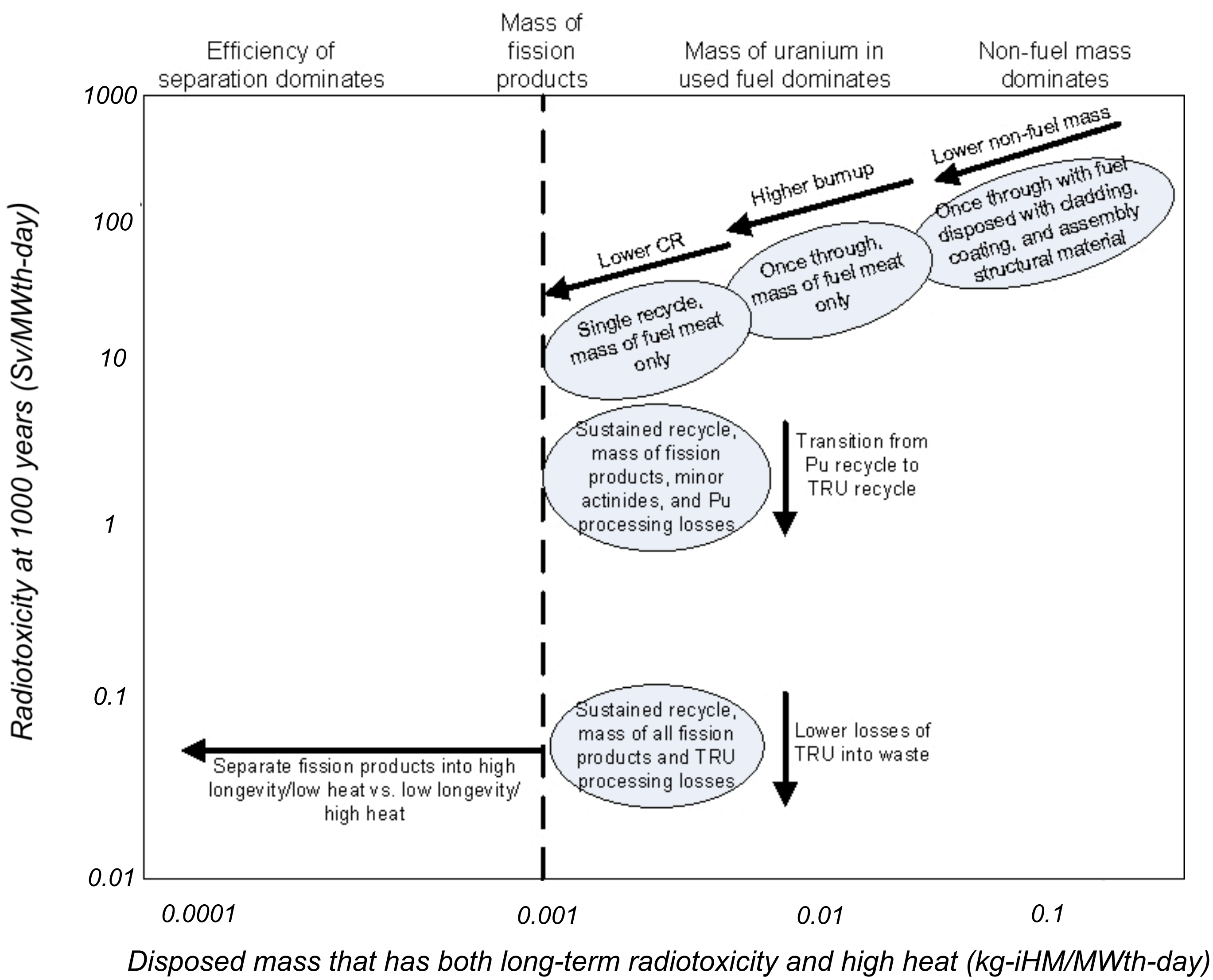


Summary

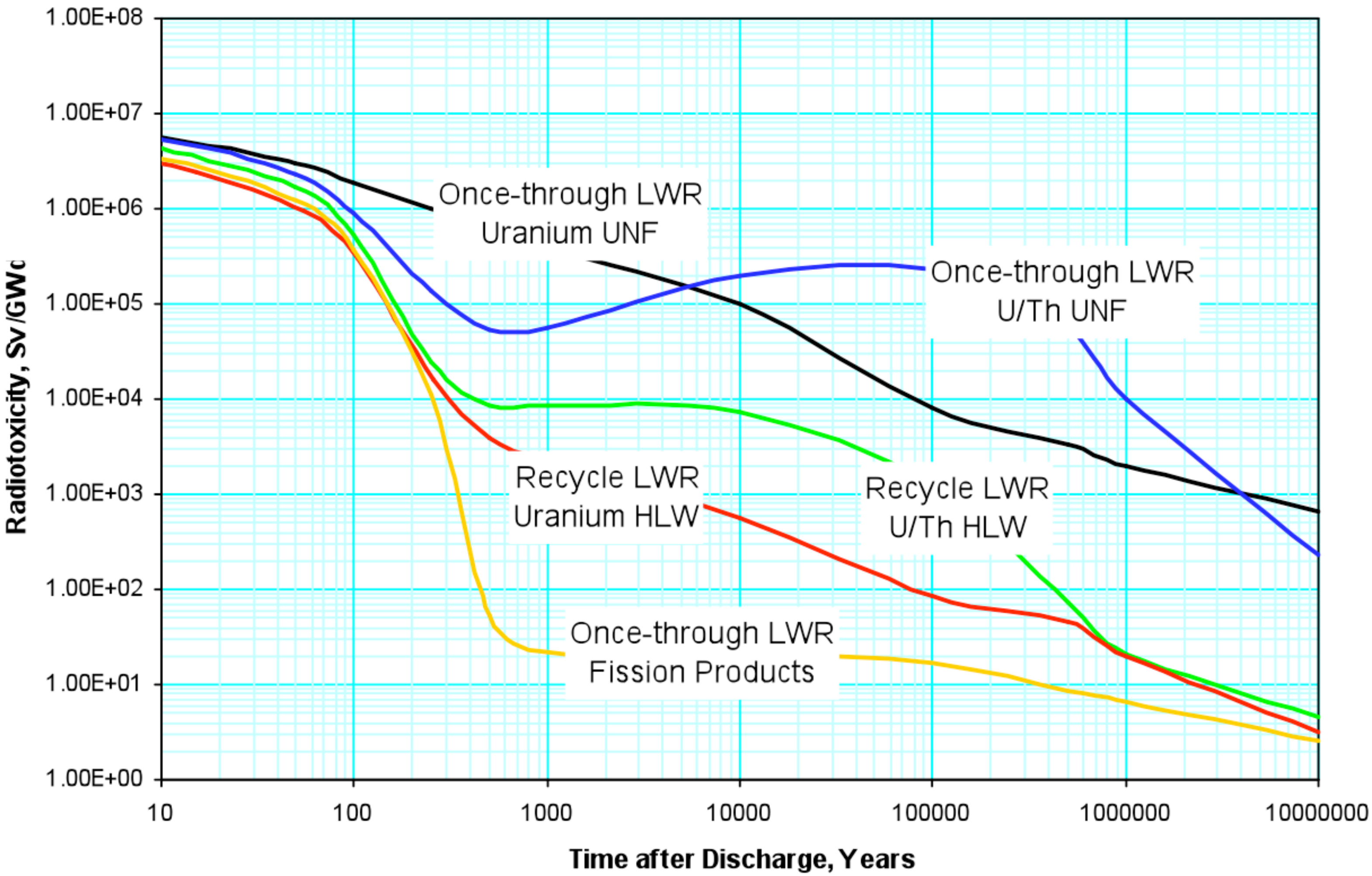
- **Choice of fuel cycle affects waste characteristics**
- **Reducing long-term radiotoxicity and decay heat can**
  - Reduce the uncertainty associated with disposing of the waste
  - Reduce the challenges associated with waste form development
- **Reducing the volume of radioactive waste can impact the real estate needed for disposal, however the characteristics (decay heat and radioactivity) can be more important than the volume**
- **The Fuel Cycle R&D Program is examining a broad range of fuel cycle options**
  - Systems studies accompanies and supports the experimental and computation activities to understand cost/benefits of fuel cycle options

BACKUP SLIDES

Trends in decay heat, radiotoxicity, and mass of waste

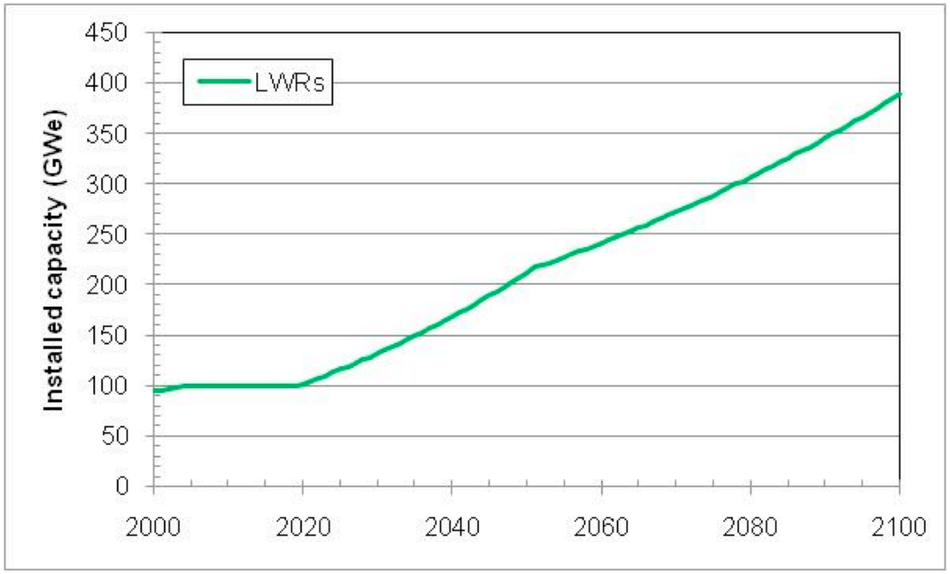


Ingestion Radiotoxicity for Uranium-based and Thorium-Based Fuel used in an LWR for both Once-through (UNF) and Recycle (HLW) Options



Example Scenario: Installed Capacity of Reactors

Once-Through



Continuous Recycle in Fast Reactors