Fission Product Partitioning and Integrated Waste Management – Advanced Approaches and Opportunities

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Presentation Outline

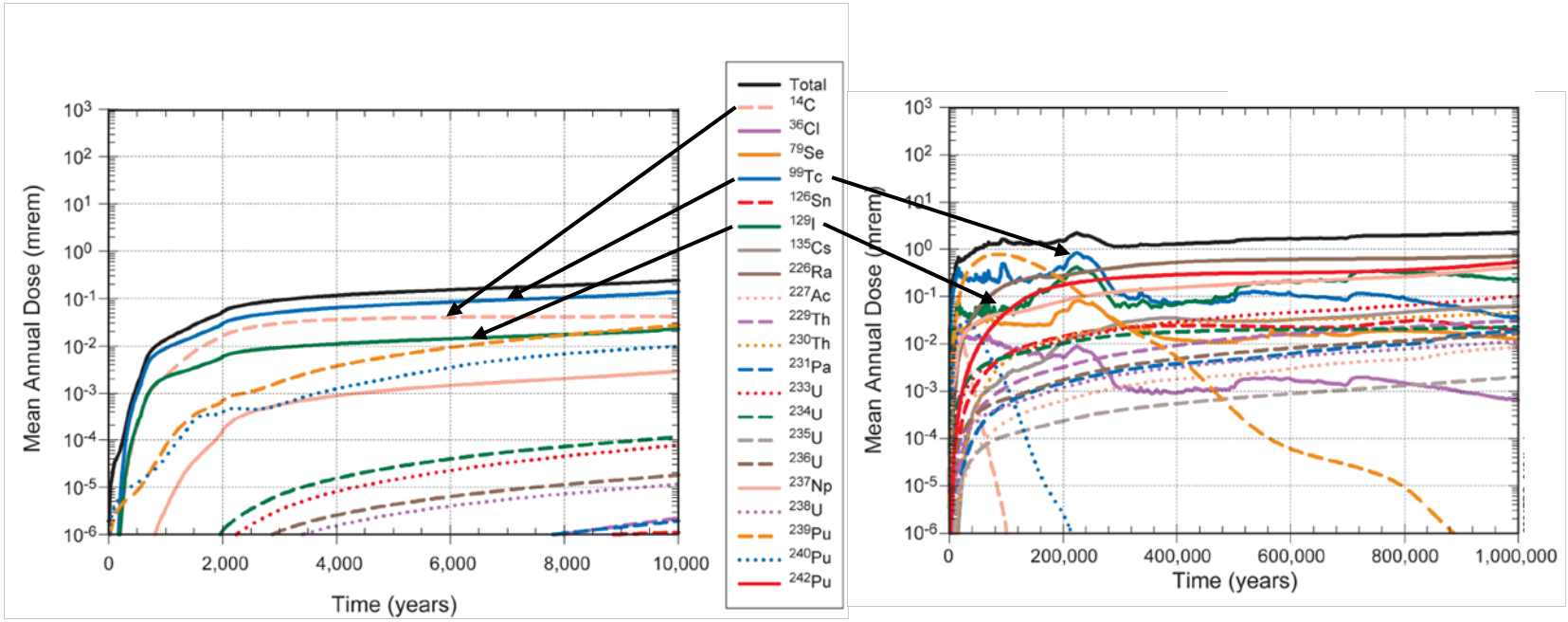
- The importance of fission product partitioning
- GNEP/AFCI goals
- The GNEP/AFCI Fuel Cycle
- The waste management system and the GNEP/AFCI Integrated Waste Management Strategy
- GNEP/AFCI waste streams and potential waste forms
- Recent evolution of waste management under GNEP/AFCI and potential waste forms
- On-going GNEP/AFCI activities related to fission product disposition
- On-going GNEP/AFCI waste form development
- Concluding Points

Fission Products Partitioning

- **Why partition fission products?**
  - Separate from U and TRU (fuel resource)
  - Reduce long-term risk from disposal
  - Reduce the thermal burden on the disposal system
  - Because it happens during processing steps
    - *Iodine, Carbon, Krypton in off-gas*
    - *Un-dissolved solids from dissolution*
- **What are the disposition pathways for partitioned fission products?**
  - Transmutation
  - Direct disposal
    - *Tailored waste forms*
  - Decay storage followed by disposal

Important Fission Products

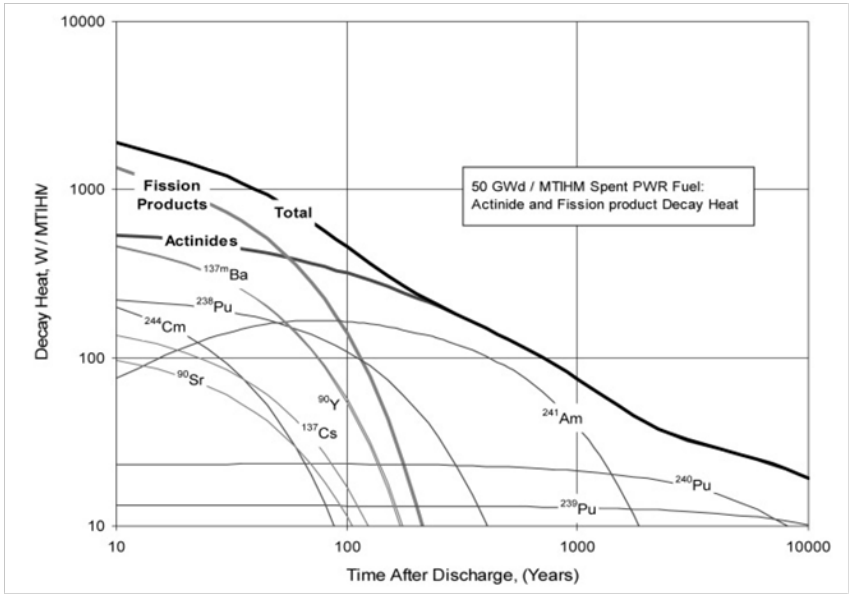
- **Tc-99, I-129, C-14: potential long-term risk following repository closure**

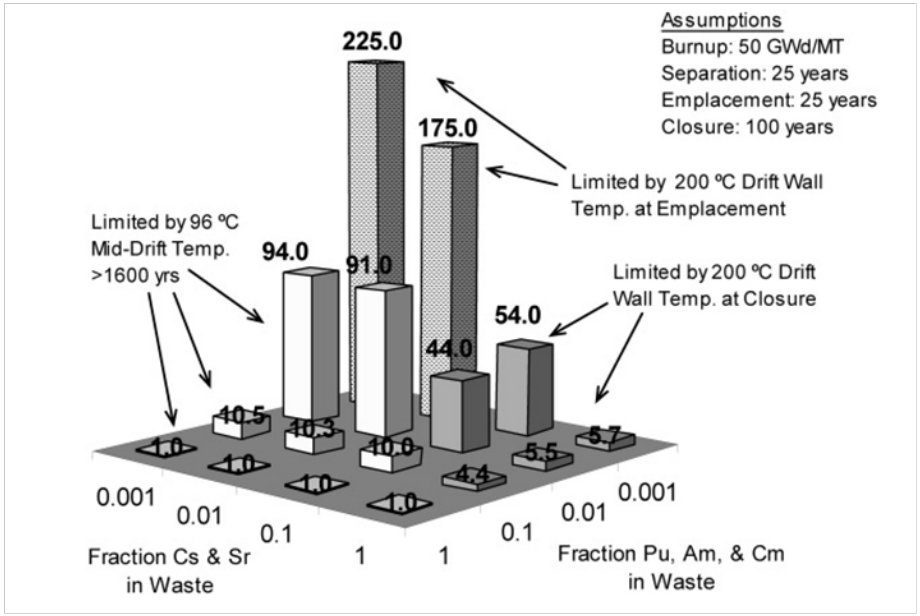


Source: Total System Performance Assessment Model/Analysis for the License Application, MDL-WIS-PA-000005 REV 00, U.S. Department of Energy Office of Civilian Radioactive Waste Management,January 2008. Figures 8.1-6 and 8.1-7 [Available at www.lsnnet.gov/ under participant accession no. DOC.20080312.0001]

Important Fission Products

- **Cs-135 and Sr-90: near term thermal response in a disposal system**



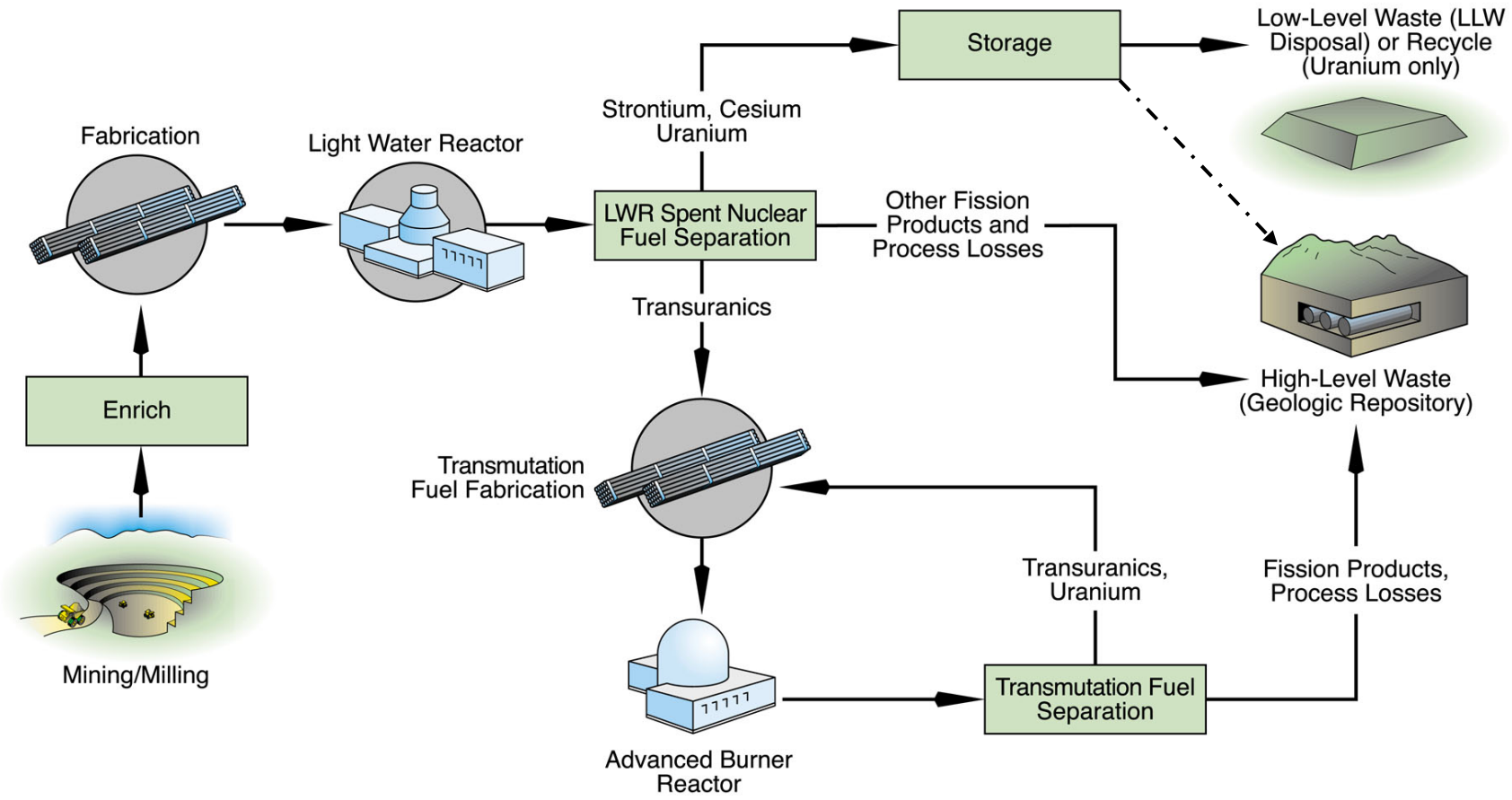


Source: R.A. WIGELAND, T.H. BAUER, T.H. FANNING, and E.E. MORRIS, "Separations and Transmutation Criteria to Improve Utilization of a Geologic Repository." Nuclear Technology, Vol. 154 (April 2006)

GNEP/AFCI Program Requirements Pertaining to Waste Management

- **Reduce the environmental and financial burden and uncertainty associated with long-term nuclear waste management**
- **Optimize nuclear waste management by:**
  - Minimizing the risk of waste that needs to be handled or stored
  - Producing only solid wastes in robust waste forms
  - Recycling and reusing materials to the maximum extent possible.
- **Support the near-term deployment of fuel cycle technologies (20 years) as well as define longer term deployments of next-generation technologies (50 years)**
- **Make the closed fuel cycle as economical as possible**
- **Reduce the number of required U.S. geologic waste repositories needed for the remainder of this century**

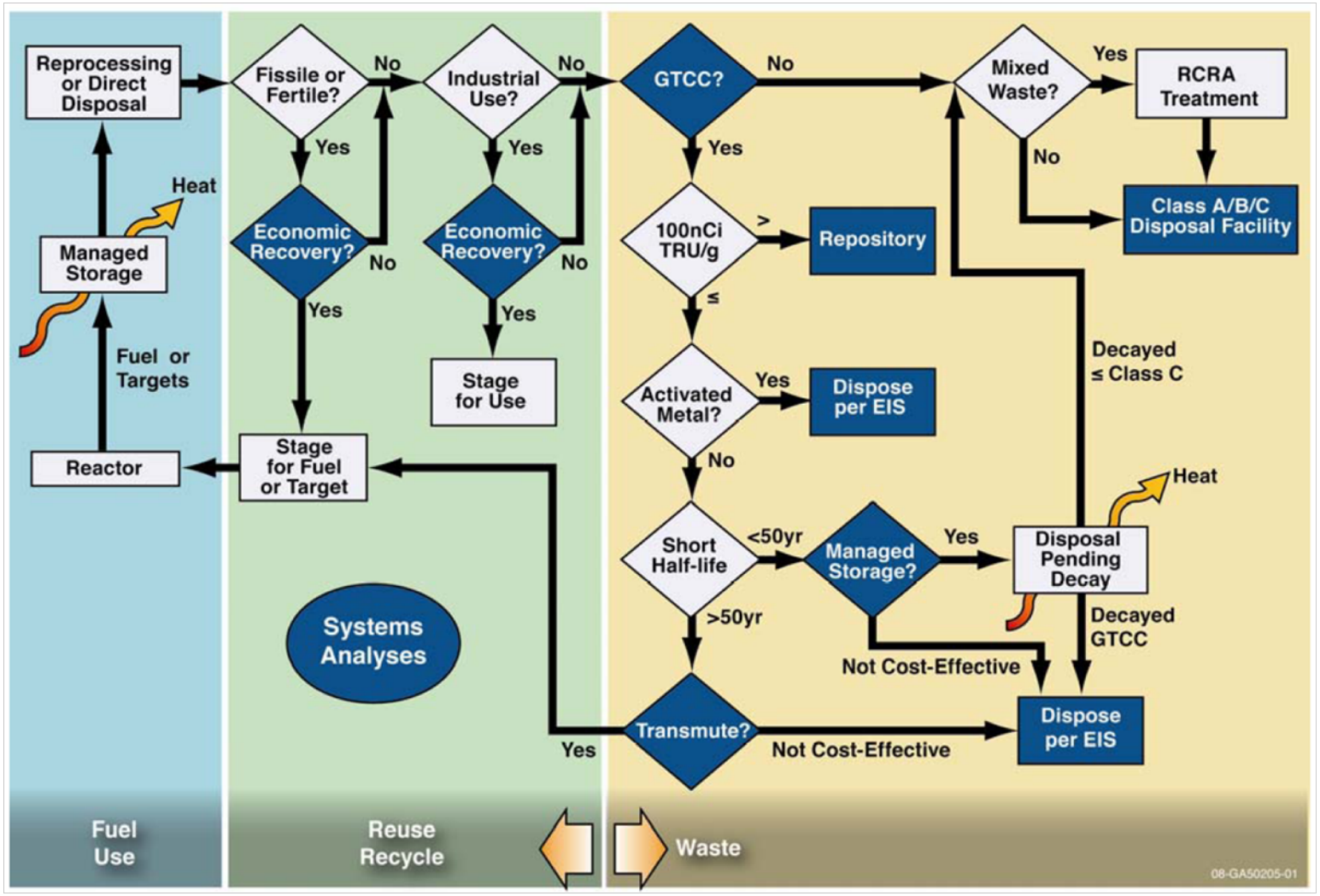
GNEP/AFCI Fuel Cycle



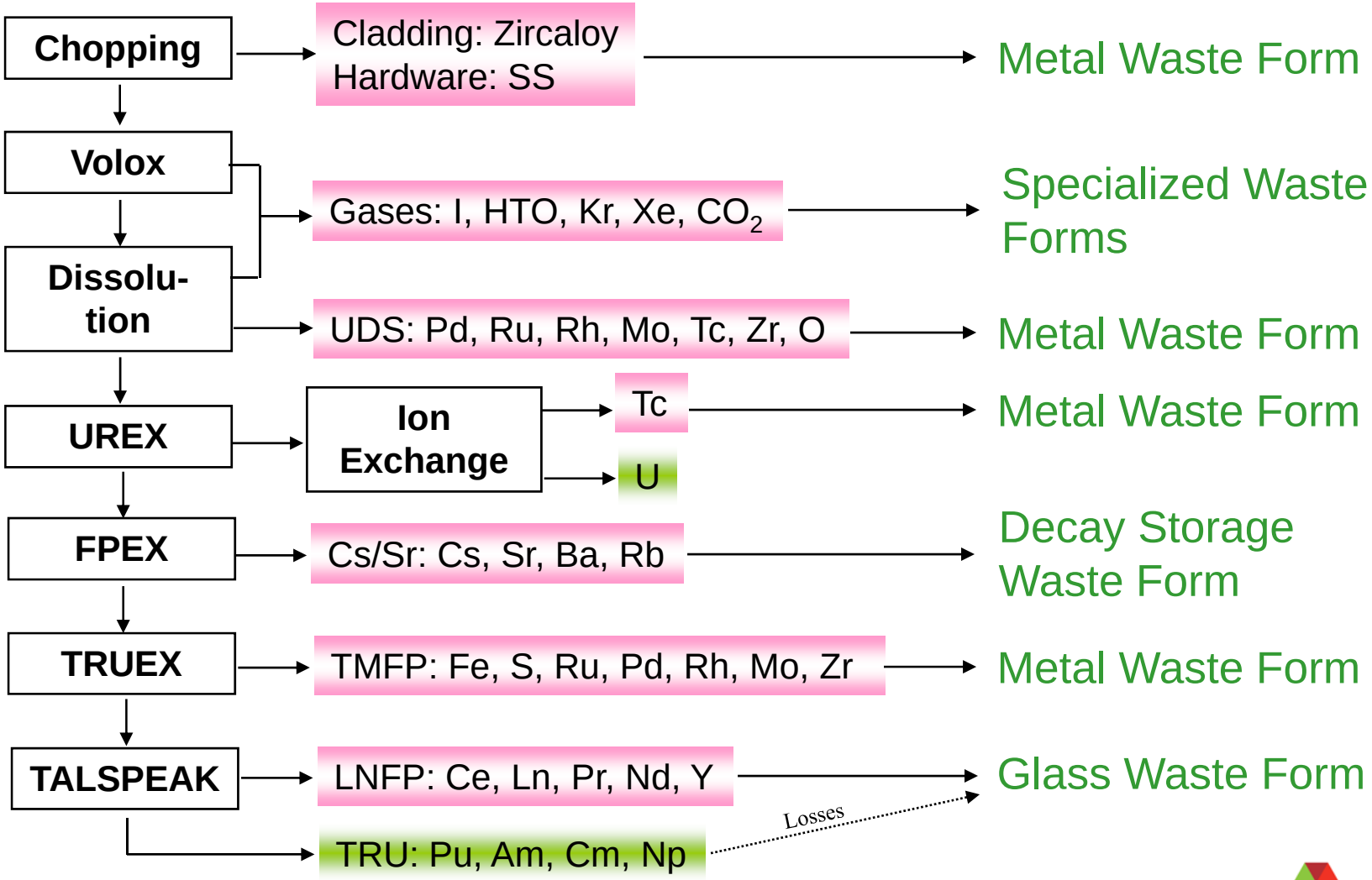
Waste Management System for an Advanced Fuel Cycle

- **The waste management system is broader than disposal**
  - Processing facilities, storage facilities, transportation, disposal
- **Decisions must consider this entire system**
  - Regulatory, economic, risk/safety, environmental, other considerations
- **Waste management under GNEP/AFCI pertains to managing and disposing of fission products**
  - TRU losses are expected to be small
- **GNEP/AFCI Integrated Waste Management Strategy establishes the framework for analyzing and optimizing the waste management system**
  - Emphasizes recycle and reuse, but based on economic recovery evaluation factoring in value of material and cost avoidance of disposal
  - Considers need for industry to have a reliable system to routinely transport nuclear materials and dispose wastes

GNEP/AFCI Integrated Waste Management Strategy Logic Diagram



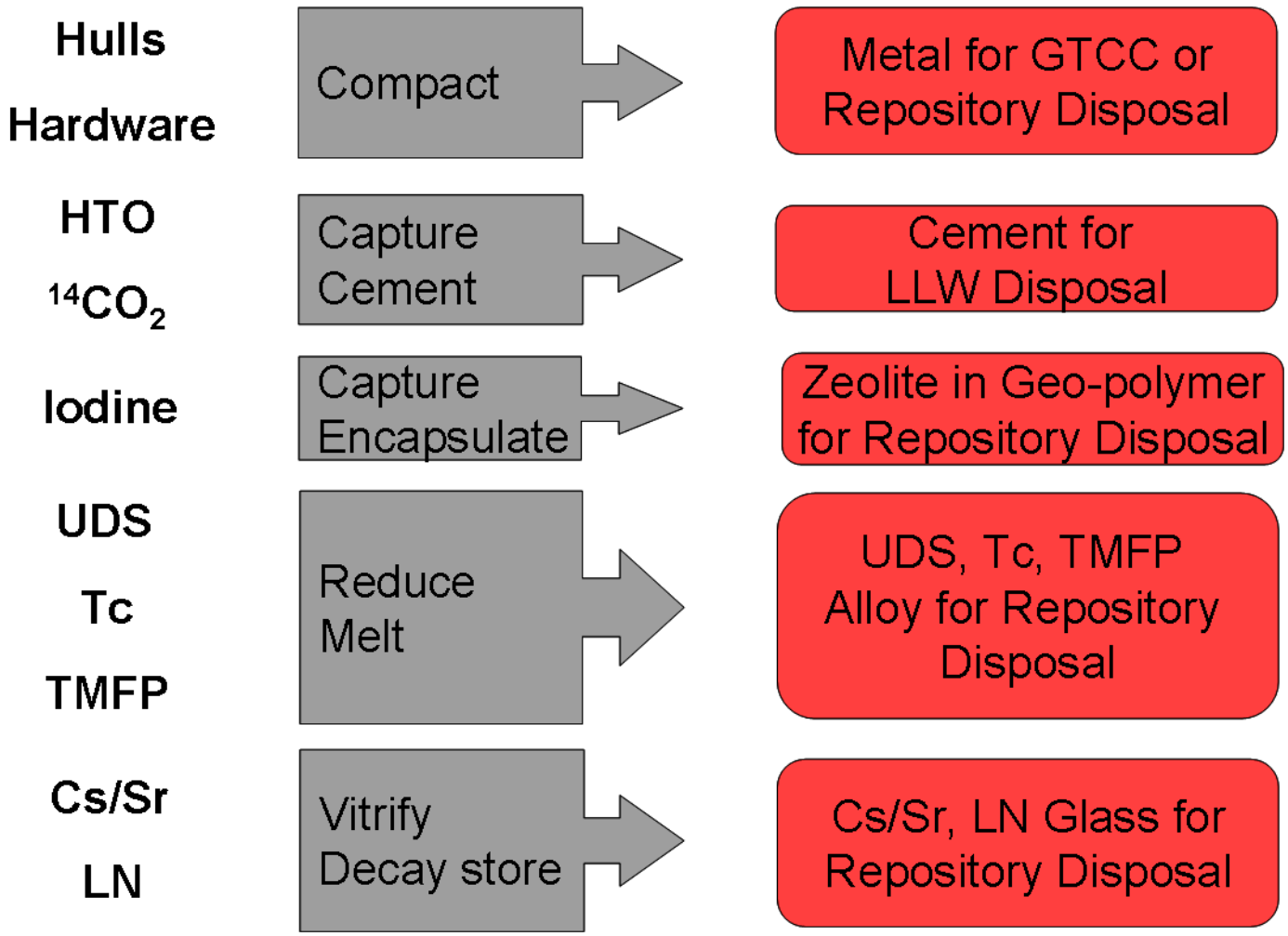
GNEP/AFCI Aqueous Processing Waste Streams



Recent Evolution of GNEP/AFCI Waste Management

- **Initially considering isolating individual waste streams into separate waste forms**
  - Tc, Cs/Sr
- **Critical evaluation of waste management baseline completed**
- **New baseline developed striving to**
  - minimize complexity and number of waste processes
  - minimize amounts of various waste types
  - use nature to guide → match waste form to waste and disposal chemistries
- **Key unknowns/uncertainties**
  - repository type (Yucca Mtn currently limited to 70,000 MTHM)
  - waste type classification (NWPA based on PUREX)
  - requirements for capture of fission product gases
  - GTCC disposal

Recent Evolution of the GNEP/AFCI Waste Management "Baseline"



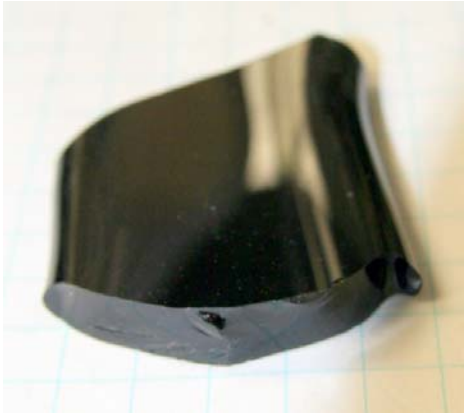
On-Going AFCI/GNEP Activities Related to Fission Product Disposition

- **Combination of transition metal fission products with Cs/Sr/LN waste form**
  - Elimination of process step
  - Trade-off is increase in waste form volume
  - Preliminary analysis indicates overall cost savings
- **Heat Management Strategy Trade-Studies of Various Concepts**
  - Extended SNF aging
  - Interim waste form storage for up to 10 half-lives
  - Storage at reactor, reprocessing plant, repository, interim facility
  - Transportation, handling, processing, security, permitting issues
  - Facility M&O costs
  - Ultimate disposition of materials

Waste Form Development

- **Completed preliminary technology readiness level assessment for waste forms**
- **Evaluated waste and storage form testing approaches**
- **Continued work on production and performance of candidate waste and storage forms**
  - Cs/Sr: bentonite and aluminosilicate glass for aqueous, glass-bonded sodalite for electrochemical
  - Tc: high-loading alloys
  - I: Ag loaded zeolites and novel materials
  - Lanthanides: lanthanide borosilicate glass
  - Lanthanides & transition metal fission products: alkali borosilicate glass
  - Electrochemical processing: metallic and ceramic waste forms

Waste Form Development



Cs/Sr Glass

Glass Bonded Sodalite

Metallic Waste Form from Electro-Chemical Processing

Lanthanide Borosilicate Glass

Concluding Remarks

- The partitioning of fission products in an advanced nuclear fuel cycle presents opportunities for improving the management of nuclear wastes
- A systematic approach is needed to develop the entire waste management system, considering a broad suite of aspects
- Activities are underway in GNEP/AFCI to develop/characterize waste forms and to optimize the waste management system per an Integrated Waste Management Strategy