U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Fuel Cycle Technologies Material Recovery and Waste Form Development Program Advanced Material Technologies Program

Patricia Paviet, Director , Office of Systems Engineering and Integration

NEUP Webinar

August 08, 2016

NE-5 Organization Structure

NE-5
Deputy Assistant Secretary
for Fuel Cycle Technologies:
John W. Herczeg

Associate Deputy Assistant Secretary
for Fuel Cycle Technologies :
Andrew Griffith

Melissa Bates

NE-5 ***NFST***
N*uclear* ***F****uel* ***S****torage and*
T*ransportation Planning*
Project

- ***Integrated Waste Mgmt. System***

Patricia Paviet

NE-51
Systems Engineering
And Integration

- ***Material Recovery and Waste Form Development***
- ***System Analysis and Integration***
- ***Fuel Resources***

Bill McCaughey

NE-52
Fuel Cycle Research and
Development

- ***Advanced Fuels***
- ***Materials Protection, Accounting, and Control Technology***
- ***Uranium Management and Policy***

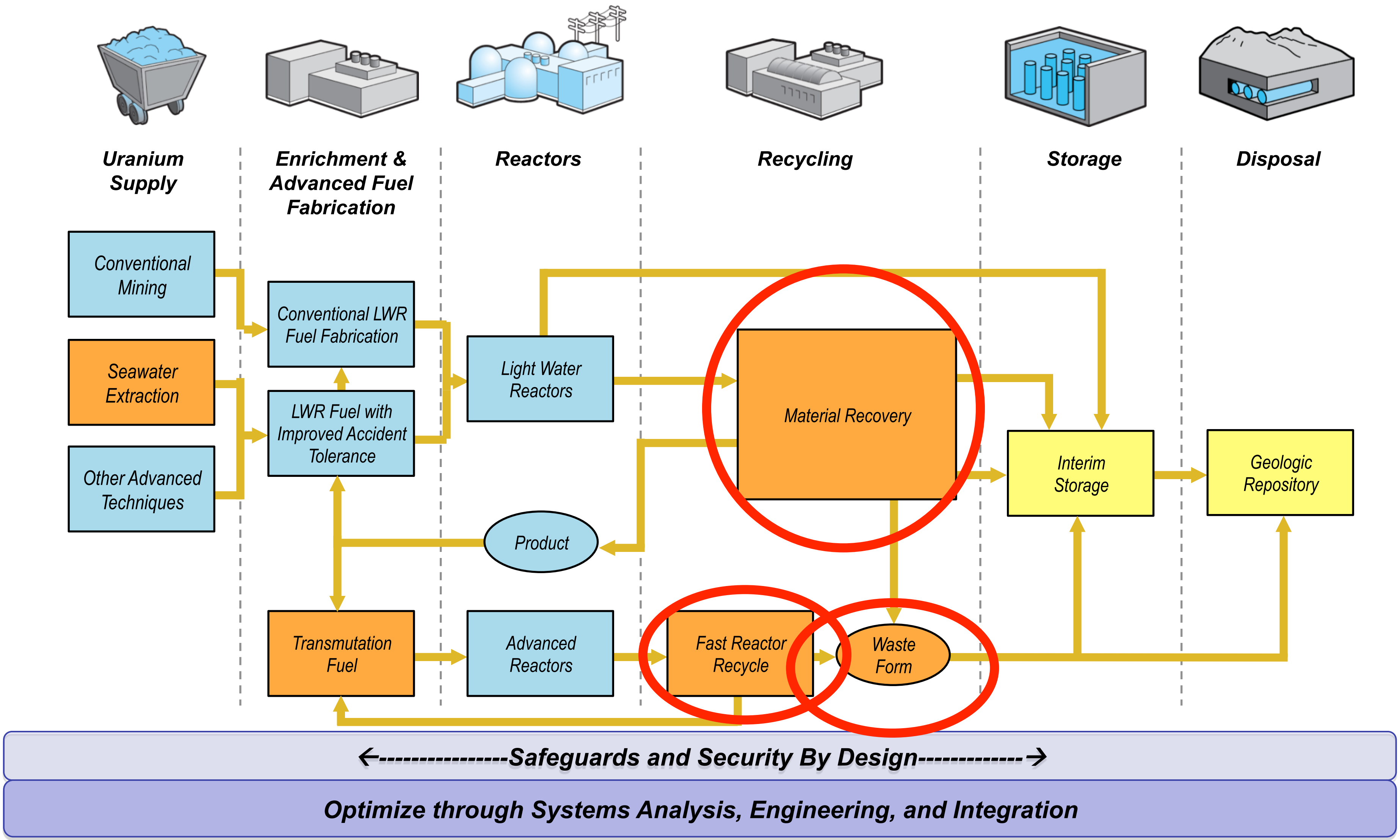
Bill Boyle

NE-53
Used Nuclear Fuel
Disposition Research and
Development

- ***Used Fuel Disposal R&D***
- ***Deep Boreholes***
- ***High Burnup Fuel Demonstration***

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

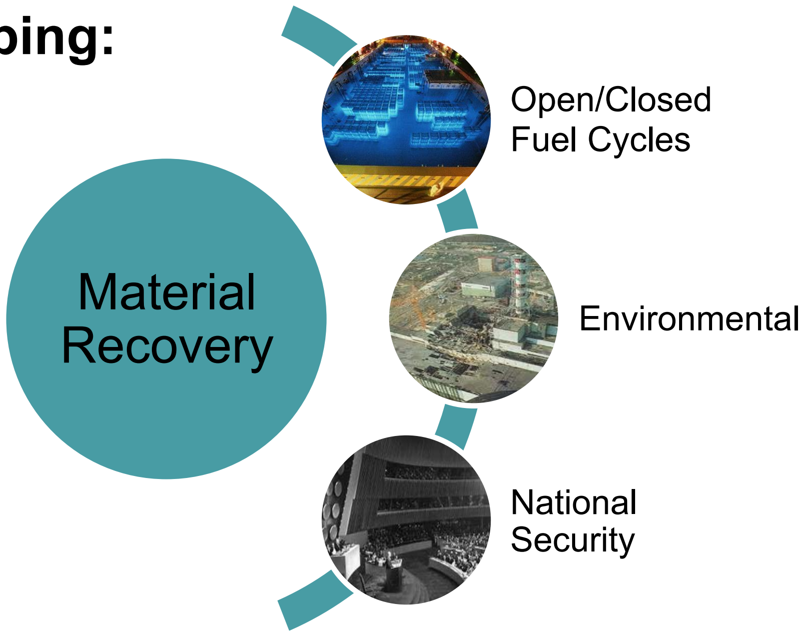
Focus Areas of DOE Fuel Cycle Technologies



Material Recovery and Waste Form Development Campaign Objectives

- **Develop advanced fuel cycle material recovery and waste management technologies that improve current fuel cycle performance and enable a sustainable fuel cycle, with minimal processing, waste generation, and potential for material diversion to provide options for future fuel cycle policy decisions**

- **Campaign strategy is based on developing:**
  - **Technologies** for economical deployment
    - *Concept through engineering-scale demonstration*
  - **Capabilities** for long-term science-based, engineering driven R&D, technology development and demonstration
  - **People** to provide the next generation of researchers, instructors, regulators and operators



U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Objectives of Some Major R&D Areas

Reference Technologies and Alternatives	• *Develop and demonstrate technologies applicable over a broad range of aqueous separation methods*
Sigma Team for Advanced Actinide Recovery (STAAR)	• *Enabling technology for TRU recycle options from LWR fuel* • *Develop cost effective technology ready for deployment*
Off-gas Sigma Team	• *Enabling technology for any recycle option* • *Develop cost effective technology ready for deployment*
Fundamental Separation Data/Methods	• *Develop advanced methods for fundamental understanding of separations processes.* • *Develop predictive models based on fundamental data*
Advanced Waste Forms and Characterization	• *Enable broader range of disposal options with higher performance waste forms* • *Develop cost effective technology ready for deployment*
Electrochemical Processing	• *Develop and demonstrate deployable and sustainable technology for fast reactor fuel recycling*

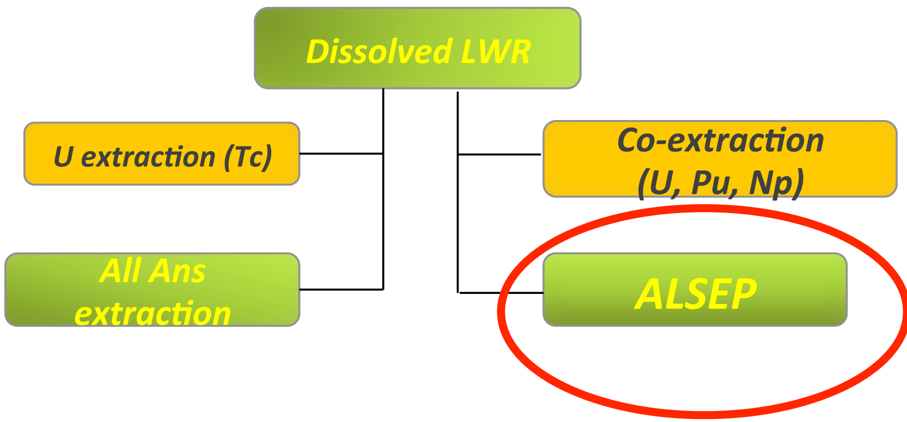
FC-1.1: ELECTROCHEMICAL SEPARATIONS (Federal POC – Stephen Kung & Technical POC – Mark Williamson)

- **Elucidate the behavior and constitution of fission products such as, but not limited to, iodine and tellurium in molten salts relevant to electrochemical processing. A more complete understanding of the behavior and constitution of fission products in molten salt solutions under conditions typical for electrochemical processing is needed and will provide additional experimentally determined data that can be used in process models.**
- **The proposed research should evaluate the chemistry of, for example, iodine present as an iodide and/or tellurium present as a telluride in the molten salt solutions.**
- **Proposals related to off-gas handling and/or capture are not appropriate to this call.**

Planar electrorefiner test module (l) and uranium product collected from tests (below)

FC-1.2: MATERIALS RECOVERY (Federal POC – Jim Bresee & Technical POC – Terry Todd)

- A number of solvent extraction technologies are being developed and evaluated for the separation of actinides from fission products and lanthanides. A deeper, fundamental understanding of advanced solvent extraction processes (e.g. ALSEP) is needed to design robust chemical separation flowsheets.
- Fundamental understanding of the kinetics of extraction and/or stripping of metals and the role of complexants to determine rate limiting mechanisms of the transfer of metal ions between phases is needed. Deeper understanding of the thermodynamic parameters of solvent extraction processes, particularly for trivalent actinides and lanthanides that can lead to improvements in solvent extraction chemistry is needed.

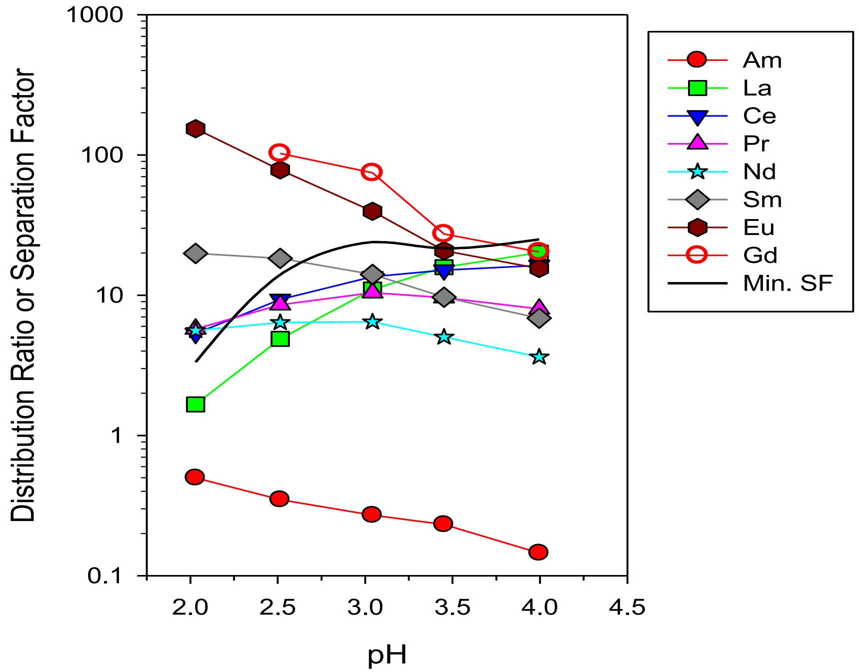


FC-1.2: MATERIALS RECOVERY (Federal POC – Jim Bresee & Technical POC – Terry Todd) (Cont.)

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

- **Finally, for all solvent extraction processes, particularly those involving multivalent metal ions, an understanding of the effects of gamma and alpha radiation on the process chemistry, with a goal of being able to predict the effects of radiation on the chemistry of the process, is needed.**



- Jointly developed between ANL and PNNL with support from WSU and other universities
- Combines TRUEX/TALSPEAK functionality into a single process
- Testing at batch contact stage, conceptual flowsheet developed and flowsheet testing with spiked simulants planned for 2015-2016
  - *Still resolving some kinetics issues and scrubbing of Zr, Mo, Ru*

FC-1.3: ADVANCED WASTE FORMS (Federal POC – Kimberly Gray & Technical POC – John Vienna)

- **Call 1: Waste Form Development**

Thermodynamics of Waste Glasses and Melts –

The fundamental mixture thermodynamics of waste glasses and melts as functions of temperature and composition are currently lacking in the scientific literature.

An improved database and model for the thermodynamics can assist in formulation optimization and prediction of waste form stability. Of particular interest is the thermodynamics of melts in the composition region for commercial high-level waste glasses.

FC-1.3: ADVANCED WASTE FORMS (Federal POC – Kimberly Gray & Technical POC – Bob Jubin)

- **Call 2a: Tritium Separations Technology**

Tritium management during reprocessing, accident response, and potentially reactor operation is a significant technological challenge. Novel, highly efficient technologies are needed to selectively remove tritium (as tritiated water) from the aqueous streams.

Just normal everyday H_2O

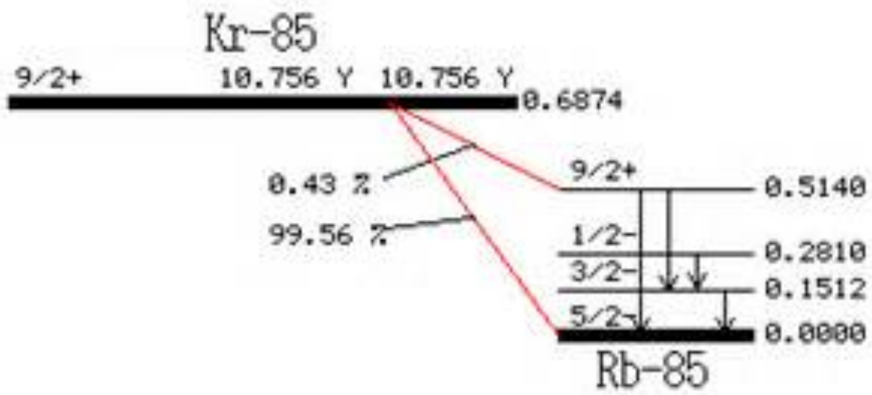
The goal of the tritium removal system should be able to selectively recover tritiated water from aqueous / acid streams with concentrations of

1 x 10^{-5} to 1 x 10^{-7} or lower and provide tritium concentration

FC-1.3: ADVANCED WASTE FORMS (Federal POC – Kimberly Gray & Technical POC – Bob Jubin)

- **Call 2b: Rb Interaction with Container Materials**

Kr-85 is released to the off-gas streams during the reprocessing of used nuclear fuel. To meet current EPA requirements the Kr must be recovered and managed. Kr may be stored as a compressed gas or in a getter material. The decay daughter of Kr-85 is Rb which is highly corrosive.



The preliminary evaluation of the legacy Kr-85 storage capsules show what appears to be significant corrosion in the inside of the capsules even with zeolite Kr getters. Fundamental data is needed on corrosion rates and mechanisms as functions of Rb concentration, storage temperature, etc. for various storage approaches (e.g., as compressed gas or encapsulated in a getter material) for typical storage container materials.

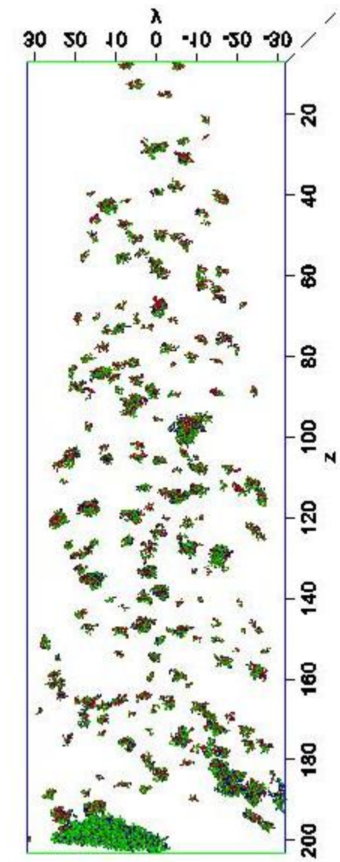
U.S. DEPARTMENT OF ENERGY

Nuclear Energy

NSUF 1.3: ADVANCED MATERIAL TECHNOLOGIES DEVELOPMENT (Federal POC – Sue Lesica& Technical POC – Stuart Maloy)

- Oxide Dispersion Strengthened Steel Joining Technologies

Proposals are sought to develop advanced joining techniques for oxide dispersion strengthened (ODS) metal alloys for high dose (>250 dpa), nuclear fission reactor applications. The mechanical properties of ODS metal alloys in nuclear environments are a significant improvement to the properties of conventional steels. ODS alloys exhibit higher radiation resistance and improved high temperature strength and creep properties. However, one of the primary challenges for the use of ODS alloys in engineering applications is the difficulty in maintaining the oxide dispersions in welds. Therefore, it is necessary to develop advanced joining techniques for these alloys. Proposals should include testing and characterization of joined plates or tubes of ODS alloys, both before and after irradiation, to understand and mitigate the effects of residual stress at or near the heat affected zones and to characterize the phase stability at the joint. These advanced joining techniques must maintain or improve mechanical properties at the joint, such as strength, irradiation resistance, corrosion resistance, and creep. Innovative methods to control and understand residual stress, heat affected zones, and/or phase stability during joining are also of interest.



APT analysis of ODS steel showing fine oxide dispersion (Odette, UCSB)[12]

Summary

- The FCT Programs are looking forward to partnering with universities to enhance their R&D portfolio and research capabilities
- This call is tailored to research topics that are well suited for university research
- The programs seek university researchers who want to actively participate in the program and enhance interactions with national laboratory research staff
- The FCT Material Recovery and Waste Form Development as well as Advanced Material Technologies Development management teams considers NEUP Principal Investigators to be an integral part of our research programs!
  - We encourage and actively seek close engagement with the campaigns

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Contact Information

- Jim Bresee: james.bresee@nuclear.energy.gov
- Kimberly Gray: kimberly.gray@nuclear.energy.gov
- Bob Jubin: jubinrt@ornl.gov
- Stephen Kung: stephen.kung@nuclear.energy.gov
- Sue Lesica: sue.lesica@nuclear.energy.gov
- Stuart Maloy: maloy@lanl.gov
- Terry Todd: terry.todd@inl.gov
- John Vienna: john.vienna@pnnl.gov
- Mark Williamson: williamson@anl.gov
- Patricia Paviet: patricia.paviet@nuclear.energy.gov