NEUP Nuclear Energy University Programs

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FY2011 NEUP Workshop Separations and Waste Forms Breakout Session

Rockville, Maryland

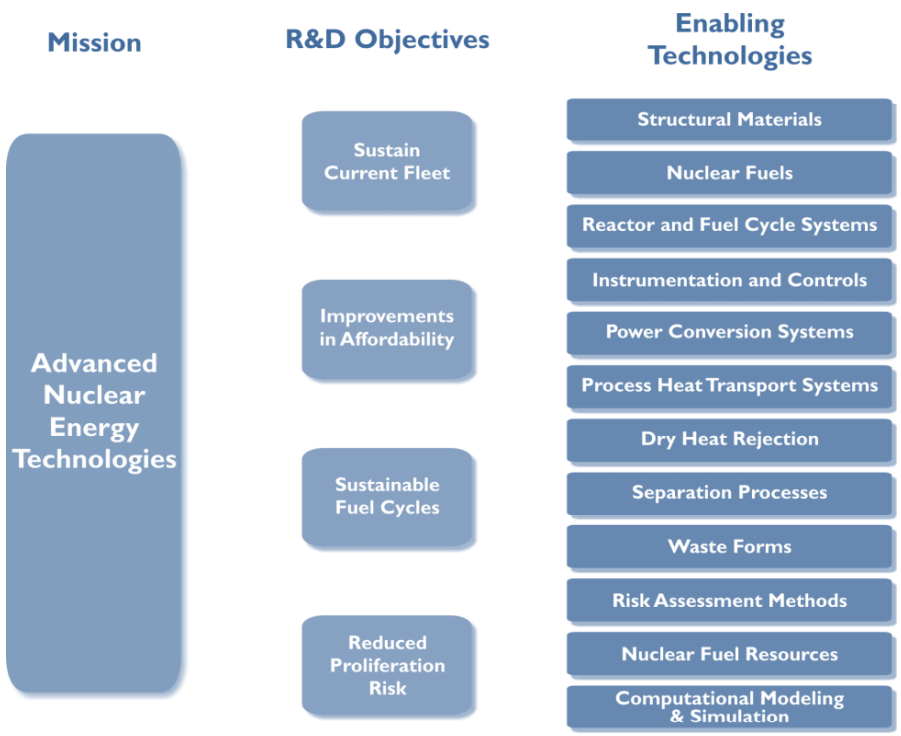
Separations and Waste Forms Organization

- **FCR&D Separations Campaign**
  - Jim Bresee, DOE-HQ Program Manager
  - Terry Todd, National Technical Director, INL
  - *Kevin Felker, Separations Deputy, ORNL*

- **FCR&D Waste Forms Campaign**
  - Jim Bresee, DOE-HQ Program Manager
  - Terry Todd, National Technical Director, INL
  - *John Vienna, Waste Forms Deputy, PNNL*

Nuclear Energy Roadmap
R&D Objectives

- **Four Research Objectives**
  1. Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors
  2. Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the administration's energy security and climate change goals
  3. Develop sustainable nuclear fuel cycles
  4. Understanding and minimizing the risks of nuclear proliferation and terrorism



Mission Statements

- **Separations**
  - Develop the next generation of fuel cycle separation and waste management technologies that enable a sustainable fuel cycle, with minimal processing, waste generation, and potential for material diversion

- **Waste Forms**
  - Develop and demonstrate durable waste forms and processes to enable safe and cost-effective waste management as an integral part of a sustainable fuel cycle by establishing a fundamental understanding of behavior through closely-coupled theory, experiment, and modeling

Separations Objectives

- Develop a fundamental understanding of used fuel separation chemistry through coupled theory, experimentation, and simulation
- Ensure that used fuel separation processes are safeguardable through a comprehensive approach that includes technology, transparency, accountability and physical protection
- Develop processes which meet specifications for product recycle and reuse, reduce waste, and convert liquid waste to durable solid waste
- Create validated modeling and simulation tools to predict separations process performance in a laboratory and industrial environment, in order to facilitate development and future deployment
- Demonstrate safe, economically-viable, industrially-deployable, and licensable processes to allow future recycling of used nuclear fuel

Waste Forms Objectives

- Develop robust and cost-appropriate waste and storage forms through testing and modeling
- Increase technological readiness of waste processes through analyses, testing, and demonstrations
- Develop fundamental understanding of waste form performance through coupled theory, testing, and modeling to support waste form qualification
- Create validated modeling and simulation tools and predict waste form characteristics and performance in relevant disposal environments and quantify their uncertainties
- Conduct and inform analyses of waste management options to derive waste form R&D requirements
- Integrate waste management into development and optimization of separations processes, both domestically and internationally
- Facilitate the reuse of materials through market/application identification, requirements development, and reuse technology development

FY 2010 Separations Focus Areas

- **Separation of minor actinides (Am or Am/Cm) from lanthanide**
  - Multi-laboratory Sigma team effort
- **Separation and immobilization of iodine and krypton**
  - Multi-laboratory Sigma team effort
- **Research into understanding fundamental properties of separation processes and developing reaction mechanisms**
  - Thermodynamics, kinetics, radiation chemistry, etc
  - Develop new fundamental research capabilities and methods
- **Demonstrate technical feasibility of electrochemical processing**
  - Increased understanding of fundamental chemistry
  - Investigation into real-time process monitoring and control
- **Initiated investigation of "transformational" separations technology**

FY2010 Waste Forms Focus Areas

- **Continue development of alloy and glass waste forms toward goal of mature, deployable technology**
- **Expand development of electrochemical process waste forms**
- **Integrate off-gas immobilization research with research into capture methods in Off-gas Sigma Team**
- **Initiate significant research activities in alternative waste forms**
  - High density, natural analogs
  - Higher durability waste form structures to specific radionuclide immobilization and geologies
- **Expand research into understanding fundamental properties of waste forms and corrosion mechanisms**
  - Interfacial science, transport phenomena, radiation-induced defects, etc
  - Develop new fundamental research capabilities and methods
- **Couple theory, experimentation and modeling to develop predictive capabilities**
  - Essential for time-scales that waste forms must perform

Separations Focus Areas for University Proposals

- **Investigate fundamental interfacial electrochemistry of actinides and fission product elements important in the fuel treatment process; for example, determination of thermodynamic properties in process relevant molten salts (e.g., LiCl, LiCl/KCl) or characterization of kinetics and mass transport properties of important species in molten salts**
- **Increase the understanding of the fundamental thermodynamic and kinetic driving forces in multiphase solutions for effective separation of actinides and lanthanides**
- **Determine the effects of radiation on the chemistry of ligands, ionic liquids, polymers, and molten salts; establish fundamental radiation chemistry data; and develop predictive models**
- **Develop methods for monitoring and controlling chemical selectivity in complex radiochemical processing environments**

Waste Forms Focus Areas for University Proposals

- **Radiation and thermal effects on waste forms; need for constitutive models for radionuclide transport in bulk waste forms leading to cracking and increased aqueous-accessible areas**
- **Development of robust, accurate, and validating methods for modeling the chemistry and transport of actinide species at a sub-continuum scale**
- **Development of mechanistic first-principles-based models for glass and ceramic bulk and surface properties and durability to tailor composition to specific waste streams and environments**
- **Development of models for corrosion resistance and dissolution rates of waste forms in severe aqueous conditions**
- **Systematic experimental studies on waste form stability and corrosion under controlled pH, temperature, and chemical conditions specifically targeted to support development and validation of quantitative models**
- **Research into new models, methods, and thermodynamic data for radionuclide speciation at high temperature, high ionic strength conditions anticipated in near-field repository environments**

Grand Challenges

- **Separations**
  - Single-step separations process for Am or TRU
  - Near-zero radioactive off-gas emissions (an order of magnitude lower than risk-based regulations)

- **Waste Forms**
  - Reduce waste volume of HLW, LLW, GTCC, by an order of magnitude
  - Increase the durability of HLW and LLW by an order of magnitude over current reference