Update on the Fuel-Cycle Technology Activities of the U.S. Department of Energy’s Office of Nuclear Energy (DOE-NE)

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Objectives of DOE’s Office of Nuclear Energy (DOE-NE) support national imperatives for clean energy, economic prosperity, and national security.

Roadmap outlines an integrated approach to meet these objectives.

Roadmap addresses transformation of programs to a more science-based approach.

Roadmap can be found at www.ne.doe.gov
U.S. Nuclear Energy Objectives

- Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors
- Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals
- Develop sustainable nuclear fuel cycles
- Understand and minimize the risks of nuclear proliferation and terrorism
Fuel Cycle Technologies Mission and Program Objectives

- **Support decision-makers by developing a suite of options to manage used fuel**

- **Demonstrate technologies that support commercial deployment of sustainable fuel cycles by 2050**

- **Sustainable fuel cycles are those that:**
  - improve uranium resource utilization
  - maximize energy generation
  - minimize waste generation
  - improve safety
  - protect the environment
  - limit proliferation risk
  - are economically viable
Three Potential Fuel Cycle Options

- **Once-Through**
  - No recycling or conditioning of used fuel

- **Modified Open Cycle**
  - Very limited used fuel conditioning or processing

- **Full Recycling**
  - Multiple reprocessing steps and transmutation of actinides
Objective is to inform fuel cycle research and development, programmatic decisions, strategy formulation, and policy development.

Office performs integrating analyses of nuclear energy systems.
- Evaluates technology alternatives
- Evaluates gaps, disconnects, and off-ramps
- Examines deployment options
- Understands system dynamics
- Identifies critical program elements to inform where R&D should be targeted

Systems engineering and analysis provide a systematic and objective process to identify and prioritize research and development activities and to manage the results to inform programmatic decisions.
- Objective is to enable the safe, secure, economical, and sustainable expansion of nuclear energy while reducing proliferation risks.

- Office conducts science-based, goal-oriented research and development in support of developing options to the current U.S. commercial fuel cycle management strategy.
  - Separations and Waste Forms
  - Transmutation Fuels
  - Materials Protection, Accounting, and Control Technologies

- Office of Used Nuclear Fuel Disposition Research and Development (covered in the next presentation)
Separations and Waste Forms

Today’s Technology Challenges

- Minimizing waste generation from the fuel cycle
- Recovering fuel resources, from natural materials or used fuel, in an economic manner

Development Path

- Develop fundamental understanding of separation processes and waste form thermodynamics
  - Exploit thermodynamic properties to effect separations
  - Elucidate microstructural waste form corrosion mechanisms
- Perform economic analysis of uranium recovery technologies

Outcomes

- Advanced separations technologies
- Robust waste forms
- Predictive models for separations technology and waste form performance
Today’s Technology Challenges

- Producing fuels that enable improved fuel cycle options (waste management and resource utilization)
- Enabling fuels with variable compositions
- Minimizing defects and process losses from fuel fabrication

Development Path

- Develop a fundamental microstructural understanding of fuels and materials
  - Separate effect testing and properties measurement at sub-grain scale
  - Effect of nano-scale implantations
  - Closure of combined transport and phase-field equations
- Develop clean and reliable fabrication techniques with tightly controlled microstructures tailored to desired performance

Outcomes

- Advanced fuel forms
- Predictive models for fuel performance
Materials Protection, Accounting, and Control Technologies (MPACT)

Today’s Technology Challenges

- Developing nuclear material management systems for advanced nuclear systems
- Improving nuclear material management systems at large fuel cycle facilities
- Moving from reactive to preventive systems approach

Development Path

- Develop next generation instrumentation enabled by new physics data
  - High sensitivity and specificity
  - New sensor materials
- Integrate disparate data in quantitative manner
  - Real time assessments
  - Probability basis with uncertainties

Outcomes

- Real time nuclear materials management with continuous inventory
- Predictive models for nuclear material management
Objective is to bolster U.S. university research and development infrastructure and to provide the next generation of nuclear professionals.

Universities are engaged to provide resources that support nuclear energy research and development.
- Program directed research
- Program supporting research
- DOE-NE mission supporting research
- University infrastructure development
- Student fellowships and scholarship grants

NEUP supports all DOE-NE research programs.
Concluding Comments

DOE’s Fuel Cycle Research and Development Program is an integrated, goal-oriented, science-based program to provide fuel cycle and used fuel management options to future decision makers.

Program is focused on development and assessment of technical options.

Research is focused on improvements to once through, modified open cycle, and full recycle.