U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Advanced Fuel Cycles and Long-Term Storage of Spent Fuel Research and Development

Dr. John W. Herczeg
Associate Deputy Assistant Secretary
Fuel Cycle Technologies
Office of Nuclear Energy
U.S. Department of Energy

Nuclear Regulatory Commission
April 22, 2013

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

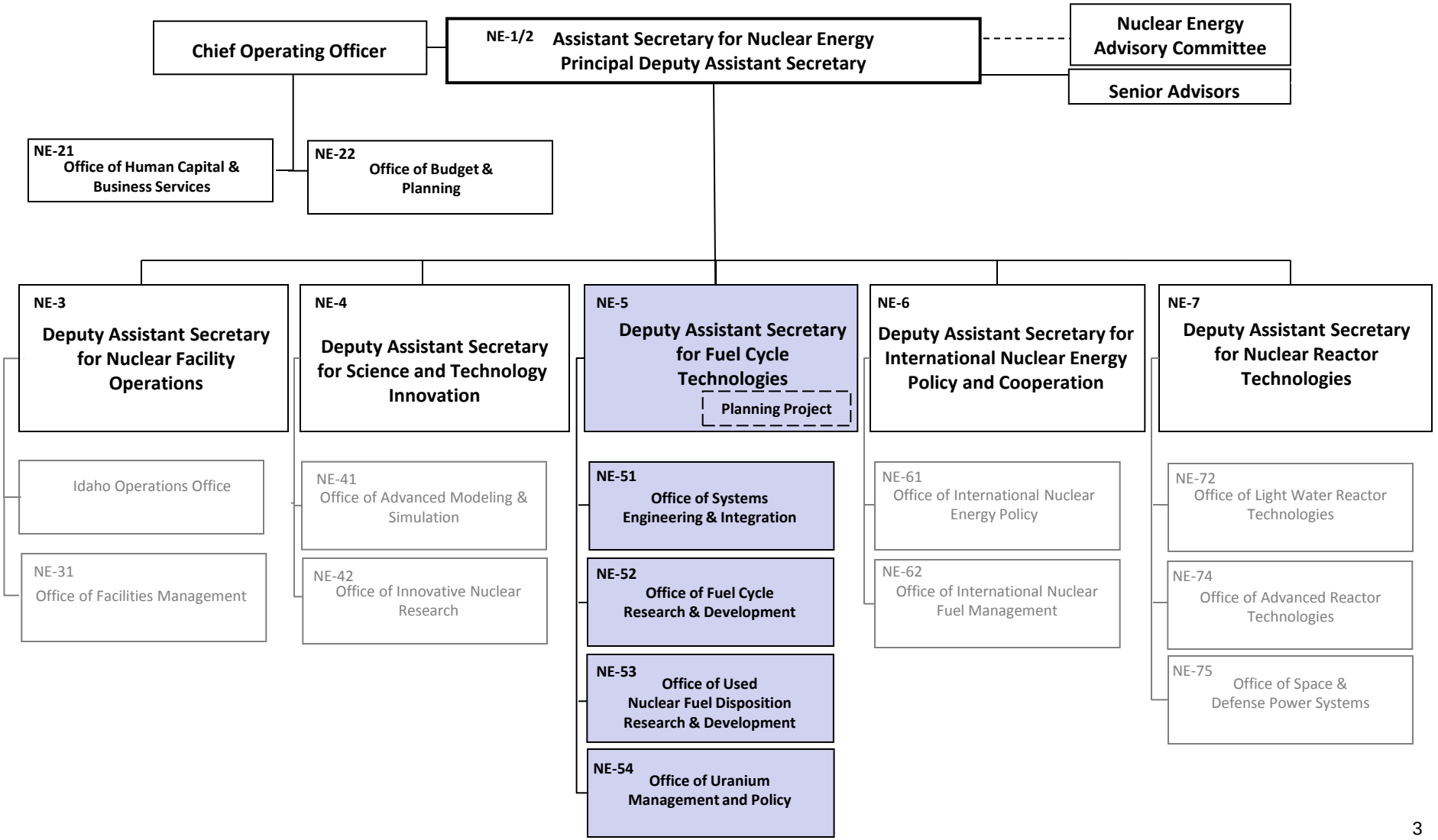
Outline

- **Overview – Office of Fuel Cycle Technologies Areas**
  - Fuels
  - Separations
  - Proliferation Risk
  - Fuel Cycle Options – “Systems Analysis”
  - Used Fuel Disposition
    - Nuclear Fuel Storage & Transportation
    - R&D: Near Term and Longer Term

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

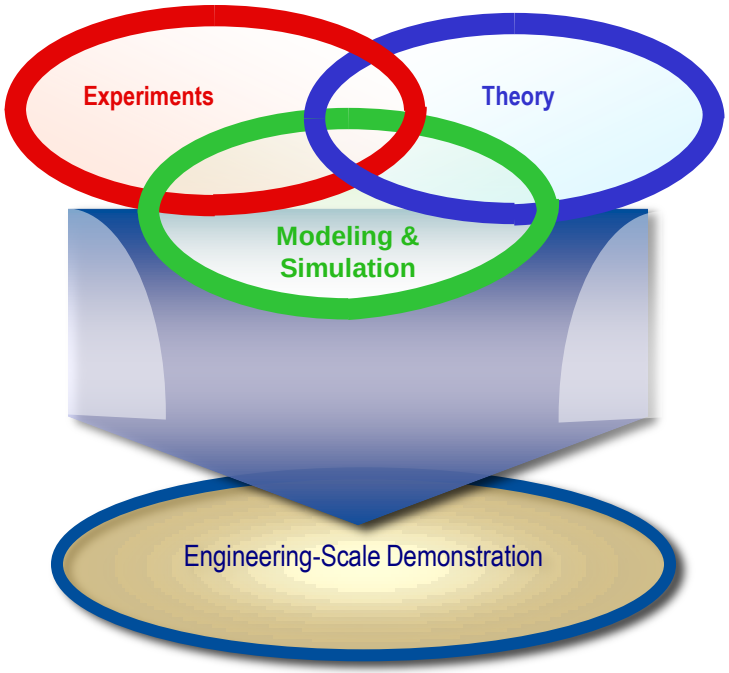
Office of Nuclear Energy



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Science-Based Approach to Nuclear Energy Development

- **Experiments** – Physical tests to develop understanding of single effects or integrated system behaviors.
- **Theory** – Creation of models of physical behaviors based on understanding of fundamental scientific principals and/or experimental observations.
- **Modeling and Simulation** – Use of computational models to develop scientific understanding of the physical behaviors of systems. Also used to apply scientific understanding to predict the behavior of complex physical systems.
- **Demonstrations** – New technologies, regulatory frameworks, and business models integrated into first-of-kind system demonstrations that provide top-level validation of integrated system technical and financial performance.



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Advanced Fuels

Next generation **LWR fuels** with enhanced performance and safety and reduced waste generation

Metallic transmutation fuels with enhanced proliferation resistance and resource utilization

Crosscutting Capability Development supporting the Science-based Approach to Fuels RD&D
-Advanced characterization and PIE techniques
-Advanced in-pile instrumentation
-Irradiation testing (steady-state & transient)
-Fuel performance modeling
-Analytic techniques

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Separations R&D

Objective:

Develop advanced fuel cycle separations 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

Strategy:

- **Long-term science based-based, engineering driven**
- **Economical deployment**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

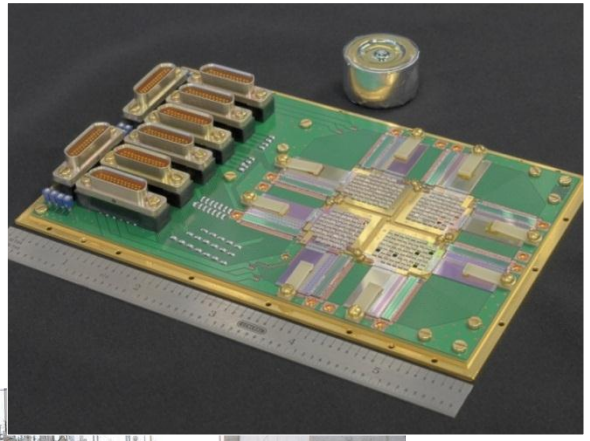
Separations R&D

Advanced Aqueous (AA)	• Develop and demonstrate technologies applicable over a broad range of aqueous separation methods
Minor Actinide Sigma Team (MA)	• Enabling technology for TRU recycle options from LWR fuel • Develop cost effective technology ready for deployment
Off-gas Sigma Team (OG)	• Enabling technology for any recycle option • Develop cost effective technology ready for deployment
Fundamental Science / Mod. & Simulation (FS&M, M&SS)	• Develop advanced methods to develop fundamental understanding of separation methods, waste forms, and waste form performance-develop predictive models based on fundamental data
Separation Process Alternatives (ASP)	• Investigate alternative process options to determine if significant cost or performance improvement can be realized
Alt. Waste Forms and Characterization (AWF, WFC)	• Open disposal options with higher performance waste forms • Develop cost effective technology ready for deployment
Uranium Extraction from Seawater (FR)	• Develop and demonstrate extractants and engineered systems with double the capacity over current technology
Electrochemical Processing (DE, JFCS)	• Develop and demonstrate deployable and sustainable technology for fast reactor fuel reprocessing

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Addressing Proliferation and Terrorism Risks - R&D Objectives

- **Develop instruments capable of real-time measurement of group transuranics in advanced fuel cycle systems**
- **Develop proliferation risk analyses applied to advanced fuel cycles and spent fuel storage**
- **Safeguards and security by design:**
  - Analyzing proliferation and terrorism risks from the very earliest stages to maximize effectiveness and efficiency and minimize S&S costs



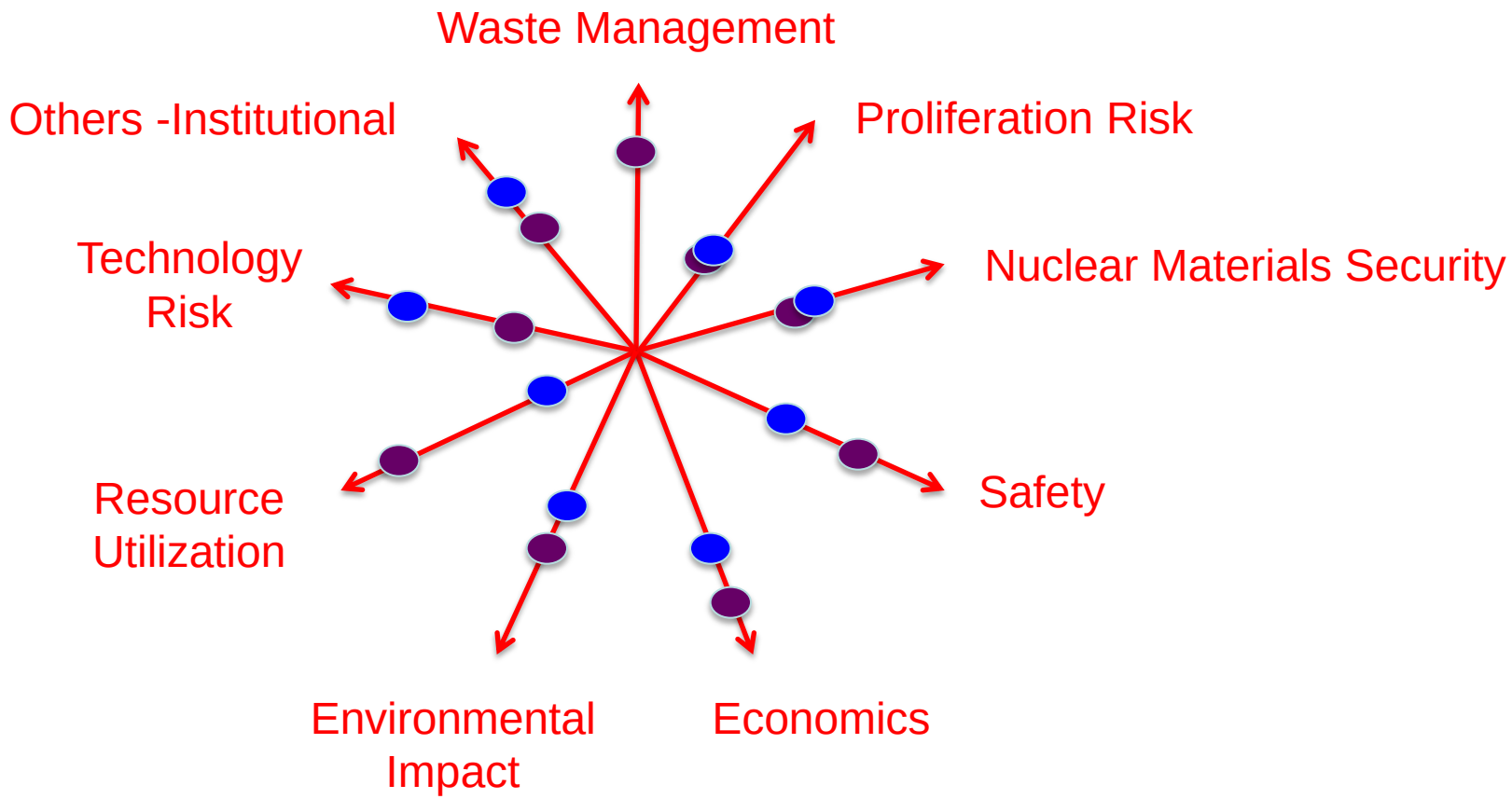
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Fuel Cycle Options - "Systems Analysis"

(technical evaluation of various fuel cycles within political, social, and economic constraints)

Objective:

Identify fuel cycles with benefits that are significant compared to current fuel cycle



U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Used Fuel Disposition

Front End

Uranium Resources

- Conventional production
- Innovative approaches

Fuel Fabrication

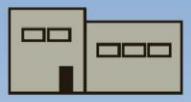
- Safety enhanced LWR fuel
- Higher performance

Reactors

Back End

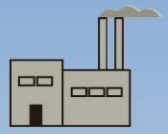
Interim Storage

- Evaluating extended time frames
- Transportation after storage



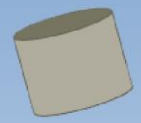
Recycle

- Separations
- Recycled fuel
- Secondary waste treatment



Disposal

- Alternative geologies
- Alternative waste forms



Consolidated Interim Storage is Key to our Strategy

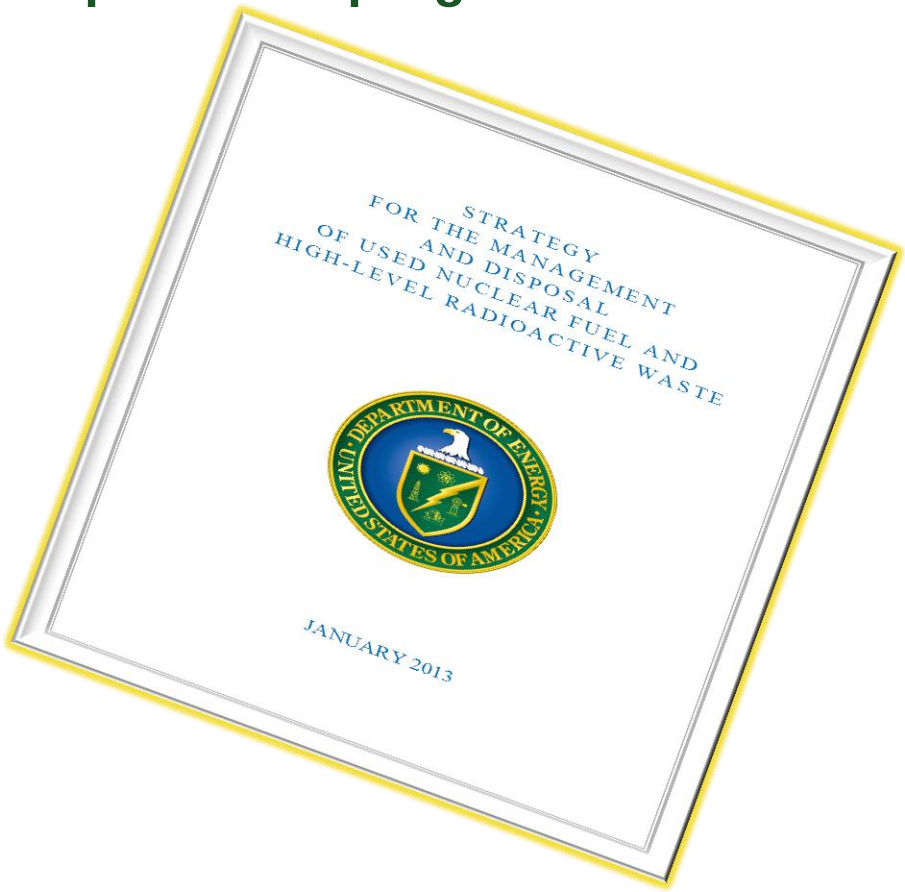
Near Term Needs

Long Term Needs

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

"Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste"

- **With the appropriate authorizations from Congress, the Administration currently plans to implement a program:**
  - Sites, designs and licenses, constructs and begins operations of a **pilot interim storage facility by 2021** with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
  - Advances toward the siting and licensing of a **larger interim storage facility to be available by 2025** that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
  - Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a **geologic repository by 2048**."



U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Used Fuel Disposition R&D:
"Near Term Extended Storage of High Burn-up Fuel Project"

- **FY 2014**
  - *R&D to support:*
    - *extended storage of used fuel*
    - transportation of extended storage fuel : field testing to assess realistic loadings during transport
  - R&D on alternative disposal environments:
    - modeling, evaluation and experiments
  - Salt Repository:
    - Implement field tests to advance salt repository:
    - science for disposal of heat-generating waste
  - Borehole research:
    - Undertake R &D as necessary to further the understanding of hydro-geochemical, physical geology, structural geology and engineering properties of deep crystalline rocks.
  - Continue evaluation of standardized containers for storage, transportation and potentially disposal.

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

DOE's New Investment in Fuel Storage "High Burn-up Used Nuclear Fuel Dry Storage Project"

- **Need:**
  - General agreement among DOE, NRC and industry to investigate extended storage of high burn-up fuel to support storage license extension and transport of high burn-up fuel.
- **Goal:**
  1. Benchmark predicative models and empirical conclusions developed from short-term laboratory testing for aging of dry storage cask system components, and
  2. Build confidence in the ability to predict the performance of these systems over extended time periods.
- **Cost & Schedule: $15.8M over 5 years**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

DOE's New Investment in Fuel Storage "High Burn-up Used Nuclear Fuel Dry Storage Project"

- **Involves:**
  - Loading a commercial storage cask with high burn-up fuel in a utility storage pool
    - Well understood fuel
    - Cask outfitted with additional instrumentation for monitoring
  - Drying of the cask contents using prototypic process
  - Cask will be housed at the utility's dry cask storage site
    - Continuously monitored and externally inspected until the first internal inspection at ~10 years
  - A second cask could be loaded ~5 years following the first with a focus on additional scientific data on fuel behavior
- **The issue of where the cask will be opened will be decided at a later date.**

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Contract Was Awarded to the EPRI Team

- The EPRI Team consists of:

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Dominion

- Surrey Plant
- North Anna Plant

AREVA Federal Services
AREVA Transnuclear
AREVA Fuels

- First task is the preparation of the Test Plan that will be shared with the Public