U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Potential Role of Nanotechnologies in Advanced Nuclear Energy Systems - DOE Perspective

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Mission

Ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

DOE

Goal 3: Secure Our Nation

- Enhance nuclear security through defense, nonproliferation, and environmental efforts.

Advance nuclear power as a resource capable of making major contributions in meeting the Nation's energy supply, environmental, and energy security needs by resolving technical, cost, safety, security and regulatory issues through research, development, and demonstration.

NE

Develop sustainable fuel cycles and Used Fuel waste management strategies that improve resource utilization, minimize waste generation, improve safety and limit proliferation risk.

FCRD

Objectives – Currently Evolving

Blue Ribbon Commission

- Recommendations could lead to near term program shifts and a major restructuring in the longer term.
- Potential to consider interim storage and associated transport to centralized storage location.

Fukushima Event

- May lead to shifting program priorities while also dealing with reduced overall program funding.
- Severe accident tolerant fuel.

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Current Objectives

Near Term

- **Address BRC recommendations for Used Fuel Disposition.**
- **<u>Increase focus on accident tolerant fuels.</u>**
- Down select fuel cycle options for further development.

Medium Term

- **Complete implementation plan for developing a Test and Validation Complex for extended storage of used nuclear fuel.**
- **Evaluate benefits of various geologic media for disposal.**
- Conduct science based, engineering driven research for selected fuel cycle options.

Long Term

- **Execute Test and Validation Complex for extended storage of Used Fuel.**
- **Conduct engineering analysis of disposal site(s) for selected geologic media.**
- Demonstrate the selected fuel cycle options at engineering scale.

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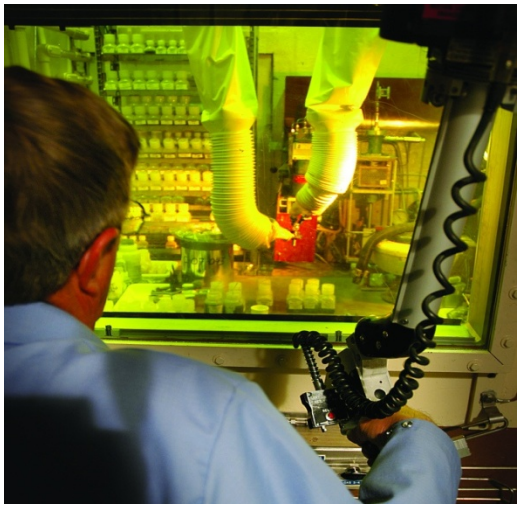
Advanced Fuel Development

Goals

- Develop "next generation LWR fuels and cladding" with enhanced performance and safety, and reduced waste generation"
- Develop "transmutation metal fuels with enhanced proliferation resistance and resource utilization



- **Focus of the research**
  - Innovative LWR Fuels and Cladding
  - Metal Fast Reactor Fuels
  - Advanced fuel fabrication methods

As an example, the following are attributes of accident tolerant fuel where nanotechnologies may help us resolve

Improved Reaction Kinetics with Steam
-Heat of oxidation rate

Slower Hydrogen Generation Rate
-Hydrogen bubble
-Hydrogen explosion
-Hydrogen embrittlement of the clad

Improved Fuel Properties
-Lower operating temperatures
-Clad internal oxidation
-Fuel relocation / dispersion
-Fuel melting

High temperature during loss of active cooling

Improved Cladding Properties
-Clad fracture
-Geometric stability
-Thermal shock resistance
-Melting of the cladding

Enhanced Retention of Fission Products
-Gaseous fission products
-Solid/liquid fission products

Based on these safety-related issues, metrics for quantifying the enhancements in accident tolerance must be developed in conjunction with the safety features of a given LWR design and based on specific accident scenarios.

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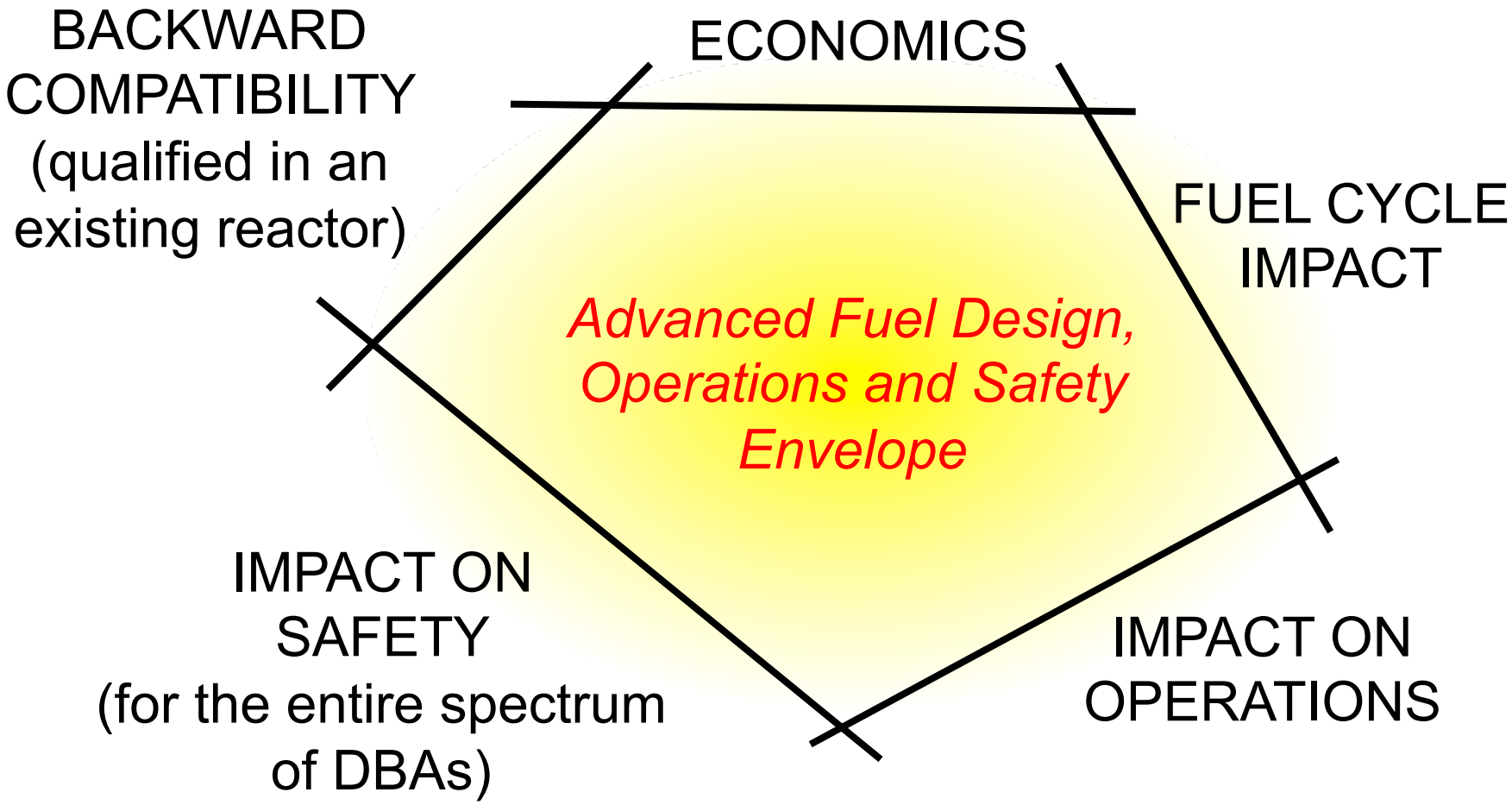
The challenge is to address these issues within the constraints of the nuclear industry – the technology must be commercially deployable!



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In summary,…….

- DOE-NE FCRD program is very interested in seeing how we can bring advances into nanotechnology into nuclear energy

- We can envision many areas where we can benefit from advances in nanotechnologies
  - Nuclear fuels and materials and micro in-pile instrumentation are good examples
    - Radiation tolerance
    - High-temperature tolerance
    - Fission product segregation/gettering/immobilization

*We are hoping that the experts in this workshop will give us a "**prioritized list of areas to pursue joint development activities in the areas of fuels and materials where feasibility can be demonstrated in the near-term.**"*