



U.S. DEPARTMENT OF  
**ENERGY**

**Nuclear Energy**

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# **Fuel Cycle Technologies Perspectives**

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**Nuclear Energy University Programs  
Integrated Research Projects Pre-solicitation Workshop  
Washington, DC  
May 2, 2012**

- **Mission**
- **Blue Ribbon Commission Program Impacts**
- **Used Nuclear Fuel Disposition Program**
- **Fukushima Daiichi Events Program Impacts**
- **LWR Fuels with Enhanced Accident Tolerance**
- **Concluding Remarks**



# Fuel Cycle Technologies (FCT) - Mission

## Nuclear Energy

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

DOE

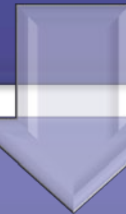
Goal 3: Secure Our Nation

- 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.

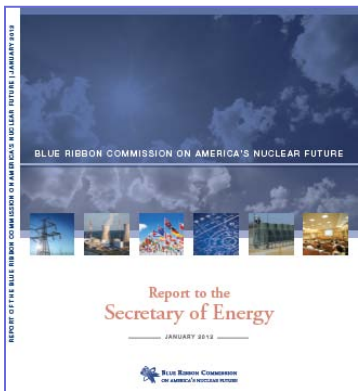
FCT



[http://energy.gov/sites/prod/files/2011\\_DOE\\_Strategic\\_Plan\\_.pdf](http://energy.gov/sites/prod/files/2011_DOE_Strategic_Plan_.pdf)  
[http://www.ne.doe.gov/pdfFiles/NuclearEnergy\\_Roadmap\\_Final.pdf](http://www.ne.doe.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf)



## Objectives – Currently Evolving



### Blue Ribbon Commission

[www.brc.gov](http://www.brc.gov)

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



### Fukushima Event

- May lead to shifting program priorities.
- Focus on the development of advanced LWR fuels with enhanced accident tolerance.



# Current Program Objectives

## Near Term

- Address BRC recommendations for Used Fuel Disposition – *Administration strategy to Congress within 6 months*
- Increase focus on advanced LWR fuels with enhanced accident tolerance.
- 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.



# Where We Are Today

Expansion of nuclear energy worldwide and the continuing build up of nuclear waste from commercial nuclear plants “Drives the Office of Fuel Cycle Technologies R&D Program”

After Fukushima – new awareness as a country of the need for a waste management strategy

- Interim storage
- Fuel cycle alternatives
- Disposal options



The BRC conducted a comprehensive evaluation of policies for managing the back end of the nuclear fuel cycle, including advanced fuel cycle technologies

The Fuel Cycle Technology Program seeks to develop innovative technologies that represent significant advantages in terms of economics, proliferation resistance, resource utilization and waste management



# FY 2011-12 Budget Summary

## Nuclear Energy

*Dollars in thousands*

Activity/Sub-Activity	FY 2011 Current	FY 2012 (a) Request	FY 2012 (a) Appropriation
Separations and Waste Forms	37,133	36,893	32,420
<b>Advanced Fuels</b>	50,648	<b>40,443</b>	<b>59,000</b>
Transmutation R & D	5,721	3,109	0
Modeling and Simulation	22,350	0	10,000 (b)
Systems Analysis and Integration	23,775	20,466	17,132
MPACT	6,674	7,864	5,176
<b>Used Nuclear Fuel Disposition</b>	32,535	<b>37,249</b>	<b>60,000 (c)</b>
Fuel Resources	3,592	4,646	3,623
<b>Total</b>	<b>182,428</b>	<b>150,670</b>	<b>187,351</b>

- a. Does not include SBIR/STTR contribution.
- b. Assess issues related to the aging and safety of storing spent nuclear fuel in fuel pools and dry storage casks.
- c. Includes:
  - \$10 M for development and licensing of standardized casks
  - \$3 M for developing models for potential partnerships to manage waste
  - \$7 M for characterizing potential geologic repository media

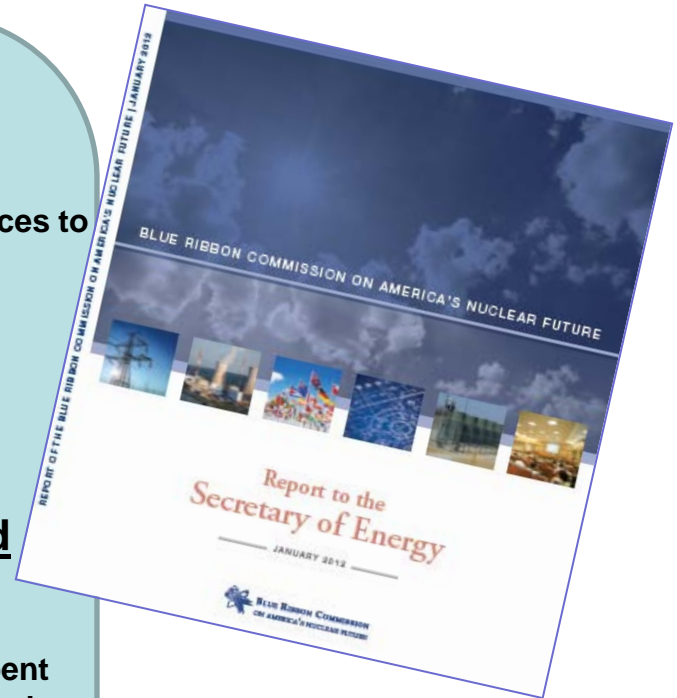
# **Blue Ribbon Commission Program Impacts**





# Blue Ribbon Commission Recommendations

1. A new, consent-based approach to siting future nuclear waste management facilities.
2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3. Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
4. Prompt efforts to develop one or more geologic disposal facilities.
5. **Prompt efforts to develop one or more consolidated storage facilities.**
6. Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
7. Support for continued U.S. innovation in nuclear energy technology and for workforce development.
8. Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.





# BRC Assessment of Current DOE-NE UFD Program (Section 7.8 Near-Term Steps)



Confirms the importance for *“DOE to keep the program moving forward through non-site specific activities, including R&D on geological media and work to design improved engineered barriers”*

Recommends the continuation of activities currently conducted under the DOE-NE Used Nuclear Fuel Disposition Campaign

*“Identify alternatives”*

*“R&D on transportation, storage, and disposal options for SNF from existing and future fuel cycles”*

*“Other non-site specific generic activities, such as support for and coordination with states and regional state government groups on transportation planning”*

# Used Nuclear Fuel Disposition Program



# Storage and Transportation R&D Objectives

- Develop the technical basis for extended storage of used nuclear fuel
- Develop the technical basis for fuel retrievability and transportation after extended storage
- Develop the technical basis for transportation of high-burnup used nuclear fuel





### ■ Begin laying the ground work for implementing consolidated storage.

- Building on previous DOE work and industry storage licensing efforts, evaluation of design concepts for consolidated storage.
- Develop communication packages for use in interaction with potential host communities, which describe various attributes of a consolidated storage facility.



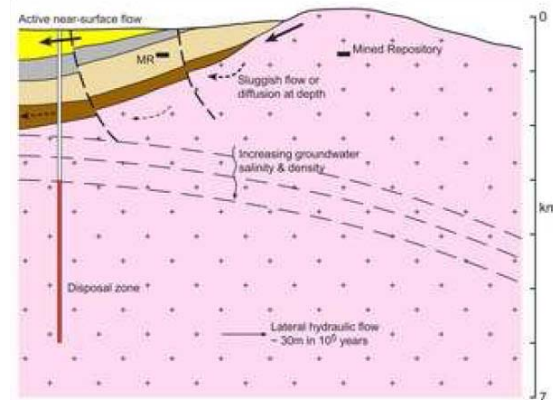
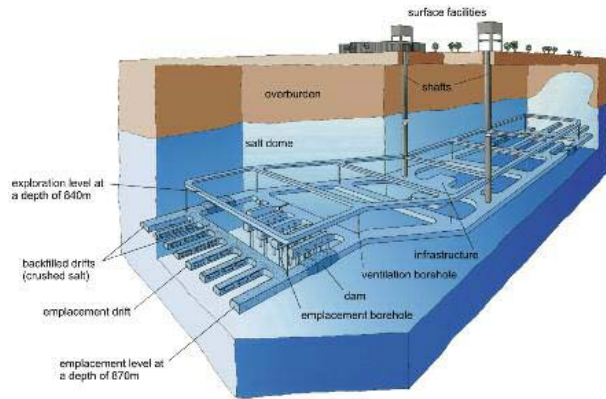
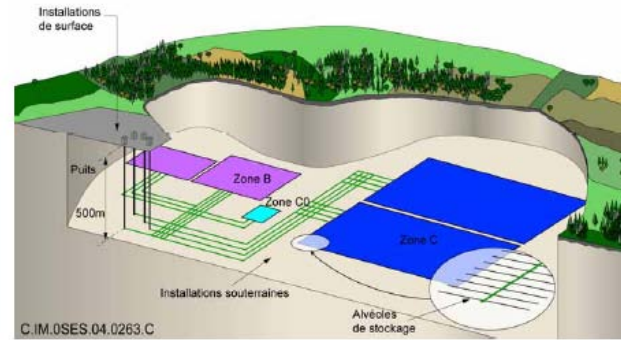
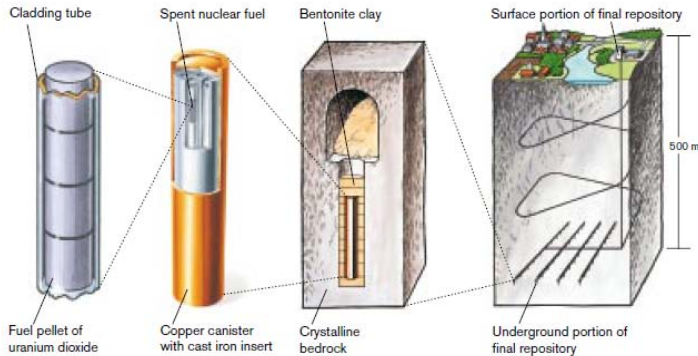
### ■ R&D to better understand potential degradation mechanisms in long term dry cask storage including:

- Continue material testing to support modeling and simulation of used fuel aging.
- Complete the identification of data gaps to support license amendments beyond 40 years for dry storage.
- Define facilities needed to conduct the required additional testing of irradiated nuclear fuel. Data with respect to high-burnup fuel is particularly needed.



# Disposal R&D is Focusing on Four Basic Options

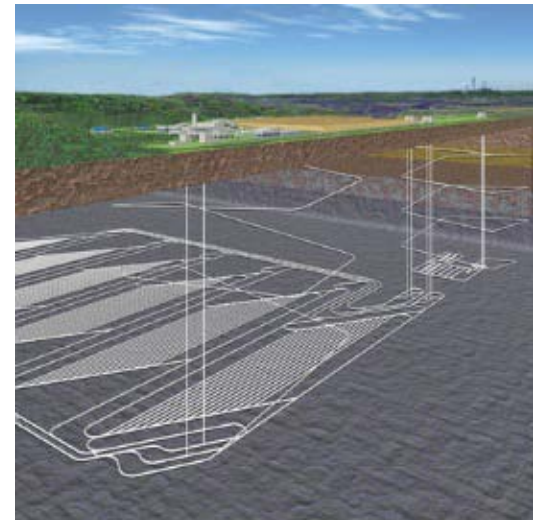
- Three mined repository options (granitic rocks, clay/shale, and salt)
- One geologic disposal alternative: deep boreholes in crystalline rocks





# Disposal R&D Objectives

- Provide a sound technical basis for the assertion that the U.S. has multiple viable disposal options
- Increase confidence in the robustness of generic disposal concepts to reduce the impact of site-specific options
- Evaluate the BRC recommendation for developing a near term plan for taking the borehole disposal concept to the point of a licensed demonstration



# **Fukushima Daiichi Events Program Impacts**





## ■ Fukushima - DOE-NE Research Impacts

- Reducing the need for Operator Actions in Accident Response, enhances overall safety
  - Passive Systems enhance safety  
*AP-1000, ESBWR, SMRs, HTGRs*
  - Better understanding of dry cask storage systems
- Re-engineering barriers can reduce complications
  - SiC cladding
  - Enhanced fuel properties
- Re-evaluation of potential natural phenomena
  - Re-evaluation of U.S. seismic criteria
- Targeted use of Modeling and Simulation
  - Improved modeling of operating reactors





# Advanced LWR Fuels with Enhanced Accident Tolerance Fuel”

## **Mission:**

Develop advanced fuels and non-intrusive reactor system components (e.g. instruments, auxiliary power sources) with improved performance, reliability and safety characteristics during normal operations and accident conditions

## **10-year Goals**

- Insert a LTA into a operating commercial reactor
- Demonstrate non-intrusive components that enhance safety (e.g. instrumentation with enhanced accident tolerance)

## **Must be acceptable to vendors/utilities**

- Better safety performance (e.g. during normal, design basis accidents and beyond design basis accidents)
- Reliability and fuel configurations similar to current fleet
- Acceptable economics
- Favorable neutronics and licensing characteristics



# Accident Tolerance Fuels (ATF)

## **Definition of Fuels with Enhanced Accident Tolerance**

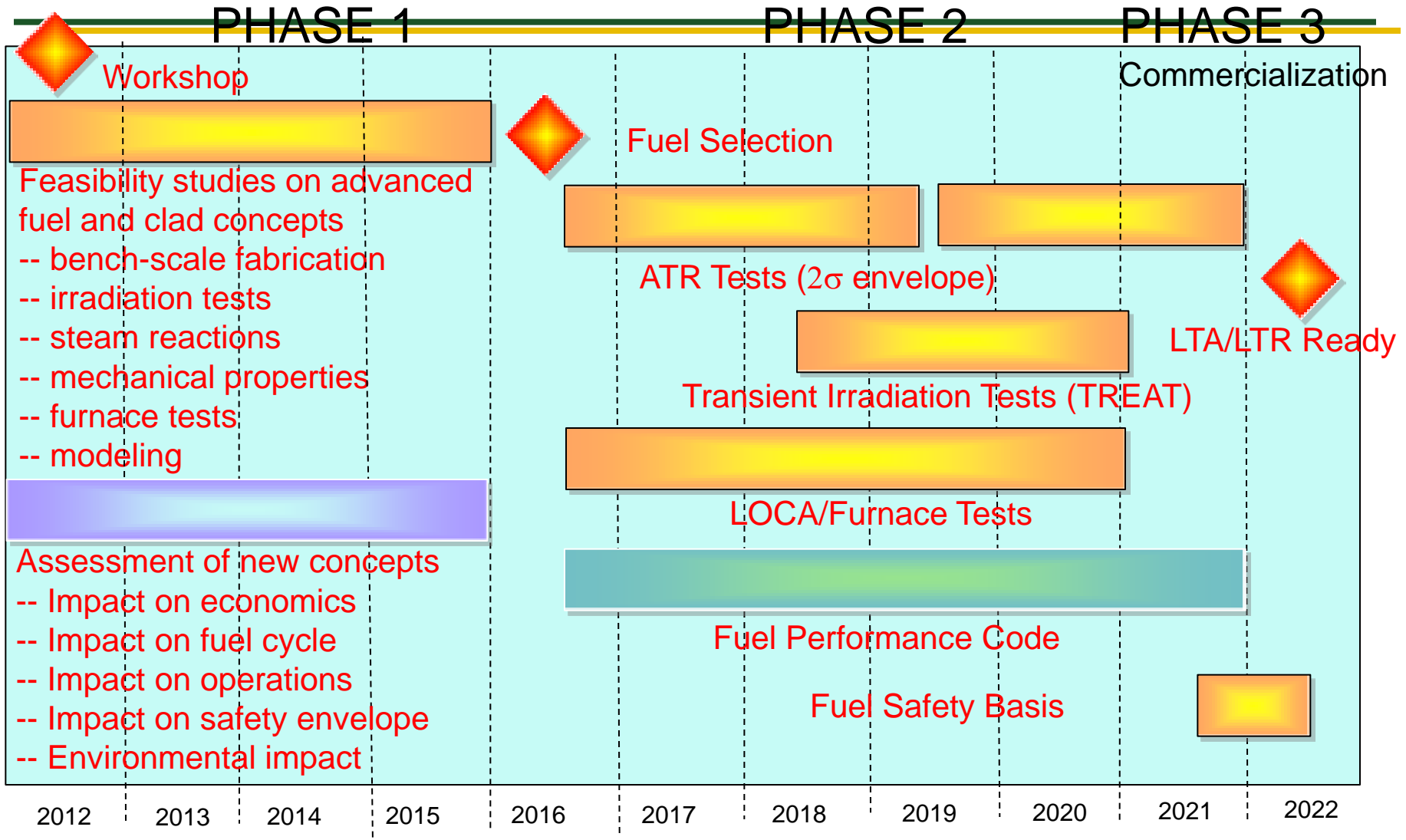
Fuels with enhanced accident tolerance are those that, in comparison with the standard  $\text{UO}_2$  – Zircaloy system, can tolerate loss of active cooling in the core for a considerably longer time period while maintaining or improving the fuel performance during normal operations.

## **Metrics Needs**

To demonstrate the enhanced accident tolerance of candidate fuel designs, metrics must be developed and evaluated using a combination of design features for a given LWR design, potential improvements and the design of advanced fuel/cladding system.



# R&D Strategy : National Labs + Universities + Industry



# Concluding Remarks

## Concluding Remarks

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- **Integrated Research Projects (IRPs) are an integral part of the R&D program in Office of Fuel Cycle Technologies – we are looking for:**
    - Innovation in Advanced Nuclear Fuels and Materials –
    - R&D to support the understanding of long-term degradation mechanisms relevant to processes and components of the storage system –
  
  - **National Laboratories and Industry are potential partners for an IRP**