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Developing the Technical Basis for Long Term Storage and Subsequent Transportation of Used Nuclear Fuel

Global 2011

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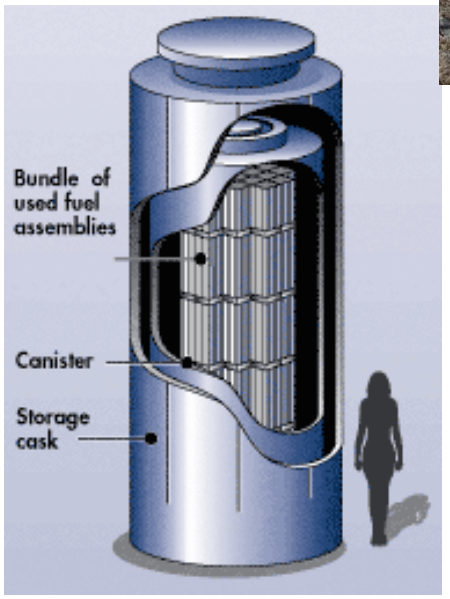
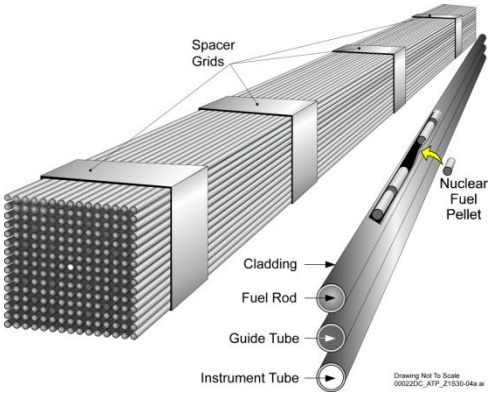




Storage and Transportation Objectives

Objectives:

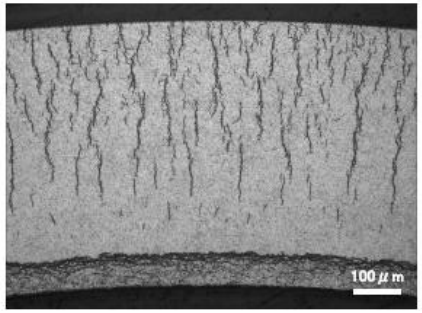
- Develop the technical bases to demonstrate used fuel dry storage system integrity for extended periods of storage.
- Develop technical bases for fuel retrievability and transportation after long term storage.
- Develop the technical basis for transportation of high burnup fuel.

2010

- **UFD Program Stood Up**

2015

- **Project Implementation Plan**
- **Development of technical basis**
  - **Near-term experiments and analyses**

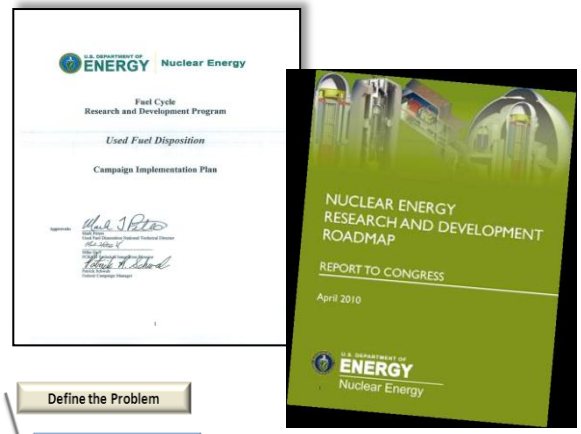


2020

- **Operational long-term storage "demo" project**
  - **Longer-term validation**

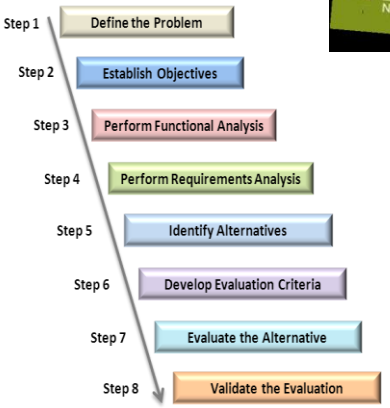
Work Packages: *Approach to meeting objectives*

A systems engineering process has been developed, followed, and continually assessed in order to achieve success in meeting our objectives

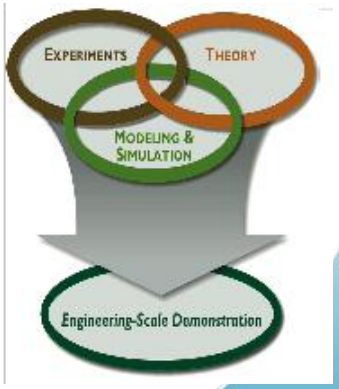


1. **Documentation of objectives**
   - UFD Campaign Implementation Plan: March 2010
   - NE Roadmap (R&D Objective 3): April 2010

2. **Implement Systems Engineering Approach**
   - Process identification and implementation
   - Technical implementation
   - Independent reviews



3. **Conduct Independent Reviews**
   - NEAC: February 2010, April 2011
   - NWTRB: September 2011



4. **Assess alignment with Blue Ribbon Commission (BRC) recommendations (consistent with NE Roadmap R&D Objective 3)**
   - Draft report from Storage and Transportation Subcommittee: May 2011
   - Draft report from Main Committee: July 2011

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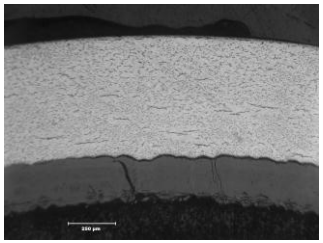
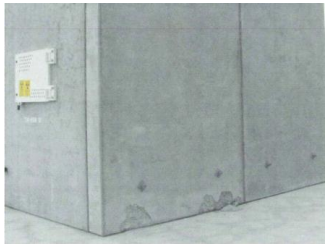
Work Packages : *Scope, Tasks, Deliverables*

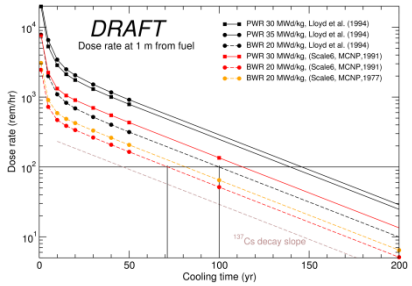
- **Based on this process, four separate work packages were established to conduct the work to meet the stated objectives.**

  - **Storage R&D Investigations**
    - Data gap analyses
    - Plan to address gaps
    - Development of technical basis

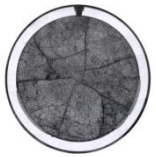


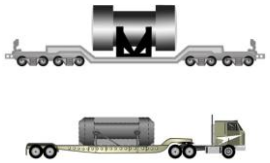


  - **Security**
    - Regulatory assessment
    - Identify issues peculiar to long-term storage
    - Evaluate vulnerability analysis methodology improvements



  - **Transportation**
    - High burnup fuels
    - Transportation of all fuels after storage





  - **Conceptual Evaluation**
    - Evaluate scenarios for accomplishing development of technical basis
    - Develop a systems framework for decision-making

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Work Packages: *R&D Investigations*

Storage system component "High" and "Medium" priorities

System Component	Issue	Importance of R&D
Cladding	Annealing of Radiation Effects	Medium
	Oxidation	Medium
	H_2 effects: Embrittlement	High
	H_2 effects: Delayed Hydride Cracking	Medium
	Creep	Medium
Assembly Hardware	Stress corrosion cracking	Medium
Neutron Poisons	Thermal aging effects	Medium
	Embrittlement and cracking	Medium
	Creep	Medium
	Corrosion (blistering)	Medium
Canister	Atmospheric corrosion (marine environment)	High
	Aqueous corrosion	High

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Work Packages: *R&D Investigations*

Storage system component "High" and "Medium" priorities

System Component	Issue	Importance of R&D
Bolted Direct Load Casks	Thermo-mechanical fatigue of bolts/seals	Medium
	Atmospheric corrosion (marine environment)	High
	Aqueous corrosion	High
Overpack and Pad (Concrete)	Freeze/Thaw	Medium
	Corrosion of steel rebar	Medium

Cross-cutting or General Gaps

- **Temperature profiles for fuel** **High**
- **Drying issues** **High**
- **Monitoring** **High**
- **Subcriticality** **High**
- **Fuel transfer options** **High**
- **Re-examine INL dry cask storage** **High**

→ **Identification of these data gaps are used to inform new initiatives for FY12**

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Work Packages: *Security*

- **Objectives**
  - To identify and evaluate security issues related to extended storage of used nuclear fuel and the associated transportation after extended storage
  - Support overall objectives for Storage and Transportation to develop technical bases for extended storage

- **Work Activities**
  - Address technical and regulatory issues
    - *Self-protection threshold*
    - *Material attractiveness*
    - *Security impacts of orphan sites*
    - *Long-term engineered protection strategies and institutional controls*
  - Perform assessments to evaluate security for extended storage and to provide a basis for recommendations to maintain security over the timeframe of extended storage

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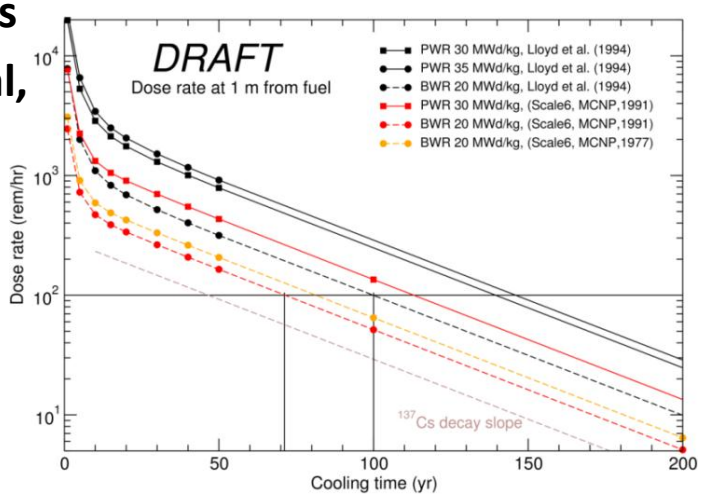
Work Packages: *Security*

- **Spent Fuel Self-Protection/Material Attractiveness**
  - **Inventory data base tools to inform security activities**
  - **Spent Fuel Standard – physical, radiological, chemical, barriers**
  - **Figure of Merit for spent fuel security storage**



- **Security Assessments**
  - **Evaluation of storage sabotage and theft scenarios**
  - **Preliminary evaluation of changes over time**
    - **Fuel/storage system characteristics, attack strategies, tech development**

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Work Packages: *Transportation*

Priorities

- Near term: address technical issues for possible transport of selected fuel rods to support possible off-site testing.

- Medium term: possible transport of UNF from Independent Spent Fuel Storage Installations to a demo and/or consolidated interim storage facility.
  - Key transportation emphasis:
    - Inventory of UNF in dry storage and transfer / transport systems available.
    - Logistical issues: e.g.: Are storage canisters currently transportable? Are transfer systems / transport casks available? Dual-purpose casks.
    - Decommissioned sites "first".

- Long term: transport of used nuclear fuel after extended storage
  - Key transportation emphasis for R&D:
    - UNF may be degraded after extended storage.
    - Canisters may be degraded.
    - Retrievability issues must be addressed.
    - Evaluation of "off-ramps" to mitigate full-spectrum of testing requirements

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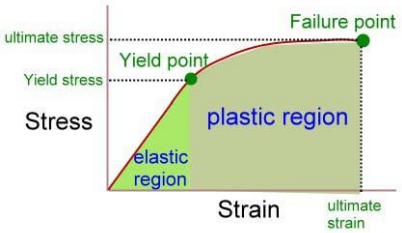
Work Packages: *Transportation – "Off ramp" evaluations*

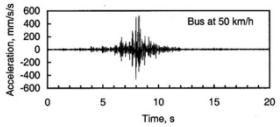
Assessments are being conducted to evaluate the feasibility of reducing the test burden on fuel clad

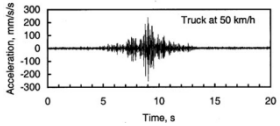


1. **Transportation over-the-road tests**
   - **Obtain data on mechanical loads that fuel is subjected to in normal transport environments**
   - **Use material properties of fuel in degraded state**
   - **Analyze degraded fuels ability to withstand transport loadings**

   → **Degraded fuel may be able to withstand transport conditions**

   FY11: Test Plan Description

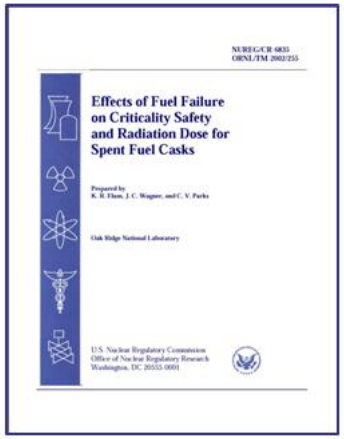




2. **Criticality analysis**
   - **Conduct criticality assessment of fuel over a range of breached states with full moderator and optimum geometry conditions**
   - **This is an extension of earlier work funded by the NRC**

   → **Breached fuel may not result in a criticality, even with full moderator**

   FY11: Initiated criticality analysis work



3. **Moderator exclusion**
   - **Develop measures to exclude moderator**

   → **Breached fuel may not result in a criticality if moderator can be excluded**

   FY11: Moderator exclusion containment concept report

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Work Packages: *Concept Evaluations*

- **Goal**
  - To integrate safety and security research needs into a comprehensive plan to provide a technical basis for licensing very long term storage and transportation of used nuclear fuel.

- **Objectives**
  - Identify early data development that could be accomplished in the next few years using existing facilities.
  - Identification of a spectrum of alternatives for fielding an storage test and validation complex (TVC).
  - Use a systems engineering approach to evaluate alternatives against an identified set of criteria and prioritize these alternatives accordingly.
  - Use this process to inform decision-making with regard to implementation of the testing and analysis work.

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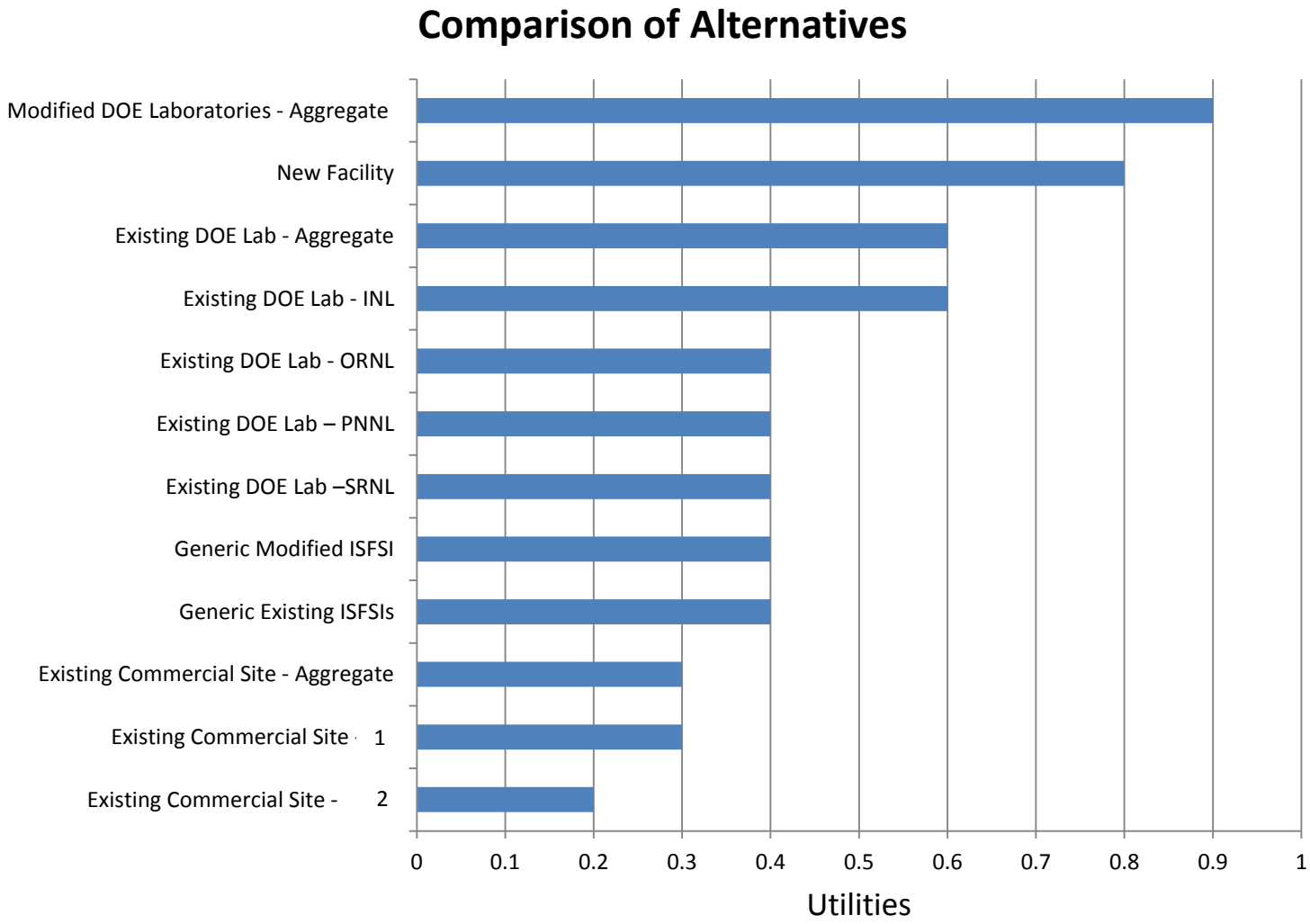
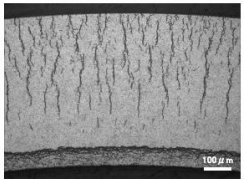
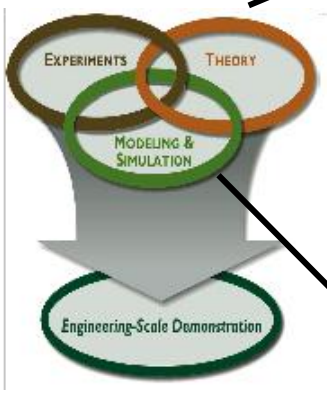
Work Packages: *Concept Evaluations – Findings*



New S&T Initiatives for FY12

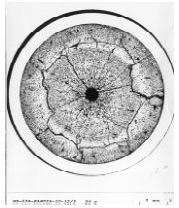
Based on the work to date, two new initiatives have been added to the S&T program:

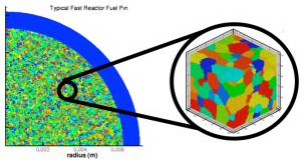




1. **Engineered Materials – Testing**
   - **Conduct ring compression tests on irradiated fuel cladding (from data gap report – high priority gap associated with hydride effects on clad)**
   - **Conduct hydride effects tests on unirradiated clad (understand hydride effects between irradiated clad and unirradiated clad)**
   - **Conduct corrosion testing on SS canisters**

2. **Engineering Analysis**
   - **Working with the R&D Investigations team, conduct modeling and analysis on data gap problems that can be addressed analytically using existing codes**





Collaboration with Industry and Regulators

The DOE program is closely integrated with industry and regulators to ensure that all applicable aspects of the storage system components are identified and considered.

DRAFT September 7, 2011

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Extended Storage Collaboration Program
International Subcommittee

Technical Data Gap Identification for Demonstrating Safety of Extended Storage of Used Nuclear Fuel

DRAFT August 2011

This DRAFT contains the outline for the full International Subcommittee report and draft input for the United States sections of the report.

1

The primary interface for this work is the Electric Power Research Institute (EPRI) Extended Storage Collaboration Program (ESCP). This committee is a working group made up of representatives from:

- **Industry (EPRI, utilities, fuel vendors, cask vendors)**
- **Regulator (NRC)**
- **DOE Laboratories**
- **International organizations**

Objectives:

- **Share information on work being conducted by individual organizations that is relevant to all ESCP members**
- **Coordinate efforts associated with identification and prioritization of data gaps**
- **Share data/information related to on-going work associated with addressing data gaps**

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Conclusions

DOE/NE is supporting development of the technical basis for certification of very long term storage of used fuel and subsequent transportation. Programmatically, this includes;

- **development of a plan to support experimental data gathering to address gaps in the existing data base,**
- **conducting experiments to gather needed data,**
- **working with the NRC to properly integrate data needs perceived by both the regulator and industry,**
- **working closely with industry,**
- **working closely with our international partners, and**
- **development of the technical basis documents.**

This work remains aligned to the original Campaign Implementation Plan as well as the NE Roadmap. It is also consistent with draft recommendations published by the BRC.

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