



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

Paul McConnell



Albuquerque, New Mexico
pemccon@sandia.gov
505.8458361

*CSG Midwestern
Radioactive Materials
Transportation Committee
December 8, 2010 - Milwaukee*



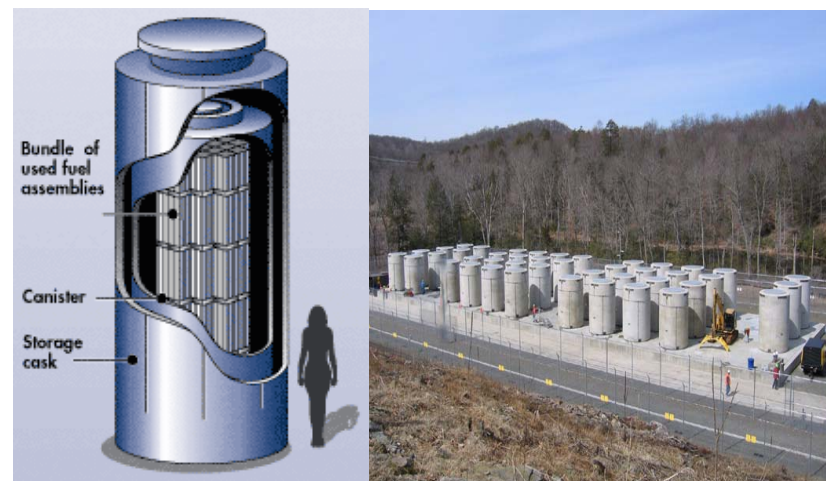
U.S. Department of Energy Nuclear Energy Fuel Cycle Technologies Program

■ Program Objectives

- Develop options for used nuclear fuel management to reduce the long-term environmental burden.
- Enhance overall nuclear fuel cycle proliferation resistance.
- Enhance energy security by extracting energy recoverable in used fuel.
- Improve the excellent safety performance and economics of the nuclear fuel cycle.

■ FCT Program Structure

- Advanced Fuels / Transmutation systems
- Separations / MPACT
- Systems Analysis/Engineering
- Modeling and Simulation
- **Used Fuel Disposition** / Waste Forms



Used Fuel Disposition Campaign

■ UFD Campaign Mission

- Identify alternatives and conduct scientific research and technology development to enable storage , transportation, and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles.

■ UFD Campaign Baseline

- Storage, transportation, and ultimate disposal.
- Includes legacy LWR used fuel and new waste streams that would be generated from alternative fuel cycles.
- Includes NRC and DOE licensed sites.
- International collaborations will be actively pursued.

• **Used Fuel Disposition** / Storage and Transportation

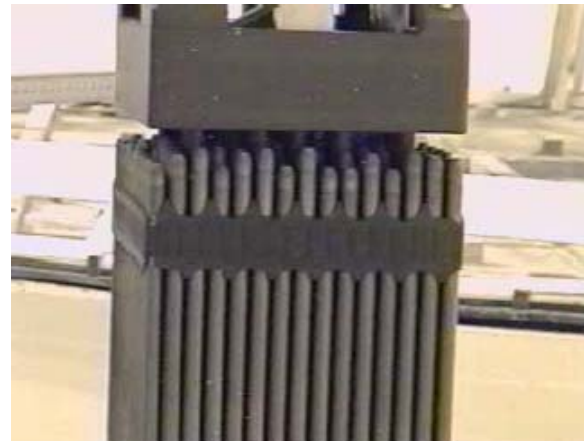
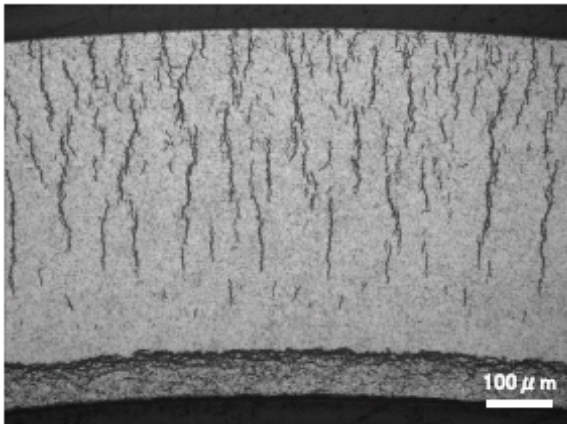
- R&D Opportunities
- Transportation
- Security
- Concept Evaluations



UFD Objectives

Nuclear Energy

- **Develop the technical bases to demonstrate used fuel integrity for a storage period of up to 300 years.**
- **Develop technical bases for fuel retrievability and transportation after long-term storage.**
- **Develop the technical basis for transportation of high burnup fuel.**





UFD R&D Opportunities

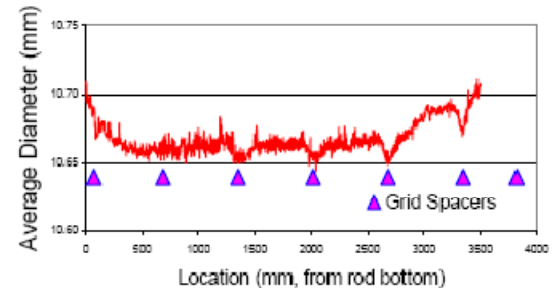
Identify all potential degradation mechanisms

■ Systems to be analyzed

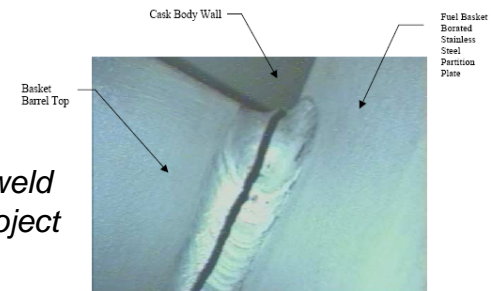
- Fuel/clad system
- Fuel assembly
- Baskets
- Neutron Poisons/Shields
- Container
- Overpack
- Pad
- Monitoring, security, institutional control



INL Dry Storage Characterization (DSC) Project



Creep data from DSC Project



BSS basket weld from DSC Project



Storage Regulatory Requirements

10CFR72

NRC rulemaking to allow for storage up to 120 years (60 yrs in-pool and 40 + 40 years dry storage)

Cladding must be protected against degradation that leads to gross failure

Must maintain confinement of intact and damaged used fuel

Must be retrievable

NUREG-1536 requires maintenance of

- 1. Thermal performance**
- 2. Radiological performance**
- 3. Confinement**
- 4. Sub-criticality**
- 5. Retrievability**



Storage Functional Requirements

■ Industry Experience: Technical issues addressed from past R&D program [EPRI/DOE/NRC Dry Cask Storage Characterization (DCSC) Project at INL]

- No cask functional degradation observed (15 years)
- Assemblies look the same
 - *No sticking; no significant bowing upon removal*
 - *No visual signs of degradation*
- No leaks during storage
- No significant additional fission gas release to rod internals
- No significant hydride reorientation
- No creep during storage
- “Creep life” remains
- **Most severe conditions during first 20 years?**

Challenge:
Demonstrate similar behavior for up to 300 years



Storage

What hasn't been addressed?

- Effect of marine environment
 - *Cannot rule out corrosion and stress corrosion cracking*
 - Development of advanced cladding materials and assembly designs
 - MOX fuel
 - Long-term concrete degradation
 - High burnup fuel (>45GWD/MTU)
 - *Hydride reorientation*
 - *Hydride embrittlement*
 - *Creep*
 - *Plenum gas pressure*
 - *Corrosion*
- Challenge:**
Demonstrate *material* degradation behavior for high burnup used fuel over a long storage period.



UFD Storage

How do we resolve technical issues associated with very long term storage?

R&D Opportunities

- Data gap analysis
- Plan to address gaps
- Development of technical bases

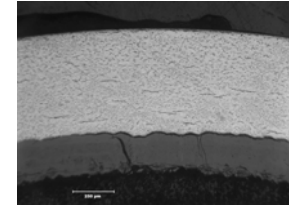
Security

- Regulatory assessment: Identify issues peculiar to long-term storage

Conceptual Evaluation

- Development of technical basis
- Evaluate scenarios for accomplishing development of technical basis

Transportation



Focus on long term storage of LWR fuel

UFD Storage Implementation Plan Goals

- 1 yr: Project Implementation Plan Framework
- 5 yr: Project Implementation Plan & Development of Technical Basis
- 10 yr: Field operating project



UFD R&D Opportunities – Storage preliminary assessment

System	Issue	Importance of R&D
Cladding	Annealing of Radiation Embrittlement, Oxidation, Creep	Medium
	H ₂ Embrittlement, Hydride Cracking	High
Container (Welds, Bolts, Metal Seals)	Humid Oxidation, Marine Environment, Wet Corrosion	High
	Temperature Fluctuations Relax Metal Seals and Bolts	Medium
Monitoring Systems	Performance Confirmation	Medium

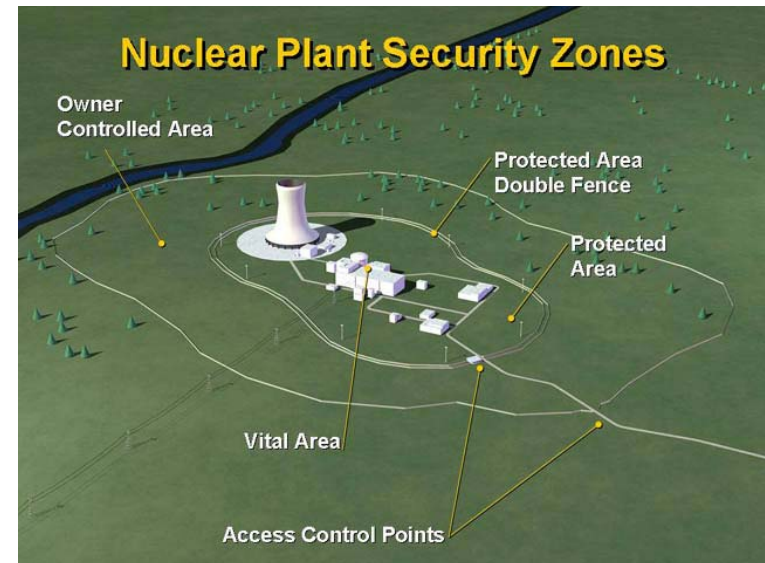
UFD Transportation

- Identify transportation technical data gaps.
- Inventory used fuel to (eventually) be transported, Inventory existing dual-purpose casks.
- Transportation support for storage R&D demonstration project.
 - High burnup issue.
 - Burnup credit for criticality safety.
- Transportation test plan for normal-transport.
- *Canisters for all stored fuel: rational and viable?*



UFD Security

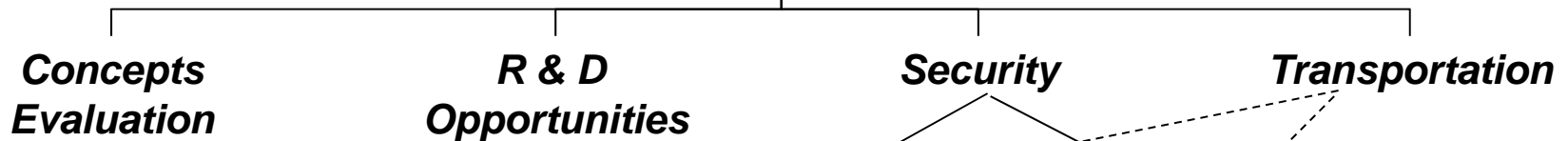
- Identify security issues associated with long-term storage
 - consequences of going below the “spent fuel standard” of 100R/hr at 1m.
- Consider facility security integrated with aspects of cask/fuel design that contribute to security.
- Evaluate long-term impacts of existing regulatory positions relative to security.





Used Fuel Disposition Security Efforts

Technical Bases

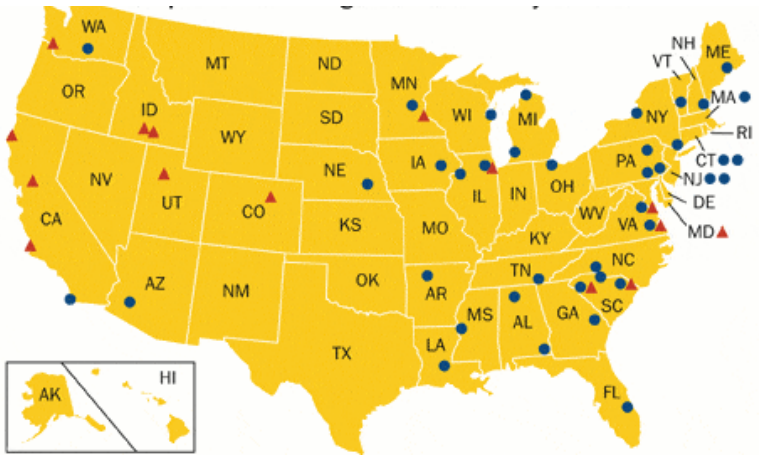


	Radiological Sabotage	Theft
Current	Established protection requirements for irradiated fuel – external dose >100 rem/hr at 3 feet	Not consider a credible threat in NRC design basis threat
VLTS	Fuel will fall below <100 rem/hr in 70 to 120 years (longer for high burn-up fuel)	
Issues	Regulatory gap?	Credible threat?
FY2011 Efforts	Security risk of used fuel storage relative to other targets – recommendations for orphan sites Recommended protections strategies – below self-protection threshold, long-term institutional control	



UFD Concept Evaluation

Potential demonstration project to develop technical basis for extended long-term storage





Current storage of LWR Fuel

- **Surface storage at operating nuclear plants is usually in an ISFSI, licensed by NRC under 10 CFR Part 72.**
- **Commercial UNF in dry storage through March 2009**

	Casks	Assemblies	Metric Tons of Uranium
PWR	776	20,220	8,735
BWR	310	20,147	3,586
Total	1,086	40,367	12,321



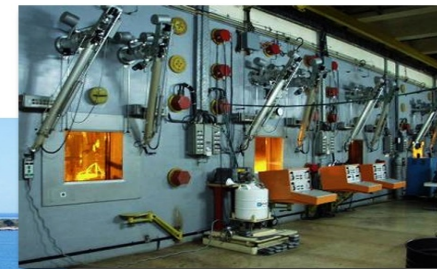
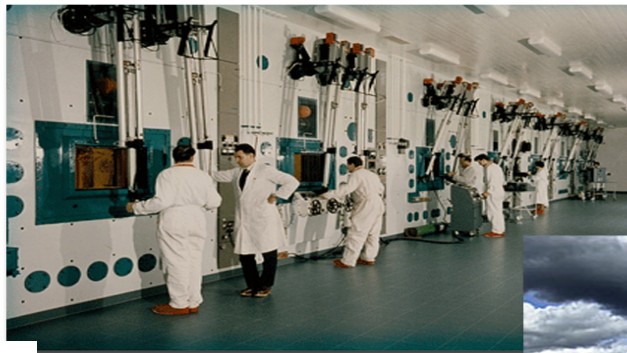
Testing & Evaluation Project

Options under consideration

National Laboratory

Existing ISFSI

Build demo facility





UFD Campaign: Collaborative Activities

- **DOE/NE** : *Program Direction, Management*
 - **DOE/RW, EM**: *Experience from related programs*
 - **National Laboratories**: *Technical support for the Work Packages*

- **Industry**
 - EPRI, NEI, Utilities, Fuel and Cask Systems Suppliers
 - *EPRI Extended Fuel Storage Collaboration Program*
 - *NEI Dry Storage Information Forum*

- **International**
 - BAM (Germany), CRIEPI (Japan), British Energy (UK/France)
 - IAEA
 - INMM, PATRAM

- **Nuclear Regulatory Commission**: *supports collaborative efforts*

Potential Blue Ribbon Commission recommendation?

Issue being evaluated:

- **On-site, Distributed, Centralized Storage**
 - Orphan sites
 - Security
 - Transportation

Draft report due July 2010

UFD Campaign: summary

- **DOE/NE is supporting development of the technical basis for certification of very long term storage of used fuel.**
- **Development of a plan to support experimental data gathering to address gaps in the existing data base,**
- **working with the NRC to properly integrate data needs,**
- **working closely with industry and international partners, and**
- **development of the technical basis documents.**