Overview Presentation on US Nuclear Waste Status

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Outline

- Status of the United States Repository Program
- DOE Used Fuel Disposition Campaign (UFD)
- LBNL’s Clay Disposal R&D Activities within UFD
Nuclear Waste Program Status in the United States

- In 2010, the Obama administration officially withdrew its pending license application for Yucca Mountain.
- A Blue Ribbon Commission was established to review nuclear waste storage, processing and disposal, and just released a draft report providing recommendations for a safe long-term waste solution.
- DOE’s Office of Nuclear Energy (DOE-NE) is now responsible for nuclear waste disposal activities, replacing DOE’s former Office of Civilian Radioactive Waste Management (OCRWM).
- NE nuclear waste activities reside within the newly formed Used Fuel Disposition (UFD) Campaign.
- UFD’s mission is to identify alternatives to Yucca Mountain and conduct research and technology development to enable long-term storage and disposal of used nuclear fuel and wastes.
- To date, no regulatory framework exists for sites other than Yucca Mountain, and only generic (site-independent) disposal R&D can be conducted.
Yucca Mountain
The Never-Ending Story?

- Several lawsuits are still pending charging that DOE had no right to withdraw license application for Yucca Mountain
- NRC has continued its evaluation of the license application, and has recently been forced by congress to release its Safety Evaluation Report (heavily redacted)
- State of Nevada recently forced NRC to restart legal process of license hearings and invitations were sent out before process was stopped
- Political pressure is mounting in congress about the sudden end of the Yucca Mountain license application
- House Committee on Energy and Commerce recently recommended to place $25 M to “continue the Yucca Mountain license application activity”
Blue Ribbon Commission – Key Findings

- The BRC strongly supports mined geologic repositories as the preferred path forward. It also recommends R&D on deep borehole disposal, but its support for this concept appears to be more lukewarm.

- The BRC supports the generic work being done by the Used Fuel Disposition campaign, including research on different geological media and design of better engineered barriers. It also strongly supports subsurface testing in underground research laboratories as an essential component of repository programs. International collaboration is strongly endorsed.

- The BRC supports the “safety case” concept as consisting of much more than a narrow reliance on quantitative PA analyses.

- The BRC suggests that a new approach is needed to site and develop nuclear waste management and disposal facilities in the United States in the future, which would need to be 1) consent-based, (2) transparent, (3) phased, (4) adaptive, (5) standards- and science-based.

- The BRC recommends that waste disposal responsibility is transferred over from DOE to a new private-public entity

- DOE is finalizing a report that describes the departments approach to acting on these recommendations
DOE Used Fuel Disposition Campaign
DOE Office of Nuclear Energy

Fuel Cycle Technologies

Used Fuel Disposition
To achieve its goals and objectives and to provide policymakers the tools to make informed decisions, the FCT program has established five R&D campaigns:

- **Fuel Cycle Options** is developing systematic, transparent, and objective processes to screen and evaluate a wide variety of proposed fuel cycles to identify potential solutions.

- **Advanced Fuels** supports both existing and next-generation reactors by developing accident-tolerant light water reactor fuel and advanced proliferation-resistant fuels for sustainable fuel cycles.

- **Separations and Waste Forms** is developing innovative processes to recover uranium and other materials from UNF while improving proliferation resistance, reducing losses, and minimizing waste. This campaign also seeks transformational breakthroughs in waste forms suitable for geologic repository environments.

- **Used Fuel Disposition** is building the scientific foundation and technology for long-term interim storage, transportation, and permanent disposal of UNF and HLW.

- **Material Protection, Control, and Accountability Technologies** supports security and safeguards by developing tools and techniques to prevent the misuse of nuclear material.
Used Fuel Disposition Campaign Structure

- UFD management coordinates R&D activities of individual national laboratories
- National laboratories are sub-contractors to DOE to conduct specific R&D projects
UFD Campaign Focus: Storage and Transportation R&D

Prepare for extended storage and eventual large-scale transport of used nuclear fuel (UNF) and high-level waste

- Develop the technical basis for:
  - Extended storage of used nuclear fuel
  - Fuel retrievability and transportation after extended storage
  - Transportation of high-burnup used nuclear fuel
UFD Campaign Focus: Disposal R&D

- Provide a sound technical basis for multiple viable disposal options in the US
- Increase confidence in the robustness of generic disposal concepts
- Develop the science and engineering tools needed to support disposal concept implementation
### UFD Disposal Research Activities

**Engineered Barrier Systems (EBS)**
- **NEAR FIELD**
  - **EBS BUFFER**
    - (backfill, liner, seals)
    - [BENTONITE BUFFER]
    - [CLAY, SALT BACKFILL]
    - [DEEP BOREHOLE SEAL]

**Natural Systems Evaluations**
- **FAR FIELD**
  - **GEOSPHERE**
    - Host Rock and Other Geologic Units
    - [GRANITIC ROCKS]
    - [CLAY/SHALE]
    - [SALT]
  - **BIOSPHERE**
    - Surface

**Thermal Load Management & (Repository) Design Concepts**

**Disposal System Environment Modeling**

**SUPPORT, ANALYSIS & EXPERIMENTAL ACTIVITIES**
- **Engineered Materials Performance**
- **Features, Events & Processes**
- **Low Level Waste Disposition Issues**
- **Inventory Projections**

- (corrosion, degradation studies)
- (how R&D is organized and prioritized)
- (part of total nuclear waste consideration)
- (LLW/HLW, used fuel, open to closed fuel cycles)
International Collaborations in Disposal R&D

- Yucca Mountain was so unique with respect to design and geologic environment that overlap with international R&D was quite limited
- With UFD addressing alternative disposal designs and geologic environments, DOE views international collaboration as a very beneficial strategy of advancing R&D
- DOE has formal collaborative R&D with ongoing programs in Europe and Asia

- Mont Terri: International underground research laboratory (URL) in clay in Switzerland
  - Joining the URL gives DOE access to data from all Mont Terri R&D, also the opportunity to conduct new experiments
- Colloid Formation and Migration Project
  - Colloid research at Grimsel granite URL in Switzerland
- DECOVALEX: (Development of Coupled Models and their Validation against Experiments)
  - DOE has participated in the past. New phase of project began Spring 2012
- KAERI Underground Research Tunnel (KURT)
  - Collaborative US/ROK experiments begin in 2013
- Others?
  - SKB Task Forces, MoU
  - ANDRA MoU
  - Clay Club, Salt Club

Major current or soon-to-be started experiments at Mont Terri

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<th>HE-E Heater Test:</th>
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<td>Focus on THM effects, bentonite-rock interaction, seal and clay barrier performance</td>
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<tr>
<td>Micro-tunnel</td>
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<td>Monitoring starts in Spring 2011</td>
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<td>Same location as previous ventilation experiment</td>
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<th>MB (Mine-by) Test:</th>
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<td>Focus on HM effects, EDZ evolution</td>
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<tr>
<td>Full-scale tunnel</td>
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<td>Monitoring phase completed</td>
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<td>Full-scale tunnel</td>
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<td>Monitoring starts in Spring 2012</td>
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<td>Work Plan for R&amp;D Cooperation with KAERI at KURT</td>
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Brief Overview of Ongoing Research Activities at LBNL:

Clay/Shale Repositories
Regional Assessment of US Clay/Shale Formations

- Assessment of geologic/hydrologic criteria for clay/shale host rocks
- Combined with other criteria (societal, land use, population density) in a GIS system developed by Los Alamos National Laboratory

Shale gas plays in the contiguous US (EIA, 2011)

Structure Contour and isopach maps of the New Albany Shale in the Illinois Basin.

Depth and isopach maps of the New Albany Shale, Illinois Basin. Figure produced by LANL from shale data populated into the GIS database.
Clay and Bentonite Diffusion

Diffuse Double Layer

Molecular Dynamics

Reactive Transport Modeling

Diffusion Experiments
- Diffusion cell experiments to characterize the effects of chemical speciation (anion, cation, neutral) on apparent diffusion rates
- Employ synchrotron X-ray spectroscopic and electron-based imaging techniques to evaluate diffusion on scales of microns up to one mm
Disturbed Zone Coupled Processes Modeling

TOUGH2-FLAC3D: Coupled THM

TOUGHREACT: Coupled THC

TOUGHREACT-FLAC3D: Coupled THMC

New constitutive relationships for clay/shale/bentonite behavior
TOUGH-RBSN : Coupled Damage and Flow

- Discrete simulation capability for flow and transport in disturbed zone with mechanistic model stress and damage/healing
- Evaluate continuity of fracture flow and transport paths

Morphology-Based Discrete Damage Models with Rigid-Body Spring Network (Asahina, 2011)

Drying Shrinkage Patterns (Asahina, 2011)

(Asahina et al., 2012)
Fracture Growth and Sealing Experiments

- Image rock properties and fracture growth/sealing during chemical/thermal/stress alteration
- Model THMC processes with TOUGHREACT-FLAC3D and fracture damage codes
- Specific focus on very high temperatures

**Triaxial Loading and Fluid Flow**

**ALS Synchrotron Micro-CT Imaging**