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Fuel Cycle Research and Development

Storage Work Packages Overview
UFD Campaign Meeting
January 28-29, 2010
Albuquerque, New Mexico

Team Members (for now)

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Contents

- **Collaborations**
- **Vision**
- **Work Package Overviews**
  - R&D Opportunities
  - Security
  - Concept Evaluations

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Collaborations

- **DOE offices**
- **Lab**
  - SNL
  - PNL
  - ANL
  - INL
- **Industry and Regulatory**
  - EPRI
  - NRC
- **International**
  - Bundesanstalt fur Materialforschung und –Pruefung (BAM – Berlin)
  - Central Research Institute of Electric Power Industry (CRIEPI – Tokyo)

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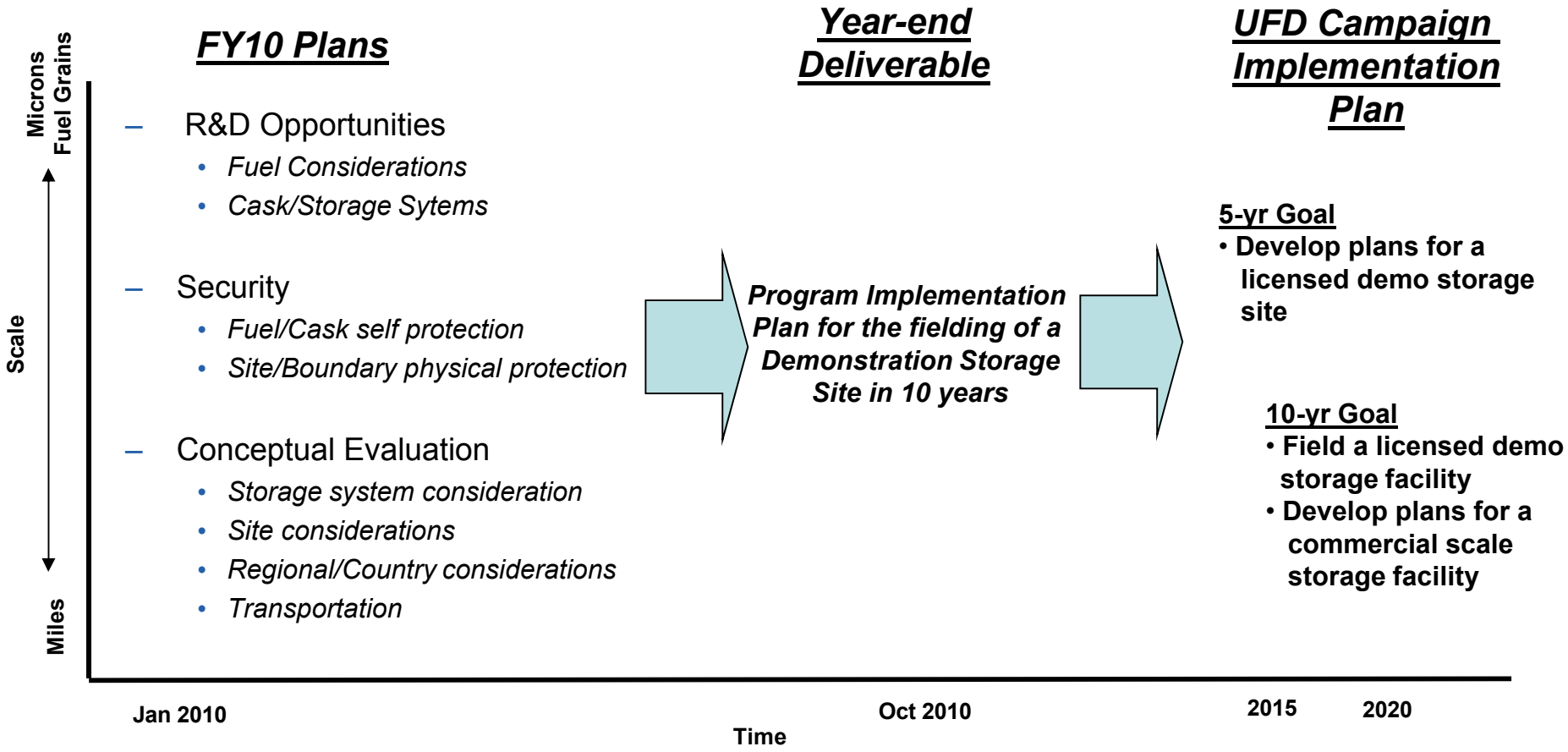
Overview of Storage Work Packages

- **These three WPs are designed to weave together a plan at the end of FY10 that will define a path-forward towards fielding a demonstration storage site**



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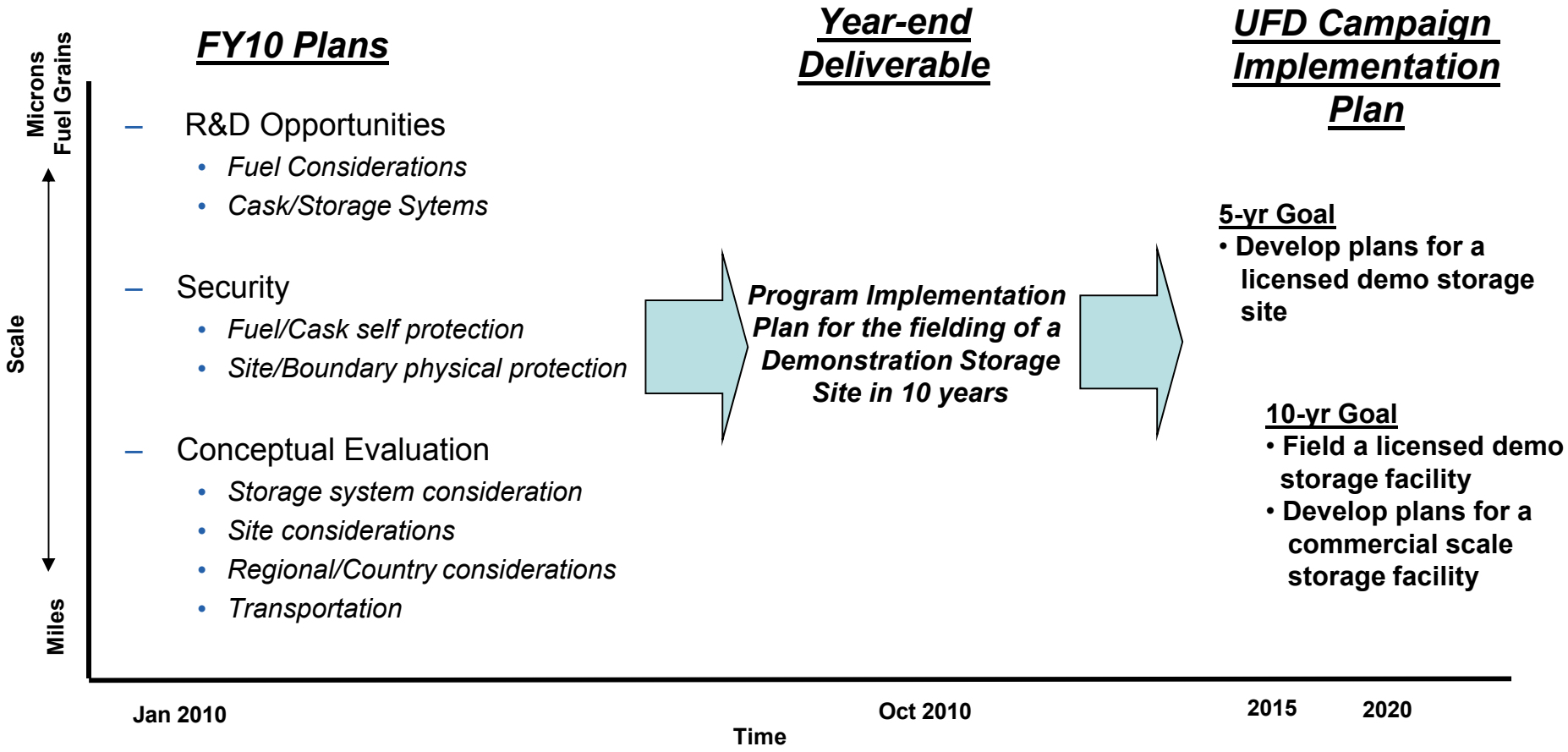

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Fuel Cycle Research and Development

Nuclear Fuel Research and Development Opportunities

Presented by:
James Buelt
Pacific Northwest National Laboratory

Used Fuel Disposition Campaign Working Group
January 28-29, 2010

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Overview of Research and Development Opportunities

- **FY10 activities include**
  - Dry storage of UOX used fuel
    - *Other fuels and materials will be addressed in future studies*
  - Evaluation of the current status of technical issues associated with long-term storage
  - Evaluation of evolving technical and regulatory concerns
  - Development of recommendations for further investigations

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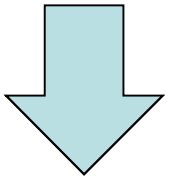
Long Term Storage: Technical Issues

- Issues related to high burnup fuel (>45 GWd/MT)
- Issues related to long term storage (high and low burnup fuel)
- Issues related to retrievability and transportation after storage



- There is no technical basis for licensing low burnup fuel for storage beyond 60 years
- There is no technical basis for licensing high burnup fuel for storage
- There is no technical basis for licensing fuel for transportation after long term storage

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Issues Related to High Burnup Fuel

- **Cladding**
  - Creep
  - Fracture toughness
  - Ductility under impact
  - Hydriding
  - Corrosion
- **Fuel**
  - Fission gas pressure
  - He pressure

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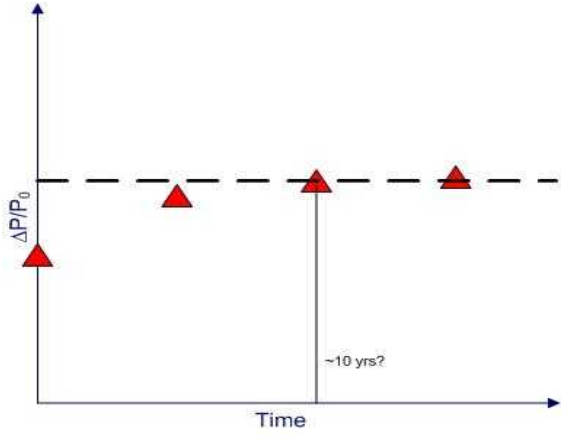
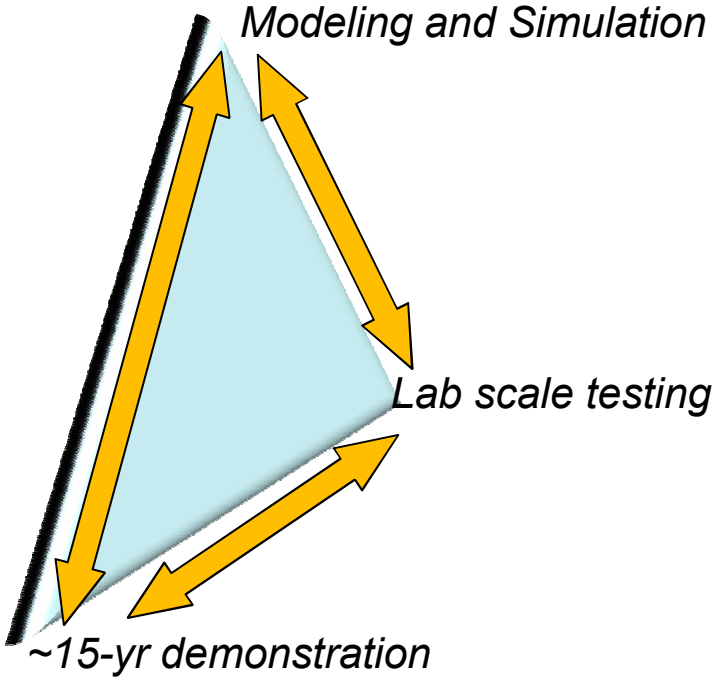
Issues Related to Long Term Storage of High and Low Burnup Fuel

- **Concrete**
  - Calcium leaching
  - Freeze thaw
  - Penetrations
  - Alkali reactions
- **Embedded steel**
  - Corrosion
- **Cladding**
  - Creep rupture
  - External oxidation
  - Stress corrosion cracking
  - Fatigue
  - Clad splitting by UO2 oxidation

Components of an R&D Program

- **Resolve technical issues via a three-pronged approach**
  - Modeling and simulation
    - *Collaboration with NEAMS*
  - Lab scale tests of spent fuel and waste samples
  - ~15-yr demonstration platform
    - *Pre-characterization*
    - *On line monitoring*
    - *Periodic characterization*
    - *Post-characterization*





Potential R&D Activities

- **Modeling and Simulation**
  - Initial conditions to end state as function of burnup
    - *Gas migration*
    - *Phase change behavior*
    - *Changes in cladding properties*
- **Lab Scale Testing**
  - Pre-characterization
  - Destructive examination and testing
  - Accelerated aging
- **~15-yr Demonstration**
  - Remotely instrumented fuel assemblies
    - *Fuel clad temperature*
    - *Clad integrity*
    - *Gas monitoring*

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Fuel Cycle Research and Development

Used Fuel Disposition Storage Security

Presented by:
Felicia A. Durán
Sandia National Laboratories

Used Fuel Disposition Campaign Working Group
January 28-29, 2010

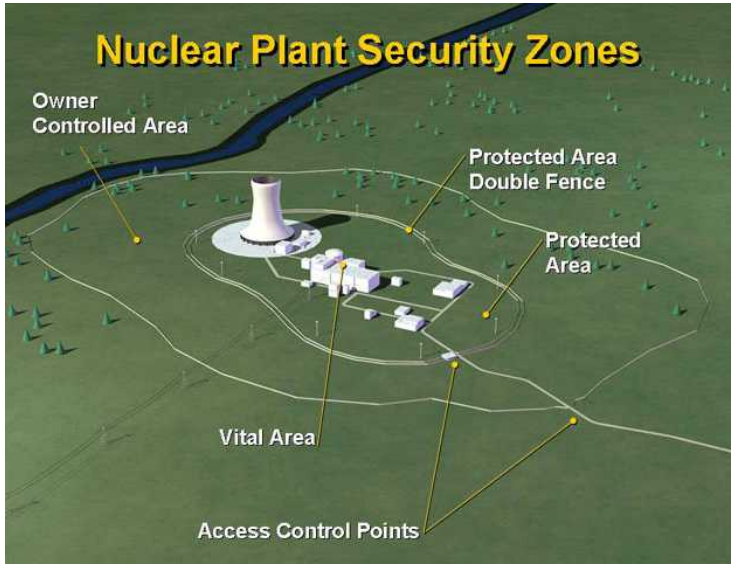
Overview of UFD Storage Security

- **Storage security for UOX used fuel addressed in this study**
  - Other fuels and materials will be addressed in future studies

- **Topic areas addressed in the work packages**
  - Review of security regulations and evaluation of their long-term impacts
  - Identification of security issues associated with long-term storage
  - Evaluation of systems for protecting and securing used fuel
  - Consideration of integrated aspects of security; i.e., facility security integrated with aspects of cask/fuel design that contribute to security
  - Development of recommendations for further investigations

Regulatory Review

- **NRC security regulations in 10 CFR 73**
  - Requirements in 10 CFR 73.51 for the physical protection of stored spent nuclear fuel and high-level radioactive waste
    - *Applicable to commercial facilities – ISFSIs and MRSs*
    - *Physical protection system to provide high assurance that activities do not constitute unreasonable risk to public health and safety*
  - Standard Review Plans, NUREGs, Regulatory Guidance
  - Applicable ongoing Rulemaking activities
- **DOE security requirements in DOE M 470.4-2A**
  - Physical protection requirements for DOE facilities
- **NRC Design Basis Threat and DOE Graded Security Protection Policy**



Issues to be Address

- **Maintaining security for very long term**
  - How does the threat (sabotage, theft) evolve over a longer time frame?
    - *Definition of threat over longer time frame*
  - Do security protections change for different concepts?
  - How do the self-protection and material attractiveness change over time and how could this impact the threat and level of protection measures?
    - *Differences in NRC and DOE categorization of materials*
  - How can we improve over all system integration?
    - *Facility protection measures integrated with aspects of cask/fuel design that contribute to security*
    - *Integration of operational activities (monitoring and institutional control)*
    - *Integration of security issues for different concepts*
    - *Identification of "intrinsically secure" system features of storage options – beneficial security characteristics that are inherent options and can be leveraged to enhance security with minimal or no additional cost*

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Options for Storage Security Design and Evaluation

- **Possible options to develop and evaluate security designs for very-long term storage**
  - NRC High Assurance Process
    - *Optional process for new reactor security assessments*
  - DOE Graded Security Protection implementation
    - *Explicitly considers undesired consequences*
    - *Includes identifying measures to mitigate consequences*
    - *Applies protection measures in a graded approach*
  - Intrinsic Security Methodology
    - *Addresses mission, consequences, and concept of operations*
    - *Applies measures to both reduce consequences and increase difficulty of attack*
    - *Identifies intrinsic security principles*
  - For all three options, analysis and assessment methods and tools are similar
    - *DEPO (Design and Evaluation Process Outline), ATLAS, new integrated path analysis method, others*

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Path Forward

- **Regulatory review, identification of issues, proposed assessment options**
- **Interim security assessment for storage options**
- **Deliverables for SNL and PNNL work packages**
  - Interim Report on Secure Storage Options for UOX Used Fuel due February 28, 2010
  - Report on Interim Storage Security Assessment for Storage Options dur September 10, 2010
- **Integration with other UFD storage work packages for Program Implementation Plan of 5-year and 10-year goals**

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Conceptual Evaluation Overview

Presented by:
Ruth Weiner
Sandia National Laboratories

Used Fuel Disposition Campaign Meeting
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Albuquerque, New Mexico

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Contents

- Goals and Objectives
- Issues
- Scenario Development
- Path Forward

Goal and Objectives

Goal

- This work package will integrate work from the R&D and Security Work Packages to develop a Very Long Term Storage (VLTS) demonstration facility Implementation Plan by the end of FY10.

Objectives

- Identify a spectrum of potential scenarios that span the range of possibilities for fielding a very long term storage demonstration facility in 10 years.
- Evaluate scenarios against an identified set of criteria to identify the best options for a demo facility.
- Select highest potential scenario for moving forward on the Implementation Plan

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Issues (not inclusive)

Fuel:
- *Type – e.g., high burnup (informed from the R&D WP)*
- *Availability of PIE facilities*

Dry Storage System:
- *NRC certified*
- *Accessibility to fuel*
- *Specific long-term storage issues (informed by the R&D WP)*

Site:
- *Existing v. New*
- *DOE v. Private*
- *Security framework (informed from the Security WP)*

Licensing:
- *DOE v NRC license*
- *Impact of NWPA constraints*

Transportation:
- *Degree of transportation involved*
- *Security framework (informed from the Security WP)*

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Demo Facility Scenarios Span of Possibilities

BASELINE: "Do Nothing"

Use existing cask with existing fuel, get data as feasible

DEMONSTRATION FACILITY

Initial conditions for demonstration

- PIE of a variety of pins
- Determine initial conditions of fuel going into dry storage
- Identify fuel types for inclusion in demonstration

1. **Current policy (commercial site)**
   - Conduct directed PIE on select fuel
   - Evaluate degradation of existing concrete systems
   - Evaluate existing security systems
   - Limited transportation (for PIE to a DOE facility)
   - Identify disposition path for fuel
   - PIE at existing DOE facilities
   - DOE R&D cask
2. **Demo at existing commercial (ISFSI) facility**
   - Bring in intra-utility fuel (e.g., utility orphaned fuel)
   - All under #1
3. **Demo at existing licensed DOE facility (Hanford, INL, SRS)**
   - Expand materials to evaluate (e.g., HLW)
   - Transport candidate fuels to site
   - All under #2
4. **Demo at a new facility**
   - All under #3
   - Siting and licensing

EVALUATION CRITERIA

Transportation
Cost
Breadth of testing
Variety of fuel types
Accessibility to fuel
Site selection and acceptance
Licensing
Disposition pathways for test products
Security

PAST EXPERIENCE

EPRI Tech Rpt 1007872 (Sept 2003) describes a planning methodology with a similar breakdown of scensrios.

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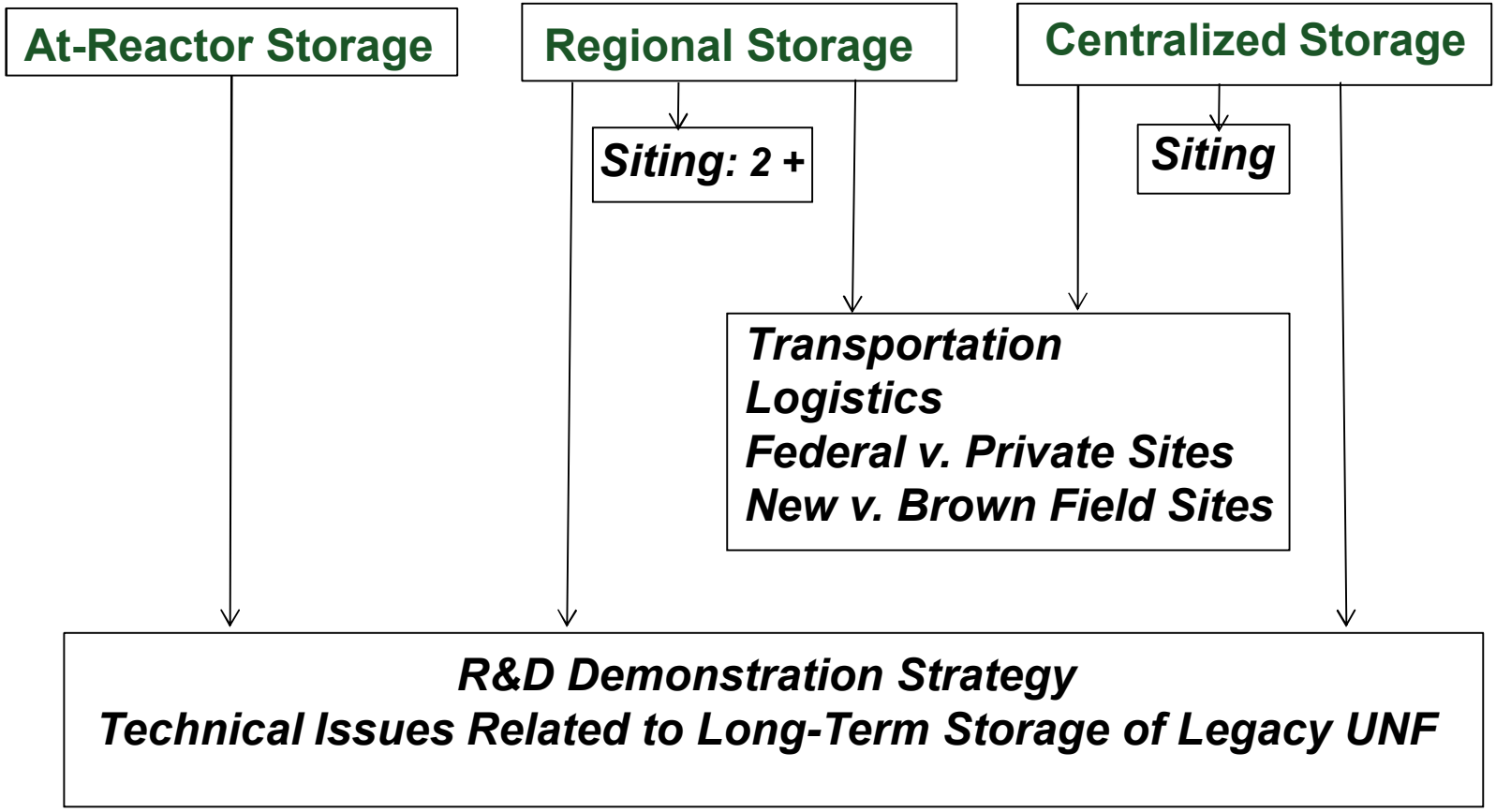
Issues for Centralized and Decentralized Storage



Past Storage Efforts

1. GE Morris

- Only away-from-reactor pool storage, originally licensed in 1982
- One 20 year license extension to 2022; first NRC storage site license extension

2. Nuclear Waste Negotiator

- Independent agency created under the NWPA: 1987 – 1995
- Chartered to site and store spent nuclear fuel
- Eventually unsuccessful

3. INL Dry Cask Storage Characterization Project

- Demo program to characterize long term storage behavior of low burnup fuels
- Joint program sponsored by DOE, NRC, and EPRI
- Program lasted 4 years; 1999 – 2002

4. Private Fuel Storage (PFS)

- Utility consortia to regionally store up to 44,000 MTU used fuel in Utah
- NRC licensed in Feb 2006 for 20 years
- Dept of Interior denied land lease in Sept 2006
- Law suit filed by PFS in 2007

5. On-site storage

- Current practice
- Dry cask storage is becoming the standard

History of Storage Efforts

Recent Events – What's Changed?

1. **Decision not to dispose fuel at Yucca Mtn**
   - Store-in place until alternative fuel cycle options are evaluated
   - Evaluate better disposal alternatives

1. **November GAO Report**
   - Evaluates centralized and regional storage compared with current practice
   - Conclusions generally favorable to centralized storage

2. **Public opinion on nuclear energy generation**
   - Although public fears regarding nuclear energy remain,there is greater appreciation for its benefits.

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Conclusions

1. **Based on initial collaboration with industry and regulators, a basis of technical and security issues have been identified.**

2. **A plan is being developed to address these issues.**

3. **Significant investment of resources needed to address these issues**

4. **Collaboration with industry, regulators, and international organizations will be sought and continued.**

The decision not to pursue Yucca Mountain and to rely on very long term storage makes these investigations critical.