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Fuel Cycle Research and Development

Used Fuel Storage Security

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Used Fuel Disposition Campaign

- **U.S. Department of Energy Office of Nuclear Energy**
  - Fuel Cycle Research and Development Program
- **Used Fuel Disposition Campaign**
  - Identify alternatives and conduct scientific research and technology development to enable storage and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles
- **Used Fuel Storage**
  - R&D Opportunities
  - Security
  - Concepts Evaluation
- **Near-term focus is on dry storage of commercial LWR fuel**

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Used Fuel Storage Context

- **Policy**
  - Decision to cancel Yucca Mountain
  - Need to store used fuel for the foreseeable future (300 years)
- **Issues**
  - Long-term dry storage of used fuel can be certified only up to 60 years
  - Transport of used fuel after long term storage
  - Storage and transportation of high burn-up fuel (> 45 GWD/MTU)
  - Long-term security
- **Consequences**
  - Technical bases needed for licensing very long-term storage and transportation
    - *Used fuel dry storage beyond 60 years*
    - *Transport of used fuel after long-term storage*
    - *Storage and transport of high burn-up fuel*

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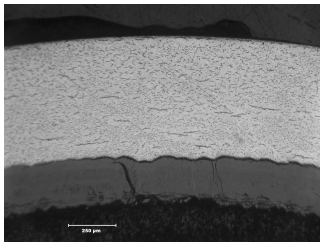
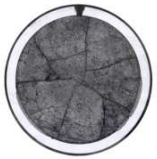
Addressing Consequences

- **R&D Opportunities**
  - Data gap analysis
  - Plan to address gaps
  - Development of technical basis
- **Security**
  - Regulatory analysis
  - Identify issues relevant to long-term storage
    - *e.g., self-protection attribute – focus of this presentation*
  - Assessments of gaps and improvements
  - Recommended protection measures
- **Conceptual Evaluations**
  - Process for development of technical basis
  - Evaluation of scenarios for decision makers





UFD Storage Implementation Plan Goals

- **1 yr: Develop project implementation process**
- **5 yr: Project Implementation Plan & Development of Technical Basis**
- **10 yr: Field used fuel storage system project**

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Self-protection for Spent Fuel

- **Within the Nuclear Regulatory Commission (NRC) regulations for Physical Protection of Plants and Materials (10 CFR 73), "self-protection" is a characteristic attributed to Special Nuclear Material (SNM)**
  - "which is not readily separable from other radioactive material and which has a total external radiation dose rate in excess of 100 rems per hour at a distance of 3 feet from any accessible surface without intervening shielding"
- **DOE material types have similar attribute for highly radioactive SNM**
  - "unshielded, emit a radiation dose measured at 1 meter that exceeds 100 rem/hour"
  - DOE material categorization for commercial used fuel would be Attractiveness Level E (all other materials – highly irradiated forms), Category IV

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Self-protection for Spent Fuel

- **Most commercial spent nuclear fuel (SNF) is considered self-protecting**
  - High radioactivity makes it extremely dangerous to handle
  - For fuel that has cooled for 15 years, a lethal dose (LD50/30) of 450 rem would be received at 3 feet after about several minutes (Lloyd et al., 1994)
  - More recent ORNL study (Coates et al., 2005) for research and test reactor spent fuel looks at radiation effects on personnel performance capability – incapacitation that prevents exposed individual from completing intended task
    - *"a dose rate of 10,000 rad/hr (100 Gy/hr) at 1 m was determined to be the level that significantly affected performance of the perpetrator and offered limited self-protection (in the range of minutes)"*

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Self-protection of Used Fuel

- **Dose rate calculations**
  - Previous calculations extended to 200 years – dose falls below 100 rem/hr at about 100 years for BWR fuel and between 120 to 150 years for PWR fuel
  - New calculations indicate used fuel falls below current threshold after about 70 years
  - Increases with increasing burn-up
  - After about 20-30 years, tracks with Cs-137 decay
- **"Self-Protection" in today's world**
  - Regulations were written prior to 9/11 events
  - NRC is engaged in discussions looking at the validity of the current thresholds and is considering raising the standard.
  - Used fuel stored for extended periods of time will go below the higher thresholds earlier

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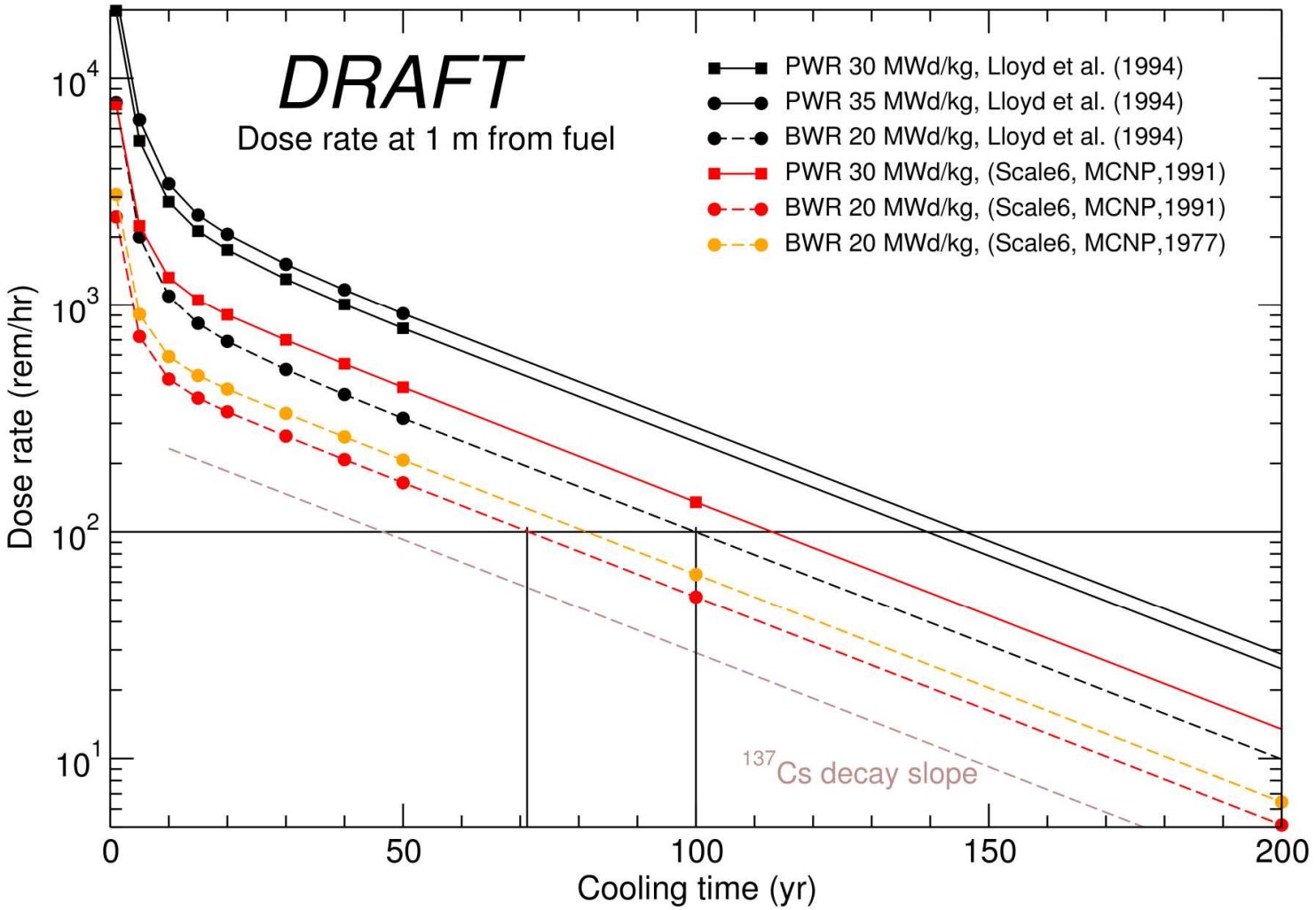
Preliminary Results - Dose Rates for PWR/BWR Low Burn-up Fuels



Dose calculations by Richard Wittman, Brady Hanson, and Amy Cassellas, Pacific Northwest National Laboratory

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Issues for Self-protection for Very Long-Term Storage

- **Issues for current level for self-protection**
  - Because of self-protection, only radiological sabotage is a concern
    - *Protection goal for physical protection is to protect against loss of control of the facility that could be sufficient to cause radiation exposure in excess of specified dose limits*
  - Is 100 rem/hr [equivalent to 100 rad/hr (1 Gy/hr) absorbed dose] the level of self-protection that is needed for VLTS of used fuel?
    - *ORNL Study concludes "that for research reactor spent fuel, self-protection from a committed terrorist does not exist" at the current level*
    - *Early onset (within minutes) of incapacitation appears to occur in all exposed individuals at levels of 2500 rad (25 Gy) and above*
    - *Follow-up study (Coates and Broadhead, 2007) on power reactor spent fuel (PWR, BWR, MOX PWR, and VVER) indicates activity stays near 10,000 rad/hr (100 Gy/hr) at 0.2 m for a period of 10 years*

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Ongoing Used Fuel Storage Security Activities

- **Comparison of NRC and DOE regulations applicable to very long term storage of used fuel**
  - Material categorization
  - Type of security area
- **Regulatory framework for different options of used fuel storage system project**
  - NRC and/or DOE sites
  - Security criteria for concepts evaluation
  - Possible impacts of current NRC rulemaking
- **Security assessment methodologies**
  - Identify and address gaps
  - Opportunity to improve performance
  - Recommended protection measures