# Overview of National Academy of Sciences Reports on Nuclear Waste Transport, Storage, and Disposal

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# Outline

- Background
- Key NAS Reports
- Report Messages Relevant to the BRC's Scope
- Concluding Thoughts

# Background

- NAS has been performing studies on radioactive waste management and related issues since the mid 1950s
- To date, over 140 reports have been issued on technical, economic, regulatory, and social aspects of radioactive waste management:
  - Processing
  - Storage
  - Transportation
  - Disposal, including site selection
  - International and “systems” issues

# Key NAS Reports

- The Biological Effects of Atomic Radiation (1956)
- Rethinking High-Level Radioactive Waste Disposal (1990)
- Nuclear Wastes: Technologies for Separations and Transmutation (1996)
- Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges (2001)
- One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste (2003)
- Going the Distance: The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States (2006a)
- Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report (2006b)
- Review of DOE's Nuclear Energy Research and Development Program (2008)
- America's Energy Future: Technology and Transformation (2009a)
- Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges (2009b)

# The Biological Effects of Atomic Radiation (1956)

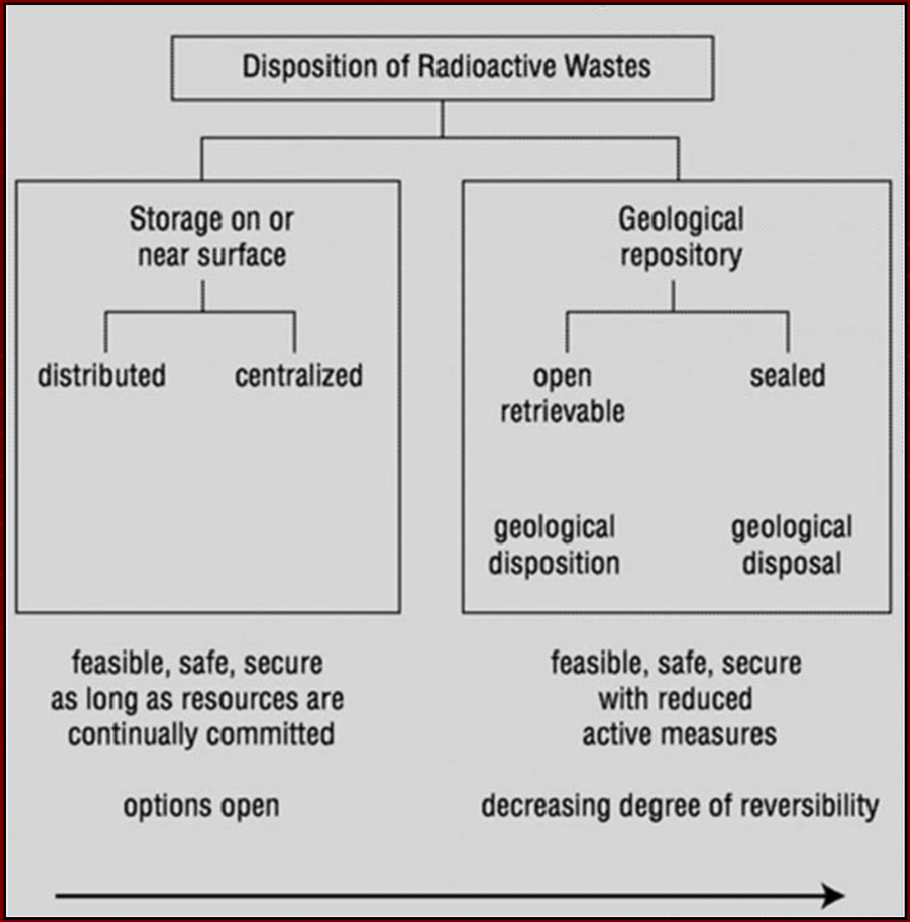
Two report messages are still relevant today:

"From a technological standpoint the highly radioactive wastes resulting from the processing of reactor fuels constitute the bulk of the problem. To date essentially none of those wastes has been disposed of …."

"Research and development have indicated possible feasible systems for ultimate controlled disposal of highly radioactive wastes, but considerably more work is required to bring these systems to the point of economic operating reality."

# SNF/HLW Disposition Options

- Monitored storage
- Geological disposition




- Disposition: Active management; reversibility; future options open
- Disposal: End to need for active management; decreasing degree of reversibility
- Transitioning from disposition to disposal may take decades to a century or more

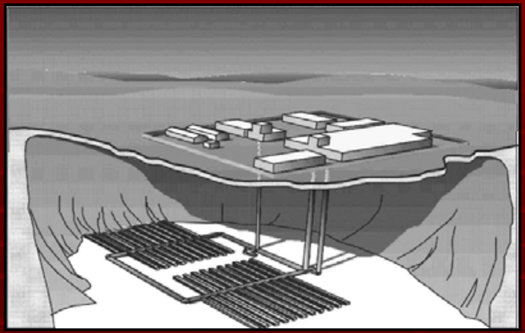
# U.S. Repository Development Program

DOE

- The U.S. program, as conceived and implemented over the last decade (1980-1990), is unlikely to succeed
- The U.S. program is characterized by a high degree of inflexibility with respect to schedule and technical specifications
- A more <u>flexible</u> and <u>experimental</u> approach for repository development is needed because:
  - Surprises are inevitable in these “first-of-a-kind” projects
  - Repository designs may need to be changed in response to new information
- Congress should reconsider the rigid, inflexible schedule embodied in the Nuclear Waste Policy Act and the 1987 amendments

(NAS, 1990)

# Geological Disposal



- There is a worldwide scientific consensus that deep geological disposal is the best option for disposing of SNF/HLW
- Whether, when, and how to move toward geological disposal are societal decisions for each country—the decision process will be lengthy, and the time can be used to improve both the technical and societal bases for decisions
- The biggest challenges to geological disposal/disposition are societal, not technical
- A management system that is flexible, responsive to surprises, capable of midcourse corrections, and effective in its interactions with concerned segments of the public has the greatest probability of success

(NAS 1990, 2001)

# Metrics for a Successful Program

- A technically suitable geologic site and engineered system have been identified using accepted regulatory, public, and political processes
- Operational and long-term safety plans for the repository are consistent with current scientific understanding
- Sufficient societal consensus is achieved to begin repository operations
- Initial waste emplacement has taken place with plans for reversibility
- Necessary measures are set up to emplace additional waste, if decided
- Procedures and funding arrangements are agreed to for either:
  - Backfilling and sealing the repository if there is consensus to do so
  - Maintaining the capability for long-term control and monitoring and for retrieval of wastes if necessary

(NAS 2003)

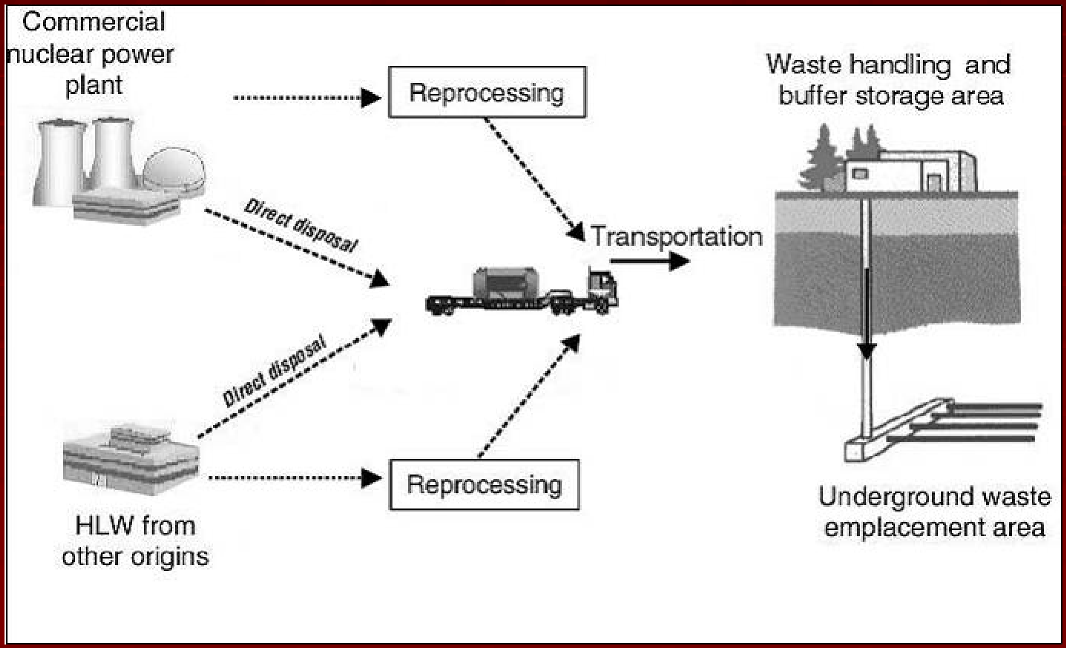
# One Way Forward: Adaptive Staging


- Adaptive Staging: A cautious and deliberate decision making process that focuses on the iteration of a *safety case*—that is, the integrated collection of arguments that the implementer produces to demonstrate the safety of the repository to all interested parties

- Some attributes:
  - Commitment to systematic learning
  - Seeks and is responsive to stakeholder input
  - Flexibility to re-evaluate earlier decisions and reverse course if warranted
  - Complete documentation of the basis for decisions

(NAS 2003)

# Other Back-End Elements of the Nuclear Fuel Cycle




- Storage
- Transportation
- Reprocessing

# Storage

- Options
  - Wet storage in water-filled pools
  - Dry storage in air-cooled casks
- Safe and secure surface storage is technically feasible as long as those responsible for it are willing and able to devote adequate resources and attention
- The major uncertainty is in the confidence that future societies will continue to monitor and maintain such facilities

(NAS 2001)

NEI

Southern Company

- It is not prudent to pursue storage without development of the geological disposal option unless a society believes that it can credibly commit to permanent maintenance of its storage facilities (NAS 2001)

# Transportation

- There are no fundamental technical barriers to the safe transport of SNF/HLW in the United States
- Radiological health and safety risks associated with transportation are well understood and generally low, with the possible exception of risks from releases involving long-duration, fully engulfing fires


Sandia

- There are a number of societal and institutional challenges to the initial implementation of large-quantity shipping programs
- Malevolent acts against spent fuel and HLW shipments are a major technical and societal concern

(NAS 2006a)

# Transportation (2)

Selected recommendations :

- An independent examination of the security of SNF/HLW shipments should be carried out prior to the commencement of large-quantity shipments to a federal repository or to interim storage
- DOE should negotiate with commercial spent fuel owners to ship older fuel first to a federal repository or federal interim storage
- The Secretary and Energy and U.S. Congress should examine options for changing the organizational structure of the Department of Energy's program for transporting SNF/HLW to a federal repository…. Whatever structure is selected, the organization should place a strong emphasis on operational safety and reliability and should be responsive to social concerns

NAS (2006b)

# Reprocessing/Recycling

- The domestic need for waste management, security, and fuel supply is not great enough to justify the early deployment of commercial-scale reprocessing and fast reactor facilities
- Any closed fuel cycle based on current designs is likely to be more expensive and to result in more proliferation risk than a once-through fuel cycle
- Recycling does not appear to be a promising option for commercialization in the United States before 2035
- A continuing R&D program on alternative fuel cycles is justified as there may be a need for such technologies in the future
- No recycling technology completely eliminates the needs for disposal facilities

NAS (1996, 2008, 2009a)

# International Considerations

- The international community should help countries provide adequate capacity for safely storing spent fuel or obtain reliable reprocessing services from existing providers to reduce countries' incentives to establish their own reprocessing facilities
- The United States, Russia, and other suppliers should increase their emphasis on establishing mechanisms for assured fuel-leasing and reactor-leasing services, including take-back of all irradiated fuel

(NAS 2009b)

# Concluding Thoughts

- Storage, transport, and disposal of SNF/HLW have technical and societal dimensions
- The primary focus of U.S. efforts to date has been on technical dimensions--societal dimensions need attention going forward
- Flexible, transparent, and stepwise processes could help lead to the development of the necessary societal consensus to move forward
- It will likely take a great deal of time (several decades) to develop and execute a new SNF/HLW management strategy in the United States
- Important lessons can be learned from other national programs