HLW Disposal Project and Social Scientific Expertise: Based on the Experiences in US

Joonhong Ahn
Department of Nuclear Engineering
University of California, Berkeley

Session 184: The Path-Finding Process for Nuclear Waste Disposal
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The Society for Social Studies of Science
4:00 – 6:00 pm, October 31, 2009, Washington DC,
Hyatt Regency Crystal City
Contents

● Past and current
  – Huge quantities and wide variety
  – Environmental contamination and remediation
  – Technological developments
  – Active public discussions
● Discussion points
  – Performance assessment for long-term safety
  – Ethical aspects
  – Public communications and decision making
● Approach from Engineering education at Universities
● Conclusion
Current status of US Nuclear Wastes (1)

- Huge quantities and wide variety
  - Civilian: DOE-RW -- NWTRB
    » Commercial spent nuclear fuels
  - Defense: DOE-EM -- DNFSB
    » Legacy wastes from weapons production (Hanford, Idaho, Savannah River)
    » Spent fuels from DOE and naval reactors

- Environmental contamination and remediation
- Technological developments
- Active public discussions
Spent Fuel Accumulation in US

Projection of Spent Fuel Discharges as of September 1999

- Actual discharges, all reactors
- Projected discharges, all reactors, no license renewals
- Actual discharges, shutdown reactors
- Projected discharges, shutdown reactors, no license renewals
- Projected discharges, all reactors (YMR Case)
  Half of reactors' licenses extended by 20 years

Source: OCRWM projections, based on EIA historical data.
No new orders

- Total discharged: ~38,000 MTUs from 118 reactors
- Of total discharged, ~3,800 MTUs are at 14 shutdown reactors

YMR capacity

September 2007

As of September 1999
DOE-EM Life cycle cost estimate

For current EM Scope

- $274B -- $330B: Environmental liability
  » $205B -- $260B: Remaining EM work scope
  » $68B: 1997 – 2007

- 306 surplus facilities
- 34 types of materials
- Footprint reduction

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Current status of US Nuclear Wastes (2)

- Huge quantities and wide variety
- Environmental contamination and remediation
  - Hanford, Idaho, and Savannah River
- Technological developments
  - Repositories
    - WIPP and related TRU waste treatment and transportation systems at the generation locations
    - Yucca
  - Fuel cycle: ATW – AAA – AFCI – GNEP
- Active public discussions
Hanford site for defense HLW

- Hanford Site, Washington, began producing plutonium in 1944; produced most U.S. Pu.
- Spanning over 584 square miles, the Site currently stores 53 million gallons of waste in 177 underground tanks.
- More than one million gallons of waste have leaked from these tanks into the surrounding soil and groundwater. The Hanford tank farms are just seven miles south of the Columbia river.
- The government is now building a plant at Hanford to treat and stably store these 53 million gallons of waste. It is the largest civil construction project in the U.S.
Buried Waste in the Subsurface Disposal Area in Idaho (Past Disposal Practice)
Yucca Mountain Repository

63,000 MTHM for CSNF
7,000 MTHM for Defense wastes
4,500 MTHM equivalent HLW
2,500 MTHM SNF (15 categories)
Waste package located in WIPP

Inside the package
Current status of US Nuclear Wastes (3)

- Huge quantities and wide variety
- Environmental contamination and remediation
- Technological developments
- Active public discussions
  - Establishment and revisions of national policies, regulations, and R&D programs
  - Leading roles of National Academies
  - Long discussions on direct disposal vs. recycle
  - “Blue Ribbon” commission?
U.S. Radioactive Waste Management History

1957 - NAS Committee recommends:
- geologic disposal, particularly in salt formations
- development of processes to solidify waste liquids
- 1957-72 -- Abandoned salt mine near Lyons, Kansas investigated.
  » Public opposition led to cancellation of this project.

The Waste Isolation Pilot Plant (WIPP) authorized by Congress in 1980
- Disposal of TRU waste; bedded salt, ~ 650 m deep, in southeastern New Mexico
- Construction began in 1981
- First disposal of waste occurred in 1999.
U.S. Radioactive Waste Management History

- **Nuclear Waste Policy Act of 1982**
  - Spent fuel and HLW to go to a geologic repository.
  - Process to select 3 sites for characterization defined.
  - Process to identify candidates for 2nd repository initiated.

- **Nuclear Waste Policy Act Amendments of 1987**
  - Yucca Mountain selected by Congress as only site for characterization.

  - Recommendations by National Academies in 1995

- **The Yucca Mountain Project** submitted a license application to construct and operate the repository to the USNRC in June 2008. USNRC docketed it in September 2008.
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1982 Nuclear Waste Policy Act

- Set the schedule for siting 2 repositories.
- EPA was charged with issuing generally applicable limits on radioactivity releases to the environment. (40CFR191)
- NRC was directed to develop regulations and criteria for construction, operation, and closure. (10CFR60)
- 9 sites —> 5 sites —> 3 sites
  - Deaf Smith, Hanford, Yucca Mountain
  - Ranking system put Yucca Mountain and Hanford 4th and 5th on post-closure performance.
- Repository capacity (70,000 metric ton) set and measured by initial mass of heavy metal.
- Requires DOE to begin to accept waste in 1998.
1982 Waste Act Policy Objectives

- Utility industry wanted early demonstration of feasibility of permanent disposal, to remove this major obstacle to expanded use of nuclear power.

- Philosophy – we benefited from the activity that produced the wastes, so we should deal with them. Fee on nuclear generated power to pay for disposal program.

- Although not in the 1982 Act, environmental groups and Carter administration wanted:
  - to assure that U.S. spent fuel would not be reprocessed
  - early disposal of spent fuel to avoid proliferation risk associated with spent fuel plutonium content
NWPA Amendment Act (1987)

- Only Yucca Mountain be characterized to evaluate its suitability as a repository.
  - No site-specific work for a second repository.
- Nullified the DOE proposal for Monitored Retrievable System at the Clinch River, TN.
- Site Characterization Plan for YM (1988)
- Subseabed program also halted.

- Mandated a separate process for setting a standard specifically for YMR.
  - 40CFR197 by US EPA
  - 10CFR63 by US NRC

- Required EPA to arrange for an analysis by National Academy of Sciences (NAS).
  - Can scientifically justifiable analyses of repository behavior over many thousands of years in the future be made?
Recommendations by NAS (1995)

- **Denial of release limits, i.e., 1000 incremental fatalities over 10,000 years**
  - The use of a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository is recommended.
  - The critical-group approach should be used.

- **Extension of time frame from 10,000 yr to a million yr**
  - The compliance with the standard measured at the time of peak risk, within the limits imposed by the long-term stability of the geologic environment, which is of the order of one million years.

- **Denial of risk-based calculation of the adverse effect of human intrusion into the repository**
  - The consequence of an intrusion should be calculated to assess the resilience of the repository to intrusion.
US Reprocessing Policy

- Early plans for commercial nuclear power assumed that spent fuel would (eventually) be reprocessed and recycled.
  - GE received license to build Morris, IL reprocessing plant in 1967 but decides not to operate it in 1972.
  - Barnwell construction begun in 1970, but halted based on commercial impracticality.

- Based on proliferation concerns, deferral of reprocessing began under President Ford in 1976 and was established as a permanent ban in 1977 by President Carter.
  - In 1981, indefinite ban lifted by President Reagan.
  - In 1992, President G.H.W. Bush disapproved Long Island Power Authority’s attempt to contract with Cogema to reprocess the slightly irradiated initial core from the Shoreham reactor.
US Reprocessing Policy

Since 2001, work on closing the fuel cycle has been conducted through DOE’s Advanced Fuel Cycle Initiative and Global Nuclear Energy Partnership.

- Integral Fast Reactor (IFR) (1984~1994) - ANL
- Accelerator Driven Transmutation of Wastes (ATW) (1999~)

Internationally,

- U.S. example was not persuasive to Europeans or Japanese, while economics of reprocessing appear to be unattractive, even with substantial increases in uranium prices.
Objectives of Waste Management and Fuel Cycle -- Then

Fuel Cycle

- Uranium availability was assumed limited; breeder reactors would be used to extend that supply.
- Proliferation concerns lead the Ford and Carter Administrations to cancel plants for reprocessing and seek to persuade other countries to forgo reprocessing.

Need for early disposal

- Demonstration of disposal seen by the industry as necessary for existing nuclear power plants could continue operating and for life extension.
- to avoid spent fuel proliferation risk

Obligation of current generation

- To dispose of wastes so future generations would not have to deal with them and to take away the reprocessing option
Considerations on Waste Management and Fuel Cycle -- Now

Fuel Cycle

- DOE GNEP pursues a concept for reprocessing spent fuel and building fast burner reactors to reduce volume of waste that would need to go to a repository.
  - Extending the uranium supply is not an objective.
- Reprocessing and actinide-burning in fast reactors could cost more than expanding repository capacity(?)

Need for early disposal

- perhaps not essential given success of dry cask storage.
- spent fuel sets the global standard for security of fissionable materials
- Planned capacity of Yucca Mountain insufficient to handle projected spent fuel and HLW inventory

Obligation of current generation

- to manage safely while preserving options for future generations
Retrievability/Ability to Modify Facility

- **Retrievability desirable if:**
  - understanding of repository performance changes and weaknesses identified
  - Innovations occur in waste treatment, packaging, or repository design
  - reprocessing becomes desirable
- **Retrievability undesirable if permanent removal of nuclear materials sought**
Discussion points

- **Performance assessment for long-term safety**
  - Not “Prediction”; therefore, “validation” in rigid meanings is not required.
  - Interpretation of results is highly abstracted and stylized. How can we use this as a basis or tool for public decision making? Or is it possible at all?

- **Ethical aspects**
  - Responsibility for future generation
    » “We generate this waste, and so we should solve this problem.”
    » “If we do not do this now, choices for future generation will be limited.”
    » “We should reserve oil for future generations.”
  - Equity, humility and charity
    » Repository siting
    » “We should reserve oil (and carbon footprint) for emerging developing countries.”
    » “Users group” vs. “Suppliers group”

- **Role of engineers and scientists in public decision making**
  - Offer technical options. (For this, they need to be good listeners before evangelists.)
  - Help the public understand and make decisions.
Yucca Mountain Doses Projected to 1,000,000 Years

Source: Draft Supplemental EIS, October 2007
Approach from Engineering education at Universities
(Traditional) Nuclear engineers’ view and belief

- Nuclear energy is important and beneficial for our lives and society.
- While there are difficulties, with more research and development of technologies, we can overcome such difficulties.
- However, due to public’s biased understanding, it takes unnecessarily long time to make ‘social decision’. Sometimes, we have to give up plans that we believe are really beneficial for the society.
  - It is often said that the public needs to be “educated.”
- To obtain the public’s “understanding” and “support”, we have done all kinds of efforts for technology improvement as well as for better communication. But, these seem not so successful. There must be better solutions.
Engineering and Social Sciences

Seeking Solutions

① Trigger for new paradigm by new Technologies.

② Solutions sought by technologies are limited views of nature, life and society.

“This method would be effective as a solution for this problem, but you should not use it because it exceeds ….”
Motivation for PAGES

- **Program for Advanced Graduate Education system for nuclear science and engineering with Social scientific literacy**

- Among many other fields in nuclear, we recognize particular importance of social-scientific approaches in the field of nuclear fuel cycle and radioactive waste disposal.

- **New-generation nuclear engineers need to be able to:**
  - Understand the social system correctly,
  - Listen to the public, and
  - Develop engineering options,

  to explore optimized solution for the people.
Aim and Goal

- This School will provide PhD-level graduate students and early career nuclear engineers with advanced studies in integrated social sciences and engineering to prepare them for some of the key challenges and demands, focusing on the geologic disposal issue.

- Successful students will leave with new viewpoints and understanding about the relationship between societal needs and the role of engineering that cannot be provided by current curriculum.

- It is the aim of the school to foster the development a next generation network of engineering scientists capable of carefully listening to the public, understanding the societal needs, contributing to the societal decision making from the engineering expertise, and then realizing the public needs in the form of engineered systems.
# 2009 Summer school contents

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Venues of 2009 PAGES summer school

All relevant information is available at:
http://goneri.nuc.berkeley.edu/pages2009/

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Final Comments

- Regardless of whether nuclear power utilization would expand or not in the future, in the US there is already huge liability for legacy nuclear wastes resulting from past defense and commercial activities.

- In the past half century, substantial development and progress have been made for technologies, regulations, and social discussions in the fields of waste treatment and disposal.

- However, there is not societal consensus for management of spent fuel and HLW. Main reasons would be:
  - Stylizedness or high abstraction is applied in performance assessment for geologic disposal,
  - Decision making process has been carried out mainly by scientists and engineers, and the public was asked only after the current performance assessment framework had been established.

- (Nuclear) Engineers should carefully listen to the public. With dialogue with the public, one step should be taken at a time. Each step should be reversible.
Final Comments (Cont.)

- A summer school was held at UC Berkeley Campus this summer as joint collaboration between UCB and U Tokyo, to develop a prototype of curriculum for social scientific literacy for engineering graduate students.
  - Stimulating discussions were observed among invited lecturers and students.
  - Some discussions especially among lecturers were deep and cross-cutting.
  - Students needed more time to digest wide range of contents, especially social scientific materials.