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Operating Geologic Repositories: A Necessity for the Nuclear Renaissance?

Introduction

In 1955, at the request of the United States Atomic Energy Commission, the United States National Academy of Sciences-National Research Council established a committee of geologists and geophysicists charged with considering the possibilities of disposing of high-level radioactive wastes en masse within the continental United States. Information on the processing and nature of the wastes having recently been declassified, the newly appointed committee and its publicly available report were one of the first open discussions on the "waste" issue in the United States.

In their 1957 report the members of the Committee on Waste Disposal declared their certainty that provided adequate time and support for extensive research and pilot testing programs that might take "several years" to complete was afforded, radioactive wastes could be safely disposed of in a variety of ways and in a large number of locations across the continental United States. The Committee defined "safe" disposal to mean that the "waste shall not come in contact with any living thing" and, considering the half-lives of longest lived radioisotopes, this would require a duration of 600 years, which could be reduced to approximately one tenth that duration if Cs^{137} and Sr^{90} isotopes could be removed from the final waste form. [1]

The Committee recommended the geologic environment and disposal method most promising for high-level radioactive waste to be injection of liquid wastes into salt deposits, of which there are many in the United States. The deposits were praised because they are generally impervious to groundwater, and because fractures in salt were self-sealing. It was believed that these properties made environments such as abandoned salt mines or cavities designed precisely for waste disposal behave like "long-enduring" tanks. [1]

The waste forms discussed were liquid - there was little discussion of environmental impacts, none of engineered barriers and retrievability was not an issue of concern. But, even in 1957, some sentiments are familiar. Members of the Committee believed the potential hazards of nuclear wastes to be sufficiently extreme as to warrant particular attention to the safety of disposal, understanding that safety should come before cost and that any disposal site should be strictly inspected and monitored [1]. In essence, the Committee on Waste Disposal understood nuclear wastes to be different from other types of waste.

Today's repository programs plan for waste forms that are solid and sparingly soluble; they will be encased in elaborate protective canisters that by some estimates could provide isolation for many thousands of years or longer (in excess of a million years in the Swedish concept, for example) [2]. They are to be interred in highly engineered and carefully constructed systems of tunnels deep below the earth's surface. Waste canisters will be retrievable, and repositories will be monitored for many years before closure, after which remaining passive protections will safeguard materials and prevent human exposure.

In the 50 years since the Committee on Waste Disposal released their report, many things have changed, but some of the fundamental ethical sentiments remain. Fifty years of research and discussion have brought us to the verge of the first spent nuclear fuel and high-level radioactive waste repository construction, probably in Finland. We are on the verge of a nuclear renaissance, but it remains unclear what role repositories play in that awakening.

National programs

Many national repository programs exist. Political environments, legal requirements, public opinion and societal expectations and any other number of mutable conditions and variables vary across the range of possibilities, yet these national programs share many common technical issues in their various approaches to the final disposal of nuclear waste.

A survey of current and historical national programs[1,2] demonstrates cross-national commitment to facilitating extensive research leading to siting and development of deep geologic repositories for the eventual permanent disposal of highly radioactive nuclear waste. In the nearly 30 years since these national programs have been active, much progress has been made, but no program has yet built a deep geologic repository for high-level waste or spent nuclear fuel.

Progress has been much slower than initially expected. This delay can be attributed to technical difficulties in site selection and characterization as well as problems with societal acceptance when specific locations of interest were identified [4]. Over the several decades of study, experts have become increasingly confident in the technical feasibility of waste disposal, but as national programs move forward, social and political aspects of the waste disposal process have become increasingly evident and often more of a factor in the delay than the technical difficulties.

"Waste issues"

What are the nuclear "waste issues" that accompany the nuclear renaissance? Nuclear is unique in the energy production industry in its long history of concern for the back end of the fuel cycle.

Several common elements are pervasive in national waste management programs and transcend national borders. They include:

SAFETY & SECURITY

The safety and security concerns related to high-level radioactive wastes and spent nuclear fuel are well known. In waste disposal, the same concerns extend to include how we adequately, yet passively, protect people and materials far beyond time periods for which we can guarantee active enforcement of safeguards and safety measures.

"USER PAYS"

The concept of "user pays" runs throughout the nuclear waste management paradigm [5]. It refers to the belief that those who create or benefit from nuclear power should finance the final disposal of the accompanying waste, which can be seen in the various ways disposal costs are accounted for throughout the power generation process.

GENERATIONAL ETHICS

The "user pays" concept is related to the ethical idea of *intergenerational equity* [6], which suggests generations who benefit from nuclear power hold the responsibility to deal with the waste issue and should avoid passing these burdens on to future generations. This belief is manifested in present day repository programs that are moving towards attaining a legitimate disposal option that will by design protect future generations while maintaining the potential for retrievability.

It is widely believed that those of us who benefit from nuclear power should share the ethical and financial burden to dispose of the wastes it creates.

ENVIRONMENTAL ACCOUNTABILITY

The call to environmental accountability is two-pronged - both power generation and repository programs are likely to need to account for their environmental impacts.

Increasingly, broad understanding and acceptance of the risks and realities of global warming as well as a general appreciation for human impacts on our environment are unavoidable elements of any proposed industrial activity in the 21st century. Any new or expanding power source is likely to be called upon to account for the *environmental impacts of power generation*.

One can assume that waste management programs will face similar questions regarding *the environmental acceptability of repositories and their capacities and designs*. In general, the concept of "safe" disposal is essentially unchanged since the 1957 National Academies report, but there is a world of difference between the understanding of what that meant then and what it means now, for example in terms of the role of engineered barriers. Successful repositories will address environmental concerns from conception through construction and operations to post-closure.

LONG TIME-FRAME

The times associated with nuclear waste disposal are foreign to the human psyche. It is difficult for the best scientists to imagine accurately predicting thousands to millions of years into the future; it is an even greater leap of faith for the public to implicitly trust those predictions.

PUBLIC OPINION

As many national programs have learned, gaining public confidence and support are significant hurdles to overcome. Having expert-endorsed technical solutions is not enough to gain broad confidence that public safety is protected. A high-level of public endorsement does not guarantee a program's success, but lack of it can ensure failure.

TELLING THE STORY

In recent years much work has been completed in the non-technical aspects of geological disposal of radioactive wastes. Across the globe, waste management programs are realizing that technical know-how alone is not sufficient to justify and gain support for deep geological disposal [7]. There is no conclusive, universal approach to achieve public endorsement, but there is a growing consensus on the types of approach that have shown success in moving towards broader acceptance of repository programs.

SAFETY CASE

In general terms a safety case is a well laid out story that describes how and why a repository's combined engineered and natural barriers will provide for and ensure the safety of a system for the long-term safe disposal of nuclear waste. The safety case shows in very explicit terms how the repository's multiple and redundant barriers work together to meet or exceed clearly identified, strict safety goals [8]. The safety case tells the story of how and why the repository's natural and engineered features will keep people safe far into the future. As repository design matures, so too does the complexity of and confidence in the safety case [7].

FLEXIBILITY AND PUBLIC INVOLVEMENT

Concerns raised by the public include the lack of involvement in decision making and a belief that accepting final disposal as a concept is tantamount to relinquishing control over the process or the emplaced materials [7]. Some of these concerns can be assuaged by maintaining flexibility in the decision making process and incorporating

stakeholders, specifically the public, in those decisions. This means that at each decision point, the direction and progression of the repository program can be endorsed, adjusted, or halted. Initially, this process may seem more costly and more risky than a traditional approach, but as the repository program progresses, many believe the broad, increased support that results will facilitate creating successful operating repositories.

DEMONSTRATION

Demonstrating effectiveness of the designed system is paramount in building confidence and gaining support. In order to maintain and solidify broad public support, when the time comes repository programs will need to demonstrate that the system designed to protect the public, is in fact, behaving as expected. These demonstrations are a necessary component to provide assurance concerning the safety case and to assure the public that their trust was not misplaced.

Closing

The key waste issues are not new, but the environment in which the nuclear renaissance is to take place is different and changing. Its openness is likely to force heightened accountability on all players. Establishing a safety case, maintaining flexibility and public involvement and demonstrating effectiveness are not an exhaustive list of possible steps toward enhanced acceptance of repository programs, and they are far from a guarantee for success. These few steps do not signify drastic programmatic changes in existing repository programs, but, rather, suggest a different way of perceiving the relationships between the technical and social sides of nuclear waste disposal.

In the 21st century, in the age of global warming, energy shortages, and terrorism, public trust will not be a given. The nuclear renaissance will be called to account for its social, political and environmental impacts, much more so than ever before. If deep geological repository programs are perceived as partners rather than adversaries, and if they are able to progress with confidence and support toward operating status, the nuclear renaissance will also be able to answer the "waste" question with an equal amount of confidence.

References

1. Committee on Waste Disposal. *Disposal of Radioactive Waste on Land*, National Academy of Sciences, Washington, DC, 1957.

2. *Engineered Barrier Systems and the Safety of Deep Geological Repositories*, Nuclear Energy Association (NEA); Organization for Economic Co-Operation and Development (OECD), 2003.

3. *Radioactive Waste Management Programmes in OECD/NEA Member Countries*, OECD Publishing, 2006.

4. Committee on Disposition of High-Level Radioactive Waste Through Geological Isolation. *Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges*, National Academy Press, Washington DC, 2001.

5. Radioactive Waste Management Committee. *Liabilities identification and long-term management at national level*, Topical Session held during the 36th Meeting of the RWMC, NEA/OECD, Paris, 2003.

6. *Geological Disposal, Past and Future*, Geologic Disposal of High-Level Waste, ITC School of Underground Waste Storage and Disposal, Las Vegas, 4-8 May, 2006.

7. *Progress Toward Geologic Disposal of Radioactive Waste: Where Do We Stand?: An International Assessment*, Nuclear Energy Association (NEA); Organization for Economic Co-Operation and Development (OECD), 1999.

8. *Confidence in Long-Term Safety of Deep Geological Repositories*, Nuclear Energy Association (NEA); Organization for Economic Co-Operation and Development (OECD), 1999.

[1] For a retrospective overview of national programs, suggested references include [3] and [4].
[2] For a brief overview of more current status of national programs, see Table 2.1 in Reference [2].