REINVENTING NUCLEAR WASTE MANAGEMENT: WHY "GETTING IT RIGHT THE FIRST TIME" WON'T WORK

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ABSTRACT

A more flexible and experimental approach to the program for establishing a radioactive waste repository at Yucca Mountain Nevada than is currently envisioned will improve DOE's ability to manage the waste program while maintaining its credibility. The key aspects of this approach are the iterative use of performance assessment, reduced reliance on efforts to anticipate problems and greater reliance on fixing problems when they occur, and implementation of an ongoing review and active renegotiation of overall program constraints such as regulatory requirements. Effective public communication is needed regarding the evolving knowledge about the site and the actions taken within the program in response to this information.

INTRODUCTION

The present U.S. approach to high-level radioactive waste (HLW) management is highly vulnerable to being derailed by minor surprises. The origin of this vulnerability is not the lack of effort or talent at DOE, NRC, EPA or among the many contractors working on the waste program. Nor is the apparent difficulty with the program due to unprecedentedly difficult technical obstacles associated with geological of radioactive waste.

If the problems of the waste management program aren't due to the inherent technical difficulty or to an inadequate level of effort, what is the cause? My view is that the program is at risk because the wrong approach to implementation is being followed. The current preplanned process, in which every step is quality-assured from the initial effort on, is inappropriate for the problem. The current policy calls for a sequential process in which, first, criteria for safe disposal and licensing are set by EPA and NRC, and second, in which DOE describes in detail what steps will be taken to move through site characterization, licensing, and operation of a facility. The major effect of this process is that any late change by any of the participating agencies is taken as an admission of error. The difficulties with the current approach are reflected by the way that frustration over the slow progress and ever-retreating target date for operation has led to intensified efforts. The issue is whether this is an effort "to do faster and more intensively what doesn't work." (2)

Successful implementation of radioactive waste disposal requires a process for achieving public acceptance that disposal can be implemented with acceptably low residual risks and uncertainties. This is a complicated objective, involving both public perceptions and technical knowledge. As argued below, the problem requires a more flexible and responsive national approach than is being pursued under the current program.

THE NATURE OF THE PROBLEM

Uncertainty in the Risk from HLW

There is no actuarial basis from which to assess HLW risk. Some scenarios for risk include low probability/high consequence events such as volcanos; other scenarios are based, implicitly or explicitly, on assumptions that cannot plausibly be proved or disproved. For example, assumptions are made about the possibility of climatic changes that could increase rainfall at a repository site.

The actual performance of a repository is difficult to predict for many reasons. Geologists often disagree about the interpretation of data as it pertains to the past; predicting the future is harder. Releases may occur many thousands of years into the future, and such releases are likely to be invisible and diffuse. The potential for human exposure far into the future will be shaped by unpredictable changes in the nature of the future society, its demography and technology. For example, water for drinking or irrigation may be monitored for radiation, or may not. Even if we could somehow predict future exposures credibly, we still would face the uncertainties in estimating what health effects might result from low-level exposures to radiation from HLW. Obviously, the magnitude and nature of HLW risk is not easily analyzed; quantitative risk estimates for radioactive waste facilities will remain highly uncertain and subject to challenge.

These uncertainties should not be taken to mean that risks from competently managed HLW are likely to be significant, or that risk analysis for HLW lacks value. Instead, the point is to call attention to the existence of irreducible uncertainties in future risks. An essential part of a successful management plan is to figure out how to operate with large residual uncertainties. An approach that anticipates that science can provide all the answers is likely to fail.

Nor does the inability to assess risks precisely mean that the public will reject efforts to site a repository. The reason for choosing geologic disposal is that the prevailing technical judgment is that through this approach, wastes can be disposed of safely. Geologic disposal has been selected by most countries working on HLW disposal, although the technical details under consideration vary widely from country to country. Similarly, site selection is based on many characteristics, the most important of which are isolation from people and water. The basis for these decisions can be

explained without promising that every conceivable problem that might occur has been considered and solved.

Risk Perception

Public perceptions of potential risks from HLW management alternatives will play an important role in political choices regarding the "how" and "where" of waste disposal. The importance of risk perceptions in setting policy for controversial technologies is evident, for example, from experiences with nuclear power plants. Studies have linked the high perceptions of nuclear power risk to certain qualities of the risk, in particular to perceptions that the risks are catastrophic, new, uncertain, and involuntary or beyond individual control. Radioactive waste poses risks with similar characteristics; the risk is uncertain and novel, the time horizon of current decisions is long, and the health concern is cancer.

The importance given to public perception of HLW risk is due to the idea that people intuitively balance perceived risk and benefit. This may be true in some cases and for some people, but, given the complexities involved with understanding potential risks from HLW, it seems likely that most people will transfer the judgment of the safety of HLW disposal to the experts. The key question is which experts people will listen to, whether it will be those involved in waste management or their critics. It depends on who is deemed more trustworthy. While most people have little experience with or knowledge about radioactive waste, they have considerable experience in evaluating other people.

While there is little that can change the troubling characteristics and uncertainties of HLW risk, the perception of the integrity and competence of the risk managers depends in large part on their performance and in their dealings with the public. The recommendations below regarding revisions to the current approach are largely due to my concerns that the current process is structured in a way that does not promote trust of those implementing waste management.

The importance of individual control in the acceptance of risk is a critical factor that should not be overlooked. The current situation, in which the political leadership of Nevada is fighting the repository and portraying Nevada as a victim enforces the perspective that the program is beyond local control. This is a most unfortunate situation insofar as it affects the prospects for local acceptance. While the attitude of the Nevada political leadership may be largely beyond the control of DOE and other federal agencies, DOE should recognize that communications about the program are likely to be ineffective in building local support as long as Nevadans perceive a lack of say in the process. The disagreement between DOE and Nevada over whether Yucca Mountain should be investigated as the HLW repository site makes it difficult for DOE to share decision-making power with Nevada. But to the extent that DOE can share power, the gain in the perception of local control is likely to improve acceptance of a repository. For this reason, Nevada officials may perceive a benefit in not cooperating with DOE.

There are still steps DOE can take, for example, establishing a review group of local technical experts.

Credibility

How scientists and engineers communicate with the public to build trust and public confidence is the essence of the issue. Given the highly polarized reactions to radioactive waste disposal, it is reasonable to anticipate that criticisms and challenges to the technical competence and integrity of the work will be made. How those in the process respond to such criticisms will affect credibility. Conversely, credibility will have a significant influence on the ability of waste managers to respond effectively when unjustified criticisms are made.

The perceived incentives to find the proposed site and technology for waste disposal suitable, and the motivation to meet schedules and budgets contributes to the perception that there may be an inherent incentive to disregard or down-play troubling findings. This concern is recognized and has been addressed through a carefully designed process for evaluation and licensing. The credibility of the site characterization effort will be aided by opportunities for participation by state and local groups and individuals and by the nature of reviews and oversight established for the process. Specification of a characterization and review process structured to reveal errors, optimistic assumptions, or omissions is a central aspect of current HLW policy, as embodied in the Waste Policy Act.

While the elaborate process for state and NRC review of DOE's analysis can help maintain or improve DOE's public credibility, the role of technical reviews should not be overstated compared with the working relationships established between the project staff, state and NRC oversight groups, independent review groups, the press, and members of communities near the site.

It is natural to think that, when dealing with a wary public, it is important for an agency to project confidence that it understands what risks are present with great precision. This perception may create an incentive for an agency to play down the uncertainties in risk. But there are many examples where attempts to understate uncertainty have been damaging to credibility and counterproductive to the action the agency was trying to promote. As a result, experienced regulatory agencies, the EPA in particular, now pay careful attention to describing the uncertainty associated with its risk assessments. Claims that accurate predictions can be made for rarely or never-experienced events such as volcanos, large earthquakes, or climate changes are likely to be challenged. Credibility can be damaged if claims regarding these risks are seen as without basis.

It is important for those involved in HLW management to avoid falling into the trap of promising to remove uncertainties as a condition for repository licensing or operation; uncertainties are certain to persist. But whether the uncertainties with geologic disposal are too uncertain to proceed can only be judged when compared to the projected risks and associated uncertainties in projections for alternatives,

such as delaying implementation of disposal or surface storage of waste.

A Central Dilemma

With regard to establishing and maintaining public trust and credibility, is it better to know too much or not enough? In a complex, potentially hazardous undertaking such as HLW disposal, the occurrence of unforeseen events would bring the validity of the technical approach and the competence of the risk analysis used to justify the approach into question. Conversely, when foreseen events occur (e.g., the failure of the sealing ring on the space shuttle booster), the question is why weren't they prevented. In either case, the technical credibility of the project team suffers. There is an obvious dilemma.

My perception is that greater harm to credibility occurs when the organization has understated the risk or uncertainty. As an example, consider the space shuttle accident. NASA's decision to send a teacher on the flight and, on an earlier flight, a Congressman, suggested that flying the shuttle was not dangerous. When the accident occurred, it appeared that NASA was either grossly overconfident or deceptive about the shuttle's risks.

In the earlier stages of the manned space program, public support for the program was maintained as the public accepted the dangers and uncertainties involved. Accidents and failures occurred, but the overall program went ahead because the accidents were not taken by Congress or the public as a signal that the program was out of control. Conversely, NASA is still struggling to recover from the shuttle accident.

ELEMENTS OF A MORE FLEXIBLE PROGRAM

The intended result of the recommendations here is to produce a system in which change is not an admission of error. The general recommendation is adopt an approach designed to be receptive and adaptable to the continuing stream of information from characterization, and in which the important issues in characterization are continuously redefined. The point is to debug the preliminary design during rather than before characterization. In comparison to the current approach, the main actors should substantially reduce detailed pre-planning and the heavy emphasis on quality assurance during initial site characterization.

The basic approach outlined here would start with a simple umbrella assessment based on known data and methods for interpretation, and proceed with the expectation that engineering modifications and experiments can accommodate uncertainties. The necessary elements for such an approach is flexibility to respond rapidly to ongoing findings in planning, budget, and engineering within broad constraints, and to continuously adjust the performance assessment to reflect new information, especially where such information indicates possible precursors of substantial increases in risk.

My recommendation is to increase flexibility and project resiliency through three steps described below: First, to start with a grossly oversimplified performance assessment and iterate. Second, to recognize that many conditions likely to be found in the investigation of a repository site are more difficult to anticipate than they are to fix once encountered. Finally, to avoid defining the program's mission too narrowly.

Iterative Performance Assessment

The suitability of a site and design for a HLW repository will depend on the quantitative projections of future risks in comparisons with licensing criteria, and on the scientific quality and credibility of the analyses on which such projections are based. As a result, the risk assessment of the repository, referred to as a performance assessment, is critical to the determination by DOE and NRC of whether to proceed with geologic disposal at a particular site with a particular engineering approach.

Because the estimation of risks from a repository involves many substantial uncertainties and technical difficulties, it is natural to view performance assessment as something that emerges after most of the site characterization has been completed. My view is that if a repository performance assessment is thought of as a product that is assembled late in the characterization process when the various pieces of work that support the analysis are completed and polished, the likely result is that large efforts will have been expended on small risks and vice versa. Conversely, an iterative process can prioritize characterization efforts towards major risks and uncertainties while there is time and money left.

The most important lesson from the use of probabilistic risk assessment (PRA) for commercial nuclear power plants is that the benefit of the analysis is in structuring what is and is not known about risk in a way that leads to increased efforts to understand and reduce important risks and uncertainties. The value of PRA is not in getting a final "answer" that defines plant risk. The bottom line risk estimate, whether of a nuclear power plant or of a repository, is sufficiently uncertain and insufficiently credible to answer whether the facility is safe enough.

Prior to major PRA efforts, the majority of nuclear power plant safety research funds went to assess the thermal- hydraulic performance of a plant in the event of a large-break loss of coolant accident (LOCA). As PRAs repeatedly found large LOCAs to be minor contributors to risk, resources were shifted to issues that many analyses found to be relatively significant to risk such as human error and the reliability of electrical power.

An iterative performance assessment provides early information on the design features and licensing criteria most likely to affect determine whether the site is suitable or should be abandoned. In this regard, one should be aware that historically, increases in resources aimed at assessing a technological risk have typically not been rewarded with significant reductions in uncertainty. As one attempts to refine a risk assessment, the number of processes and pathways assessed increases, and more contributors to uncertainty are explicitly considered. But while the uncertainty associated with the assessed risk may not decline, the depth

of understanding and insight into physical processes important to risk improves.

Anticipating Problems Versus Fixing Problems

A natural reaction by those managing the waste effort, given the pressures of schedules and budgets as well as an adversarial public process, is to plan and document work carefully. The idea is to "Get It Right the First Time." One has only to look at the size of the Site Characterization Plan for Yucca Mountain (6300 pages) and at the attention paid to quality assurance to see the results of these incentives. As laudable as these efforts apparently are, my view is that an approach based on getting the needed measurements and analysis with acceptably high quality in one pass through the process is not likely to succeed.

There are political and legal pressures to adopt an anticipatory approach. The DOE must project an attitude of confidence that it knows what it is doing and that there are not significant technical unknowns in its approach. DOE would be unlikely to get public confidence or a license from the NRC without a detailed plan in which solutions to a long list of foreseeable potential problems are presented, and in which the significance of unforeseen problems is minimized. The general agreement that the technical approach must achieve public protection with high confidence requires that uncertainties be tightly bounded.

In spite of these pressures, the feasibility of a fully anticipatory approach is doubtful. Several examples illustrate the kinds of unanticipated problems that arise. The common aspect of these examples is that conditions were discovered during construction that were not and probably could not have been anticipated beforehand.

- The Canadian waste program's underground research laboratory in Pinewa, Manitoba is in a shaft cut in granite. While digging the shaft, a large fracture was found that would intercept a planned horizontal shaft. The design was altered (the direction of the horizontal shaft was changed) so that the fault would not be encountered. Before digging the main vertical shaft, the fault was not identified; by making an appropriate adjustment to the planned direction of the horizontal shaft, the fault was avoided.
- On May 12, 1987, an accident occurred in the HLW repository under construction in Gorleben, West Germany. One worker was killed and five others injured by a falling support when a ring, placed in the shaft to handle higher-than-expected pressure, failed. It was necessary to fill part of the shaft with concrete after the accident. A newsletter report (3) on the Gorleben accident included the comment that "The cause of this accident was not faulty building material as the construction company first announced but a direct consequence of the geological conditions of which experts had already warned the PTB (Federal Institute for Science and Technology) years ago."
- The Waste Isolation Pilot Plant (WIPP) in New Mexico encountered pockets of pressurized brine in salt thought to contain little water. Based on this finding, a group opposed to WIPP was able to get an Albuquerque paper and with New Mexico's Congressional delegation to pay attention to charges that WIPP was unsuitable for waste disposal. This attention led to a National Academy of Sciences review of the issue. (4)

An additional reason to avoid an approach that puts too much faith in anticipation and pre-planning is that whatever technical approach is initially adopted, the design can be improved by matching the design to specific features of the site. Experiments are now going on at the WIPP site to examine the characteristics of various engineering approaches not originally part of the design, e.g., use of backfill. However, much analysis at WIPP appears to be aimed at defending designs made before the shaft was dug. Rather than adapting new information to improve the design, the effort is to show that an early design is good enough. (4)

Define the Problem Broadly

As characterization proceeds (and especially if it proceeds with guidance from an iterative performance assessment) DOE will have a sense of whether it can meet EPA criteria as interpreted by NRC. It seems quite likely that DOE will find some criteria set by EPA or NRC difficult or impossible to meet. If this occurs, it will not necessarily mean that Yucca Mountain is unsuitable for a repository.

It may be that Yucca Mountain is fine and that the problem is with the criteria or the licensing conditions. It is important that the lack of national experience in setting criteria for a repository and in repository licensing is recognized. A process is needed to determine whether the inability by DOE to satisfy a particular regulatory requirement is due to a disqualifying deficiency at the site or to an unreasonable regulatory requirement unlikely to be met at any site and unnecessary to protect public health. In addition to a credible process for reviewing requirements, DOE should communicate the reasons why changes in criteria are justified. To the extent that regulatory criteria can be corrected earlier rather than later in the process, the more likely it is that changes to criteria will be accepted as technical corrections rather than as diminution of public protection. My view is that DOE has been taking the EPA criteria and NRC licensing plan as immutable constraints and has been insufficiently active in negotiating requirements with EPA and NRC.

It is also important that DOE, NRC, and EPA regard the Congressional mandate as evolving and negotiable rather than rigid. The history of U.S. efforts to dispose of HLW shows a series of plans laid and abandoned. This history suggests that current plans for waste disposal have a small chance of progressing without major modification over the twenty years it will take to get a repository in operation. Changes in the basic underlying law, currently the Waste Policy Act and its amendments, are to be expected. One only has to consider how the 1987 amendments arose in response to the perception that the HLW program was in trouble to see that evolution of the approach is a normal part of the process.

While many of the suggestions here may be inconsistent with current law and policy, law and policy can be changed if the case is made that changes will improve the prospects for success without diminishing public safety. But for the process to succeed it must converge. One way this can occur is if those closest to the waste disposal process and most knowledgeable about the strengths and weaknesses of the current approach take an active role in refining the process and approach.

Finally, those at Yucca Mountain should learn from WIPP. The program at WIPP has many analogous features to Yucca Mountain, except that WIPP is easier in every notable way and well ahead of Yucca Mountain in time. The key differences are: WIPP is intended to accept transuranic waste, much less radioactive that HLW; New Mexico's political leadership is supportive of the project, while Nevada's leadership is hostile to Yucca Mountain, the geology is simpler at WIPP than at Yucca Mountain, and WIPP does not require an NRC license. The problems encountered at WIPP may be similar to but easier to resolve than those that will occur at Yucca Mountain; the experience at WIPP can be good practice for Yucca Mountain.

FINAL COMMENTS

The major arguments presented here are that public confidence in DOE and DOE contractors is central to acceptance of a repository, and that a flexible approach, based on the expectation of unanticipated events during characterization and construction, has the best chance of succeeding. While it is necessary for the project team to have confidence that their technical approach is valid, it is also important to avoid a "nothing can go wrong" mindset. Such an attitude is publicly interpreted as arrogant and patronizing. Actions by DOE such as implementation of an active public information and outreach program reflect awareness of the importance of public understanding and trust in the program. It is important in these activities that DOE not be defensive about not having all the answers at this time. It is also important to recognize the importance of local control to acceptance of a repository.

If, as is suggested here, the current activities at Yucca Mountain are seen as experimental, preliminary, and not documented and quality controlled to the extent necessary to get a license from the NRC, would the program be delayed and costs increased? Probably not, in my view. A two-step process in which the first step is to define the important characteristics of the site that contribute to its suitability and to establish the analytical framework, and the second step is to rigorously analyze and document the aspects of repository performance important to safety, may well prove to be the shorter path to establish a repository.

Finally, the question of the acceptable residual uncertainty in risk from a waste repository needs thinking and analysis. This question also should be applied to the reexamination of licensing criteria. While reduction of uncertainty through investigations carried out in site characterization is necessary and desirable, the track record in risk analysis is that uncertainties in risks from activities for which there is no actuarial basis for assessment fall slowly if at all.

REFERENCES

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