Experience Gained On the Management and Disposition of High-Activity Waste

Presentation to the Blue Ribbon Commission on America's Nuclear Future

U.S. Nuclear Waste Technical Review Board
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November 16, 2010

Thank you for inviting me here today to discuss lessons learned from U.S. and international waste disposal efforts. I am John Garrick, Chairman of the U.S. Nuclear Waste Technical Review Board. Four members of the Board are in the audience to provide assistance in answering your questions.

About the Board

I know that two of your subcommittees have heard from other Board members and staff, so I will only very briefly describe the Board and its role. The Board is an independent federal agency composed of 11 technical and scientific experts. It is nonpartisan and apolitical. Members are appointed by the President to 4 year terms from a list of nominees submitted by the National Academy of Sciences. By the way, I should mention that former Congressman and current Commissioner Phil Sharp played a pivotal role in crafting an amendment that created the Board in the 1987 amendments to the Nuclear Waste Policy Act. I know that Senator Domenici also played an important role in the passage of that legislation. The Board is charged with conducting unbiased ongoing technical peer review of activities undertaken by the Secretary of Energy related to the implementation of the Nuclear Waste Policy Act. In particular, we assess the technical and scientific validity of DOE activities to manage and dispose of spent fuel and high-level radioactive waste, which I lump together under the rubric of "high-activity waste." The law requires us to report our findings, conclusions, and recommendations at least twice a year to Congress and the Secretary.

I should establish at the outset that the Board's statutory mandate continues even as alternatives to a Yucca Mountain repository are considered. The Board's current review work and priority tasks reflect the transition of DOE's nuclear waste-management activities to include potential fuel cycle alternatives to direct disposal of spent fuel.

What are our current priorities?

I will list very briefly some of the Board's current priority tasks:

- Since June 2009, the Board has reviewed the technical issues of *very long-term storage* of commercial spent fuel. The Board is developing a White Paper on this subject that we will use as the basis for reviewing DOE's research related to extended storage of both commercial and government-owned high activity waste.
- Another effort supporting our ongoing review is a material-balance analytical tool called NUWASTE, which was introduced to the Blue Ribbon Commission's Reactor and Fuel Cycle Technologies Subcommittee last month by my Board colleague Mark Abkowitz. The results provide

important insights on the potential benefits of different back-end processes and activities such as recycling of uranium and plutonium and long-term storage of spent fuel.

- To determine the technical effects of how a delay in repository availability affects the plans of federal facilities that store government-owned high-activity waste, the Board has visited most of the facilities where these wastes are stored. We plan to issue a report on our findings and conclusions during 2011.
- We are in the process of revising the report we published a year ago that presents information on the programs being developed in other countries for managing high-activity waste. Board staff member, Daniel Metlay, presented the original report at the Blue Ribbon Commission's Disposal Subcommittee meeting in July this year. The revised report will be extended to include a qualitative and historical assessment of how the countries we surveyed are going about developing their geologic repository programs, and it will draw some conclusions on how external factors have impacted the repository programs in those countries.
- Last, but far from the least, is the Board's preparation of a report of technical lessons learned from the U.S. and repository programs worldwide. This report will be made available to the Blue Ribbon Commission when it has been finalized. Much of the balance of my talk will focus on the highlights from this report.

Deep Geologic Disposal

First however, the Board feels compelled to express its support of the opinion voiced by many others that regardless of the nuclear fuel-cycle option adopted, a repository for permanent disposal of high-activity wastes will be necessary. In addition, I personally believe that having a plan in place for permanent disposition of the waste, on which there is agreement and a path forward, is essential to gaining public confidence in the nation's ability to manage nuclear waste.

Right now, I think we have a temporary fix for a problem that very much requires a permanent solution. Government-owned high-activity waste is being stored at several federal facilities, and commercial spent nuclear fuel is being stored at more than 100 nuclear power plants nationwide at over 70 different sites. The current inventory of high-activity waste in storage is greater than 60,000 metric tons of heavy metal and is being added to at the rate of about 2,000 metric tons per year.

So, what is *the solution?* That is, of course, part of what the Blue Ribbon Commission has been asked to consider. But, deep geologic disposal must be at least part of the answer.

The objective of deep geologic disposal is to isolate high-activity radioactive waste from humans and the accessible environment for durations that are unprecedented in our history. This is, of course, easier said than done. Some of the more important technical challenges to waste isolation are that high-activity waste is made up of diverse radioactive species with widely differing inventories; different types of radiation; different rates of decay; and different physical, chemical, and thermal properties. The waste generates heat in the geological environment, which results in high temperatures for a relatively long period of time — on the order of a thousand years. The high temperatures significantly affect geochemical processes associated with mobilizing the radionuclides as well as the rates and mechanisms of degradation of the engineered barriers. Additional complexity is introduced by hydrogeological and "coupled processes," that is, the interactions of nuclear, thermal, chemical, and mechanical processes.

The result is a dynamic system and considerable complexity in predicting the long-term performance of a repository.

Experience Gained from Efforts in the U.S. and Other Countries to Develop a Geologic Repository

Every time I think or talk about learning from experience, I'm reminded of what President Truman once said, "There is nothing new in the world except the history you do not know." And the late great nuclear pioneer Walter Zinn several decades ago often pointed out that many scientists and engineers complain that there is too little data, when in fact the problem is that we seldom take advantage of the data that is available. In the spirit of President Truman and Dr. Zinn, we have attempted to capture some nuggets from what has been learned during the last several decades from disposal efforts in the U.S. and other countries that might be useful in the future. Because we know the U.S. program from our own involvement, the Yucca Mountain Project provides the primary source of information for our retrospective. Obviously we have learned much more about geologic disposal than I can cover in a few short moments, but let me highlight a few examples.

Preliminary Findings

- First and foremost, the cumulative experience of the Yucca Mountain program, the Finnish, French, Swedish, Swiss, and the Waste Isolation Pilot Plant program provides a high level of confidence that deep geologic repositories are indeed feasible. And it should be noted that the planned repositories for these programs and the operating Waste Isolation Pilot Plant are located in different geological environments including tuff, granite, clay, clay and granite, and salt.
- We learned to expect surprises when you get underground during the site-characterization phase, so the sooner you go underground the better. Two examples of surprises at Yucca Mountain were (1) the possible discovery of bomb-pulse chlorine-36 at the repository level, which if eventually confirmed, means that a small amount of surface precipitation could reach the repository level in 50 years or less; and (2) the discovery of a repository environment riddled with pockets (the technical term is lithophysae) ranging in size from the diameter of your thumb to the diameter of a basketball and larger, which considerably complicated geotechnical and heat transfer modeling. Another example of a surprise is that in the early days of the Waste Isolation Pilot Plant characterization, experiments with heat-generating surrogates demonstrated that the creep rate of the salt at higher temperatures was far greater than had been determined in the laboratory.
- We learned that including a robust engineered barrier system can have significant advantages over a program that relies primarily on what is referred to as the "natural system." Because the materials and manufacturing methods used for the engineered barriers can be specified and controlled, confidence in their predictability may be greater than that of the natural system. Of course this assumes that the environment in which the engineered barriers would operate is understood. The result can be much greater confidence in the form, quantity, and rate (the source term) of radioactive material from the disposed waste entering the natural system.
- We have learned a great deal about the importance of analyzing the contribution to overall risk of different waste forms. A much improved knowledge base now exists to guide future efforts in specifying the most appropriate waste forms for permanent disposal.

- A disposal facility involves many first of a kind systems and components for which there is minimum experience. A carefully planned and systematic program of prototyping such systems and components in their expected environments is essential to understanding and modeling their potential performance.
- We learned how important it is to have a waste package design that allows for direct disposal of a variety of canisters, including loaded dual-purpose canisters, to minimize the handling of high-activity waste. Waste handling is considered a significant contributor to the risk of any high activity waste management system.
- Major advancements were made in the Yucca Mountain Project on how to use the risk sciences to quantify postclosure performance over extremely long time periods. An important spinoff of this work is the use of phased and interactive probabilistic performance assessments to identify what is important to focus on in the characterization program.
- We learned how important it is to implement a rigorous and integrated total systems approach to characterizing a repository site, developing a repository, and designing and operating a waste management system that involves such diverse activities as transportation, storage, packaging, handling, and disposal. It is important to know how decisions made in each functional area of the waste management system affect other parts of the system. In particular, the impact of decisions and design requirements having to do with postclosure have to be traceable to their impact on preclosure activities including waste handling and transporting, and the actual design and construction of the surface facilities for the project to be efficient in its operation.
- We learned that it is essential to have a close relationship between the science program and the engineering activities in such projects to control costs, schedules, and other performance goals. Experience indicates the importance of making the transition from a science program to an engineering project at the right time.
- And finally, experience tells us that a license application in the U.S. can be developed that meets the requirements of the Nuclear Regulatory Commission for accepting a license application to review—a major achievement.

Experience in Other Countries

Experience in other countries could become increasingly significant depending on when the United States resumes efforts to site and develop a deep geologic repository.

Some findings from the experiences of programs worldwide are:

- Repository systems can be developed in a variety of geological environments.
- Most proposed disposal concepts rely on both natural and engineered barriers, although the degree of reliance on one or the other varies considerably.
- Research carried out at-depth in underground research laboratories has been extremely valuable.

Moving Forward

These are some of the lessons that the Board learned from its review of different high activity waste repository programs, although I have only had time to present them here at the highest level. As I mentioned, I believe that keeping a focus on a permanent solution is critical regardless of what interim alternatives to managing high-activity nuclear waste are recommended. The basis for this view is:

- A permanent solution is critical to building public confidence that there is indeed a way of isolating high-activity waste;
- History teaches us that institutional stability is not guaranteed forever. The longer the delay in resuming a repository program the higher the probability that it could be disrupted during the operational phase by institutional changes;
- An international scientific consensus exists that a permanent geologic repository is the preferred disposal option and that it is technically feasible.

It appears that the following are necessary to move forward:

1. An assessment of repository-development experiences to date should be used as a baseline for future geologic disposal programs; site-selection and site-characterization activities in the U.S. would benefit from such an assessment.
2. Characterization of waste forms together with existing inventories of high-activity waste should be revisited, and the issue of the optimal method of disposal for each waste form should be addressed. In other words, the one-size-fits-all approach used at Yucca Mountain may or may not be the best approach.
3. Once a site has been selected, characterized, and found suitable, an engineering-oriented project plan for the design, construction, licensing, and operation of a geologic disposal facility for high-activity waste should be developed. At the same time, a scientific research program that is tailored to the requirements of the engineering plan and the repository site selected should continue in parallel, both for better technical understanding and to identify potential improvements to the engineering plan.

I hope that this brief representation of some findings from the Board's work undertaken as part of its review of DOE activities has been useful. We look forward to providing other technical information that you feel would be helpful to your deliberations, and, of course, all the Board's reports, correspondence, congressional testimony, and meeting materials are available on our website.

Thank you for your time. I will be pleased to respond to questions.