WM2016 Conference Panel Report

PANEL SESSION 90: **US DOE Featured Site: Sandia National Laboratories**

Session Co-Chairs: **Paul E. Shoemaker**, *Senior Manager, Sandia National Laboratories*
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Panelists:

- **Evaristo (Tito) Bonano**, *Senior Manager, Sandia National Laboratories*
- **Christi Leigh**, *Technical Department Manager, Sandia National Laboratories*
- **Sylvia Saltzstein**, *Technical Department Manager, Sandia National Laboratories*
- **Ken Sorenson**, *Technical Department Manager, Sandia National Laboratories*
- **Kevin McMahon**, *Technical Department Manager, Sandia National Laboratories*

A panel convened at the 2016 Waste Management Symposium which focused on Sandia National Laboratories, a DOE/NNSA national laboratory. It was intended to showcase Sandia's roles in and contributions to a wide variety of technical activities related to the back-end of the nuclear fuel cycle, across multiple programs and in support of multiple sponsors and customers. A summary of the panel discussion and audience questions is presented below.

Summary of Presentations

The session was introduced by Co-Chair Paul Shoemaker, who provided a quick overview of the various technical and programmatic topics to be covered by the members of the panel. Mr. Shoemaker noted, for the record, that the other Co-Chair, Frank Hansen, had committed giving a technical presentation in another session, a session that wound up being scheduled on top of this Featured Site Panel, and therefore, Dr. Hansen would not be at the head table for this panel session.

Tito Bonano, discussed Sandia's role as Lead Lab for the proposed Yucca Mountain repository. He noted that, in January, 2006, the United States Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) designated Sandia National Laboratories (SNL) as its "lead laboratory to integrate repository science work for the Yucca Mountain Project." DOE's plan built on the successful experience at the Waste Isolation Pilot Plant, "where a single national laboratory [SNL] coordinated 'post-closure' science work while a contractor performed work on the design of 'pre-closure,' or above ground facilities." The goal was to provide OCRWM with "strong centralized leadership for its science program… and increase technical credibility with the scientific community, as well as the project's regulators and stakeholders." SNL was to "provide management and integration services for all Yucca Mountain scientific programs … in support [of] OCRWM's license application and its defense in the Nuclear Regulatory Commission's [NRC's] review process, including the allocation of funding and the assignment of technical tasks to selected supporting organizations such as other national laboratories, subcontractors, federal agencies, universities, and expert panels." SNL was to assume these responsibilities on October 1, 2006, with Bechtel SAIC Company, LLC, retaining responsibility for the management and operations of the project, including facility design, pre-closure safety analysis, and overall leadership for preparation of the DOE's application to the NRC for authorization to construct the repository.

Bonano reported that the Lead Laboratory began operations in October, 2006, with a commitment to support the DOE's stated objective of submitting a "high-quality and docketable license application to the Nuclear Regulatory Commission no later than Monday, June 30, 2008." As OCRWM Director Ward Sproat stated in testimony to the House of Representatives Energy and Commerce Committee on July 2005, success of this admittedly aggressive objective would not be "measured only by the calendar but also by the quality and completeness of the application." SNL responded to this challenge by rapidly standing up an organizational structure that included offices of quality assurance, performance assessment, business operations, organizational support, test coordination, performance assessment, and licensing, all reporting directly to Andrew Orrell, the Yucca Mountain Lead Laboratory Program Director. One of the guiding principles of the Lead Lab was to find and engage the right technical expertise, regardless of institutional affiliation, and the technical team needed to support the post-closure basis for the license application was drawn from multiple national laboratories and contractors. By the fall of 2007 more than 100 technical documents supporting the license application had been completed under an approved quality assurance program, and the first iteration of the total system performance assessment that would underlie the post-closure safety assessment was in technical review. By the spring of 2008 documentation of the post-closure technical basis for the license application was complete, and the Lead Laboratory focused on supporting production of the post-closure portions of the 8000-plus page License Application and Final Supplement to the Environmental Impact Statement. The DOE delivered the license application to the NRC on June 3, 2008, ahead of schedule, and the NRC docketed the application for review on September 8, 2008.

The Lead Laboratory provided ongoing support to the DOE throughout the NRC's review of the License Application in the fall of 2008 and 2009, supporting preparation of an update to the application in November 2008 and assisting in the preparation of hundreds of responses to NRC "Requests for Additional Information" (RAIs). The Lead Laboratory also assisted the DOE Office of General Counsel's preparation for anticipated adjudicatory hearings before an Atomic Safety Licensing Board (ASLB), including identification and preparation of expert witnesses.

On March 3, 2010, the DOE formally moved to withdraw its license application to the NRC, and although that action was eventually denied by the ASLB, the project was suspended and the Lead Laboratory was directed on May 11, 2010 to withdraw all OCRWM-related work except for tasks "necessary to comply with DOE's ongoing Licensing Support Network obligations and to preserve those records and materials that are needed to maintain the DOE's ability to participate in the proceeding if it were to resume." All Lead Laboratory tasks other than those identified as necessary to meet this direction were terminated May 24, 2010.

Christi Leigh reviewed Sandia's role in providing leadership for international collaborations in repository science. She noted that Sandia's stance on international outreach in areas related to waste management is broad-minded given that Sandia National Laboratories' roots lie in World War II's Manhattan Project, which built the world's first nuclear weapons. Our motto adopted from President Truman is exceptional service in the national interest. As Sandia has grown our service in the national interest has expanded to encompass environmental and economic issues faced by the United States. An openness to international collaboration in several areas leverages collective understandings for the benefit of all countries involved.

Sandia can count a host of collaborative successes across a reach of challenges as compelling as and varied as excess uranium/plutonium disposition and consequence mitigation for reactor accidents,

such as Chernobyl and Fukushima. Countries with which Sandia has established collaborations include China, Korea, Japan, Russia, numerous countries of Europe, and Saudi Arabia. But in particular, it is Sandia's authority on the nuclear fuel cycle established through our reactor safety programs, our storage and transportation programs, and our deep geologic disposal programs that has led to the strongest international partnerships. The nuclear fuel cycle is an economic and environmental concern for all countries currently using or planning to use nuclear as a power source. As a result, organizations and their researchers are highly motivated to establish forward leaning programs on issues nuclear. Within these venues of international outreach, we focus here on mined geologic disposal, the very back end of the fuel cycle.

Sandia was the start-to-finish leader in both the Waste Isolation Pilot Plant and also played a similar role in the Yucca Mountain projects. Researchers at Sandia National Laboratories have gone through multiple safety-case cycles for these two repository programs. Because of this unique experience, Sandia offers guidance and perspective both technically and programmatically to our international colleagues who do not currently have the benefit of a specific site, facility, or in some cases regulation to target. Longer-term research and development engendered by our partnerships with international programs returns benefits to the United States. International partners bring experience in essentially all of the geologic media, which is helpful as we reflect on our national options.

For our colleagues in other countries, working toward the goal of opening a safe and secure disposal facility for radioactive waste, mostly from nuclear power generation but also from other nuclear activities, has been a challenging endeavor given levels of commitment from their respective governmental agencies that vary over time. Typically, international programs are engaged in research and development that may ultimately be applied to a safety case for radioactive waste disposal, but without a chosen site or design, they are more or less in a holding pattern until decisions to move forward are made. By contrast, Sandia has established and matured elements for a safety case: characterizing the site, establishing the technical bases for performance assessment, and contributing extensively to two comprehensive license applications.

We share our experience by way of Work for Others Agreements, Memoranda of Understanding, and participation in IAEA, EU, and NEA programs. Sandia has leveraged its science and technology via active participation with international programs in deep geologic disposal, transportation and storage, features events and processes, thermodynamic databases, operational demonstrations, sealing systems, and virtually all dimensions of waste management, including stakeholder outreach.

Sylvia Saltzstein discussed radioactive waste storage and transportation activities at Sandia, noting that the Laboratory has decades of experience contributing to the R&D necessary to develop the technical bases for the safe and secure storage and transportation of radioactive materials. SNL has been able to contribute by integrating the labs' deep technical capabilities in mechanical engineering, materials science, nuclear engineering, chemistry, modeling and simulation, large and small scale testing, and systems analysis. Recent work in the Used Nuclear Fuel area is focused on the increased understanding and characterization of stress corrosion cracking (SSC) of Dry Storage Canisters; quantification of residual stress in DSCs; uncertainty quantification of the data parameters that contribute to SSC; management of DOE's High-Burn-Up Confirmatory Data Demonstration which will collect confirmatory data on how/if high-burnup fuel changes during typical long-term storage conditions; the stresses, strains, and fatigue fuel experiences during normal conditions of transport; logistical analyses of transportation and consolidated storage

campaigns; thermal analysis of BWR storage conditions; security analyses of terrorists attacks on UNF during storage and transportation; safeguards analysis and monitoring scenario analysis for different reprocessing activities; as well as research into the public perceptions of UNF Management in the US. This breath of work gives Sandia a broad perspective on radioactive waste management and exercises the depth, breadth, and passion of our work in radioactive waste management.

Ken Sorenson presented an overview of the High Burn-Up Spent Fuel Data Project, in which Sandia is teaming with five other US DOE national labs to undertake technical evaluations of data from the project. This project involves loading a commercial TN-32B storage cask with high burn-up fuel in a utility storage pool. The fuel will be well characterized (using Zircaloy-4, Zirlo, and M5-clad high burnup fuels), and the cask will be outfitted with additional instrumentation for monitoring. A license amendment is actually required for lid design, high burnup fuel and additional heat load. The cask contents will be dried using typical processes. Then the cask will be housed at the utility's dry cask storage site. Gas sampling will be performed and externals of the cask inspected before moving to the pad. The issue of where and how the cask will be opened after the storage period will be solved at a later date. Participants in the project also include an industry team – led by the Electric Power Research Institute (EPRI) under a contract with the US DOE Office of Nuclear Energy – and six US DOE national laboratories. Tasks to be performed under the existing contract with EPRI include these: Acquire the cask, modify the cask lid for instrumentation, develop a design and licensing basis document, submit License Amendment Request, extract sister rods, plan the fuel loading, ship sister rods, secure the license amendment, load fuel in the cask, store the cask at North Anna Power Station (in central Virginia), and begin monitoring the cask and take internal gas samples. Many of these tasks are already complete. Cask cavity data acquisition will begin before the cask is drained. After backfill and pressurizing, the cask will remain in a cask preparation bay for 2-3 weeks for cavity temperature, pressure, and gas composition monitoring. Periodic cavity gas samples (fission gas, hydrogen content, and oxygen content) will be obtained and analyzed. Moisture data will provide immediate valuable insight to cask drying method.

Kevin McMahon provided an update on Sandia's support for the US DOE's Used Fuel Disposition R&D Campaign. He noted that the DOE is conducting research and development (R&D) activities within the Used Fuel Disposition Campaign (UFDC) to support the implementation of the DOE's 2013 Strategy for the Management and Disposal of used Nuclear Fuel and High-Level Radioactive Waste. The mission of the UFDC is to identify alternatives and conduct scientific research and technology development to enable storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles. UFDC R&D activities focused on storage, transportation, and disposal of used nuclear fuel (UNF) and wastes generated by existing and future nuclear fuel cycles are ongoing at nine national laboratories. Additional relevant R&D is conducted in parallel at multiple universities through the DOE's Nuclear Energy University Program.

Storage and transportation (S&T) R&D continues to focus on closing technical gaps related to extended storage, fuel retrievability and transportation after extended storage, and eventual large-scale transport of UNF and high-level radioactive waste. Emphasis for FY16 is on experimental and analytical activities that support the DOE's high-burnup fuel full-scale storage demonstration project initiated at the North Anna Nuclear Power Plant in Virginia by the Electric Power Research Institute. S&T activities include work to develop an understanding of how temperature and pressure affect cladding integrity in high-burnup UNF through both predictive modeling and

experimentation, developing an understanding of how corrosion and stress corrosion cracking affect performance of stainless steel dry storage canisters, and characterizing external loadings on UNF during normal conditions of transport.

Disposal research (DR) continues to provide a sound technical basis for multiple viable disposal options in the US, increase the confidence in the robustness of generic disposal concepts and develop the science and engineering tools needed to support disposal concept implementation. Current planning in FY16 calls for a significant increase in R&D associated with evaluating the feasibility of deep borehole disposal of some waste forms and initiating drilling at a deep borehole field test with testing completed by 2019. DR plans to complete the evaluation of direct disposal of dual-purpose canisters, develop experimental and modeling basis for understanding long-term performance of disposal systems in host rock disposal in argillite, salt, crystalline, or deep boreholes, and to develop reference cases for these generic disposal concepts. International collaborations that allow the U.S. program to benefit from experience and opportunities for research in other nations remain a high priority within DR.

Tito Bonano presented perspectives on the challenges of integration at the back-end of the nuclear fuel cycle. The back end of the nuclear fuel cycle in the United States (US) for commercial power generation starts when the spent nuclear fuel (SNF) is pulled out of the reactor and concludes when it is geologically disposed and consists of three basic components: storage, transportation, and disposal. Currently and due to the lack of a final disposal solution, nuclear power utilities in the US have established Independent Spent Fuel Storage Installations (ISFSIs) at both operating and shutdown reactor sites. As of 2013, there were 71,000 MTHM stored (49,000 MTHM in spent fuel pools and 22,000 MTHM in large dry-storage casks), and the current 100-nuclear reactor fleet is generating ~2,000 MTHM per year. It is projected that by ~2050, when the current US policy expects a geologic repository to be able to start operations, there will be ~140,000 MTHM of SNF in dry storage. In order to optimize space, labor, and cost efficiencies, utilities are loading SNF assemblies into on-site dry storage casks, which are evolving into a wide variety of very large canisters that can contain up to 37 PWR SNF assemblies with heat loads of up to 50kW. At present (i.e., 2015), there are ~2,000 loaded dry-storage casks of ~24 different basic designs, and – assuming the current practice continues – it is projected that by 2050 there will be ~10,000 loaded dry-storage casks. While, this practice is expedient for the utilities, it creates many downstream inefficiencies and challenges. The current loading of SNF in dry-storage casks has created an operationally complex system for managing the back end of the nuclear fuel cycle because it commits the system to one of three alternatives: (1) leaving the SNF in the dry-storage casks above ground for very long periods of time, (2) directly disposing of the large casks, or (3) opening the casks and repackaging the SNF for disposal in purpose-built canisters. The nuclear waste management system in the US was not designed or envisioned to implement any of these "sub-optimal" alternatives and each is accompanied by considerable technical, operational, regulatory and social challenges. Sandia National Laboratories have been examining these challenges and exploring options that can lead to a better integration of the storage transportation and disposal.

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Synopsis of Audience Questions/Responses

- *Bob Halstead, Director of the State of NV Nuclear Waste Project Office, made comments about review of the Yucca Mountain license application he and his staff conducted in 2008; he indicated that about 300 contentions need to be resolved and perhaps 30 more contentions will need resolution if and when the LA review resumed. He indicated that there will be additional sessions at WMS regarding YMP.*
- *With regard to testing related to stress corrosion cracking in spent nuclear fuel canisters, a questioner wanted to know if we would use stored, spent fuel.*
    - Ms. Saltzstein responded that surrogate fuel will be used due to the need to place strain gauges and accelerometers directly on the fuel to receive measurements (equipment and gauges that could not be used in a radioactive environment).
- *How long cladding will persist at the 400^0 C before reorientations occurs?*
    - Ms. Saltzstein noted that it does not take long at all. But modeling is showing that the fuel is not expected to reach the 400^0 C level.
- *Will the High Burn-Up Project shed any light on Cs release?*
    - Mr. Sorenson noted that the project will not be looking at that at this time for Cs, but that it will be looking at gas releases.
- *Is there a plan within the High Burn-Up Project to research the Ductile to Brittle Transition Temperature for high burnup fuel?*
    - Mr. Sorenson said that there is a plan to work on that area. Argonne National Laboratory is funded to continue research in this area.
- *Bob Halstead made some additional comment, this time on the High Burn-Up Demonstration Project. He noted that it is a good project. He went on to note that it was unfortunate that this couldn't have been done ten years ago when we were working on the package performance study for Yucca Mountain.*
- *Do we have a map of areas where we do not research or that are not suitable for a repository?*
    - Mr. McMahon noted that we don't have maps for parts of the US where we have or have not done research. We do have maps of the geologic attributes of the nation. US law currently prohibits us from performing site-specific research.
- *Wouldn't we want to know if there are areas in the US that are not worth considering?*
    - Mr. McMahon responded that we are not at that point yet. Many engineers would state that we could make any site work.
- *Disposal is problematic; baby sitting the waste is problematic. Should we as taxpayers be focused on just disposal or should we consider reprocessing?*
    - Mr. Bonano responded that Sandia National Labs is not in a position to decide on reprocessing, as it is a policy and not technical issue.
    - An audience member pointed out that the existing inventory in the US is such that reprocessing is not an option. The ORNL review of inventory concluded that only a very small percentage of the inventory should be considered for reprocessing.
    - The original questioner asserted that the ORNL study was inadequate and that we may need a larger amount of feedstock.

- *As Sandia studies issues related to integration at the back end of the nuclear fuel cycle, do those studies include an objective to try to come up with a life cycle cost to inform what the Nuclear Waste Fund should deal with in the future?*
    - Mr. Bonano noted that, if we need to repackage, that is a cost not contemplated in the past. We will also generate process waste streams, and the implications of these for life cycle cost will also have to be considered.