UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201-3367

April 24, 2024

Dr. Kathryn Huff
Assistant Secretary for Nuclear Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Dr. Huff:

The U.S. Nuclear Waste Technical Review Board (Board) is charged with evaluating the technical and scientific validity of activities undertaken by the U.S. Department of Energy (DOE) in implementing the Nuclear Waste Policy Act (NWPA). The Board is also required to report its findings, conclusions, and recommendations related to the management and disposition of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) to Congress and the Secretary of Energy. In discharging these responsibilities, the Board holds public meetings two or three times each year and then transmits its feedback to DOE in writing. This letter provides the Board's feedback on the topics discussed during the International Workshop on Siting of Radioactive Waste Facilities and Summer Board Meeting that the Board held on August 29-30, 2023, in Idaho Falls, Idaho.

On behalf of the Board, I want to thank you and your staff, as well as the staff from the national laboratories, for supporting these meetings. One purpose of the workshop was to obtain information that may be applicable to the DOE, Office of Nuclear Energy (DOE-NE) efforts to develop one or more federal interim storage facilities for commercial SNF using a consent-based siting process. The other purpose was to hear how DOE has addressed, or plans to address, the Board's previous recommendation to incorporate lessons learned into its consent-based siting efforts. The purpose of the Summer Meeting was to hear about DOE-NE's activities in the areas of consent-based siting, high burnup SNF (HBF),[1] and advanced reactor SNF and HLW disposition. Materials from the workshop and Summer Meeting are available online.[2]

The Board also thanks the staff from DOE as well as the staff from the national laboratories, for supporting technical non-public fact-finding meetings on June 29, 2023, and July 17, 2023. These fact-finding meetings enabled the Board to better prepare for the workshop and Summer Meeting.

[1] Fuel burnup is a measure of the thermal energy generated in a nuclear reactor per unit mass of nuclear fuel as initially loaded in the reactor and is typically expressed in units of gigawatt-days per metric ton of uranium (GWd/MTU). In the U.S., the U.S. Nuclear Regulatory Commission defines nuclear fuel utilized beyond 45 GWd/MTU as high burnup fuel.

[2] The agenda, presentations, transcript, public comments submitted online during the Summer Meeting, and an archived recording of the webcast for the meeting are at https://www.nwtrb.gov/meetings/past-meetings/summer-2023-board-meeting---august-30-2023. The same materials for the workshop and an independent consultant's report, are at https://www.nwtrb.gov/meetings/past-meetings/summer-2023-workshop---august-29-2023.

Background

Over the past decade, DOE has been conducting research and development (R&D) activities to enable the storage, transportation, and eventual disposal of SNF and HLW from existing and potential future nuclear fuel cycles. In addition, DOE's Office of Integrated Waste Management (IWM) mission is to construct one or more federal interim storage facilities, using a consent-based siting process, ready to receive commercial SNF as soon as practicable. The Board has previously reviewed DOE's activities on its consent-based siting process and found that there were additional actions DOE could consider to further strengthen its consent-based siting effort, including learning from domestic siting experiences and siting processes in other nations.[3] DOE's recent efforts to use a consent-based siting approach included development and release of a consent-based siting process for federal consolidated interim storage of SNF. Also, DOE funded twelve awardees (i.e., consent-based siting consortia) from its funding opportunity announcement to serve as information, engagement, and resource hubs. DOE has conducted research to learn from past siting activities and environmental justice[4] practices and developed digital tools for engagement. IWM has been conducting technical activities related to transportation preparations, storage implementation (e.g., storage facility design), and system analysis needed for implementation of a federal consolidated interim storage facility within an integrated waste management system that includes disposal.

DOE's HBF R&D has focused on developing a better understanding of the characteristics of HBF to determine the performance and potential degradation of HBF during extended storage and subsequent transportation. DOE's efforts include the High Burnup Spent Fuel Data Project (or "Demo Project") that includes a demonstration cask that stores HBF assemblies from pressurized water reactors. That project also included detailed examinations of 25 HBF "sister" rods (aka sibling pins) withdrawn from assemblies in the demonstration cask or assemblies similar to those in the cask. The Board has evaluated DOE's efforts,[5] most recently at the Board's Winter 2022 meeting on March 1-2, 2022.[6] Examination of the 25 sister rods is ongoing but nearly complete. DOE plans to examine SNF from the demonstration cask after it is transported to a hot cell facility in 2027.

In addition to the HBF related projects, DOE completed a preliminary R&D gap analysis for the performance of accident tolerant fuels and other advanced fuels, including metallic and TRISO

[3] Bahr, J.M. 2022. Board letter to DOE following March 2022 meeting (June 7, 2022). https://www.nwtrb.gov/docs/default-source/correspondence/jmb041.pdf?sfvrsn=4. (last accessed April 4, 2024).

[4] As described by DOE, environmental justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, Tribal affiliation, or disability with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

[5] NWTRB. 2021. *Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Spent Nuclear Fuel During Extended Storage and Transportation*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. July.

[6] Bahr, J.M. 2022. Board letter to DOE following March 2022 meeting (June 7, 2022). https://www.nwtrb.gov/docs/default-source/correspondence/jmb041.pdf?sfvrsn=4. (last accessed April 4, 2024).

(tri-structural isotropic) fuels, during storage and transportation.[7] The Board reviewed DOE's R&D activities related to advanced nuclear fuels for light water reactors, including accident tolerant fuels, and the impact of these fuels on SNF management and disposal.[8] DOE's advanced reactor SNF and HLW disposition R&D efforts were recently accelerated due to dedicated funding in fiscal years 2022 and 2023. DOE is seeking information from advanced reactor developers necessary to address regulatory and legal issues (such as, with the Standard Contract[9]) and to identify storage, transportation and disposal R&D gaps related to SNF and HLW that could be generated by advanced reactors.

Overview of the International Workshop and Summer Meeting

The workshop included presentations, facilitated panel discussions and an open house at the conclusion of the workshop.[10] Presentations by invited speakers from Canada (remotely), Sweden, and Switzerland (in person) focused on those country's siting processes for nuclear waste repositories and the lessons from those activities. An invited US speaker addressed lessons from past US waste facility siting attempts and the efforts of the Office of the Nuclear Waste Negotiator. The morning session ended with a facilitated discussion among the Swedish, Swiss, and US speakers. In the afternoon, DOE staff described how DOE is incorporating international siting and domestic best practices and lessons into their consent-based siting activities. Next, they described how DOE is using best practices and lessons from environmental justice. A facilitated discussion among the Swedish, Swiss, and US speakers and DOE staff followed.

The morning session of the Summer Meeting focused on DOE's consent-based siting activities. DOE staff provided an activities update, addressed how they are incorporating environmental justice and social science in consent-based siting, and described how they are developing digital tools for engagement.

During the afternoon, DOE and national laboratory staff provided an update on their HBF R&D. The speakers summarized the Phase I sibling pin test campaign and provided an overview of the draft Phase II test plan. DOE staff described how they are addressing back-end management of SNF and HLW from advanced reactors. The national laboratory staff described a detailed R&D gap analysis that is under development for accident tolerant fuels, high burnup/higher enrichment fuels, and advanced reactor SNF and waste forms for storage and transportation. DOE staff

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[7] Honnold, P. et. al. 2021. *High Level Gap Analysis for Accident Tolerant and Advanced Fuels for Storage and Transportation*. Albuquerque, New Mexico: Sandia National Laboratories. April https://www.osti.gov/servlets/purl/1813674 (last accessed April 4, 2024).

[8] Bahr, J.M. 2022. Board letter to DOE following May 2021 meeting (August 12, 2021). https://www.nwtrb.gov/docs/default-source/correspondence/jmb035.pdf?sfvrsn=6. (last accessed April 4, 2024).

[9] The *Standard Contract for Disposal of SNF and/or HLW* ("DOE Standard Contract") establishes the terms and conditions under which DOE will make available nuclear waste disposal services to the owners and generators of SNF and HLW. DOE will take title to, transport, and dispose of SNF and/or HLW delivered to DOE by those owners or generators who execute the contract.

[10] DOE displayed three-dimensional (3-D) models of storage and transportation equipment, written materials describing DOE's consent-based siting efforts, and an immersive 3-D virtual reality tour of an SNF interim storage facility. These materials were the focus of the open house and remained available during the Summer Meeting.

stated that they plan to conduct an analysis of features, events, and processes for these same materials to identify the R&D gaps for disposal applications. The Board appreciates the thorough presentations given by the DOE and national laboratory speakers as well as their detailed responses to the Board's questions throughout the workshop and Summer Meeting.

Board Conclusions, Findings, and Recommendations

Based on the information presented at the workshop, Summer Meeting, the June 29, 2023, and July 17, 2023, fact-finding meetings, and in related technical reports, the Board has developed several conclusions, findings, and recommendations on DOE's consent-based siting activities and its HBF and advanced reactor waste disposition R&D. The Board has also developed a number of observations on topics that are outside of DOE's control under the NWPA, as amended, but are likely to impact DOE efforts to construct one or more federal interim storage facilities using a consent-based siting process. These conclusions, findings, recommendations, and observations follow. The enclosure provides more background and details regarding the meeting topics, the Board's evaluation, and again presents the Board's conclusions, findings, recommendations, and observations.

<u>DOE's Activities on Consolidated Interim Storage Facilities for Commercial SNF</u>

DOE's current consent-based siting efforts, which began in 2021, are still relatively new. Nevertheless, it is apparent that there has already been significant forward movement, especially in building capacity.[11] The Board commends DOE for its important, continuing efforts to assemble the needed consent-based siting scientific and technical personnel and expertise. For this extended process, which is currently estimated to last more than 10 years,[12] the Board has identified several areas that DOE could strengthen as it moves ahead:

- Access to scientific and technical information.
- Communication of complex scientific and technical information.
- Building capacity and incorporating scientific and technical information from the disciplines of public health, medicine, emergency management, and health physics.
- Measuring and evaluating progress toward achieving goals.
- Addressing intergenerational issues.

Finding 1: The Board finds that effectively meeting public information needs is an important component of consent-based siting. For interested parties to be informed about and empowered

[11] "Building capacity" is the process of developing and strengthening the skills, abilities, processes, and resources that DOE needs to implement a consent-based siting process, including the provision of funding to interested parties. DOE describes building capacity as including federal funding that would be provided to interested parties to learn more, increase engagement, and strengthen their capacity to participate in the consent-based siting process. (DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.)

[12] DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.

in the siting process,[13] they need consistent and timely access to scientific and technical information. Providing such information will support effective engagement, help inform understanding of the many complex consent-based siting issues, and foster trust between the public and DOE.

Recommendation 1: The Board recommends that consent-based siting-related information that will be produced by DOE and the consent-based siting consortia be made available to the public in as timely a manner as practicable.

Finding 2: The Board finds that the communication of complex scientific and technical information is a crucial part of consent-based siting efforts, and notes that DOE is contemplating various efforts to disseminate such information. In successful siting cases for radioactive waste facilities in Sweden and Switzerland, members of the public often preferred communication and information to come directly from scientists and engineers involved in the program rather than from public affairs or public relations staff. To meet this need, some program scientists and engineers engaged directly with the public, and worked to become more adept at explaining complex scientific and technical information about radioactive waste management facilities in clear, jargon-free language. The vital communication role played by scientists and engineers in successful siting efforts is consistent with what is also known from research and experience. The International Radiation Protection Association considers this a best practice.[14]

Recommendation 2: The Board recommends that DOE use successful siting cases for radioactive waste facilities in other countries, results from research, and best practices to explore what training or other efforts would be most helpful in preparing various scientists and engineers associated with the U.S. consolidated interim storage program to be able to engage in sustained and effective dialog with members of the public.

Finding 3a: The Board commends DOE for incorporating a wide range of social and behavioral science disciplines into its consent-based siting efforts. At the same time, the Board finds that additional cutting-edge work in radiation risk communication and related topics has taken place in such fields as public health, medicine, emergency management, and health physics. These fields need to regularly interact and communicate with members of the public about radiation, uses of radioactive and nuclear materials and technologies, and radiation safety and health. The Board finds that DOE has not yet fully incorporated this important, additional cutting-edge work in radiation risk communication and related topics into its consent-based siting efforts.

Finding 3b: The Board finds that although DOE has been able to successfully increase consent-based siting capacity and staffing, additional sustained resources and personnel (including full-time staff with expertise in such areas as risk communication) would further strengthen the

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[13] NWTRB. 2015. *Designing A Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: An Overview and Summary*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. November.

[14] International Radiation Protection Association. 2020. *Practical Guidance for Engagement with the Public on Radiation and Risk*. https://www.irpa.net/members/IRPA%20Guidance%20Public%20Engagement.pdf. (last accessed April 4, 2024).

consent-based siting process as it proceeds. By not having such expertise, important and directly relevant work could be missed or repeated unnecessarily by DOE.

Recommendation 3: As DOE continues to assemble needed expertise and information related to consent based siting, the Board recommends that DOE take steps to broaden its approach, such as: a) ensuring a high level of expertise and experience in such areas as risk communication, and b) systematically including technical literature and research from the disciplines of public health, medicine, emergency management, and health physics. Likewise, the Board recommends that when DOE gives public presentations on its consent-based siting activities, insights from these fields and publications describing key sources of information informing project efforts be included in slides.

Finding 4: The Board finds that as part of successful siting programs in Sweden and other countries, different evaluation approaches, methodologies, and metrics have been employed by each country to help assess the effectiveness of consent-based siting efforts. For example, in Sweden, the implementer collected, analyzed, and reviewed data over an extended time on the percent of the population willing to engage as part of the overall evaluation strategy. DOE described that in fiscal year 2024 it will be looking at potential metrics that could be applied to its communications and to its consent-based siting program. Likewise, the Board finds that such methods and metrics could be used by DOE, for example, to analyze which program-related activities are working well and which ones need to be strengthened, to measure whether consent-based siting program communications are effective, and to assess the extent to which different interested groups are being reached and engaged.

Recommendation 4: As DOE's consent-based siting effort continues to develop, the Board recommends that DOE identify state-of-the-art evaluation approaches, methods, indicators, and metrics that can be utilized to gauge the extent to which key goals are being achieved.

Finding 5: Consent-based siting issues have important implications not only for the present but also for the future (siting could take a decade or more and the transportation of SNF and storage at a sited facility could last decades). Thus, it will be important to understand key intergenerational issues and include the perspectives of younger people in the process. The Board finds that as DOE develops its own consent-based siting process, it would be valuable to identify and implement effective mechanisms to directly engage young people and gain a better understanding of intergenerational aspects of siting decisions.

<u>Observations on Implementing Consolidated Interim Storage</u>

As stated at the beginning of this letter, the Board's mandate is to evaluate the technical and scientific validity of activities undertaken by DOE. However, as a result of its past and ongoing reviews, the Board has come to recognize two key societal challenges that will likely affect DOE's efforts to successfully implement a consolidated interim storage program. These challenges are: 1) the need for timely progress toward the long-term solution of disposal of SNF

and HLW in an underground geologic repository;[15] and 2) the need for a legal and regulatory framework that is fully supportive of a consent-based siting approach, including the satisfactory treatment of the key role that states have in decision-making.[16] Solutions to these challenges will likely require budgetary and policy decisions by policymakers.

In keeping with the Board's technical mandate, the Board takes no position on whether a new effort should be undertaken to site either the country's first or second repository, or how to implement a consent-based siting approach; policymakers will make those decisions. The Board offers the following two observations that can inform Congressional decision-making regarding a path forward on SNF and HLW management and disposal *if* policymakers decide to move forward.

Observation 1: Information from the Board's past and recent reviews (including the experiences from other countries) show that timely progress on a geologic disposal program for SNF and HLW is needed now to provide confidence that storage of SNF at a federal consolidated storage facility will be interim and not permanent. Such confidence will be necessary for consent from states, Tribes, and communities.

Observation 2: If a consent-based siting approach is used for a federal consolidated interim storage facility or a repository, a consultation and concurrence approach with states and Tribes, rather than the consultation and cooperation approach currently embodied in the NWPA, as amended, will likely need to be explored both in terms of the timing (for example, when does consultation and concurrence begin and end) and extent (for example, what issues are subject to concurrence and who are the responsible concurring parties).

<u>High Burnup SNF</u>

DOE's R&D has focused on better understanding the characteristics of HBF, including the fuel's cladding, to determine the performance and potential degradation of HBF during extended storage and subsequent transportation. The Phase I testing of HBF sibling pins is ongoing, and largely complete. DOE has completed an extensive multi-modal transportation test with surrogate SNF. The mechanical loads expected during transportation are well within the capacity of the fuel cladding to resist degradation. The cladding temperatures and hoop stresses in the HBF rods examined have been determined to be too low to cause potentially damaging radial hydride formation within the cladding. As a result, our opinion is that many of the information gaps on issues of potential importance to HBF performance during storage and transportation can be closed. However, the Board notes that DOE has not addressed all the Board's 2021 recommendations on HBF.[17] The Board understands, from discussions at a

[15] NWTRB. 2021. *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. April.

[16] NWTRB. 2015. *Designing A Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: Detailed Analysis*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. November.

[17] NWTRB. 2021. *Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Spent Nuclear Fuel During Extended Storage and Transportation*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. July.

February 28, 2024, fact-finding meeting, that DOE may soon make significant changes to its HBF storage and transportation R&D program and that the start of Phase II testing has been put on hold. The Board will provide, in a separate letter, the Board's assessment of the status of DOE's current R&D efforts relative to the Board's 2021 recommendations on HBF.

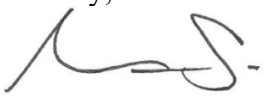
Advanced Reactor Waste Disposition

The NWPA, as amended, stipulates that an operating license for a reactor cannot be issued by the U.S. Nuclear Regulatory Commission unless the applicant has entered into a contract with the Secretary of Energy for the disposal of SNF and HLW generated from the reactor's operation.[18] DOE will need enough data, describing the characteristics of both the initial fuel and the discharged SNF and HLW and operations (e.g., storage canister design and what constitutes "failed fuel"), from a potential applicant to allow DOE to determine whether to enter such a contract.

Finding 6: DOE has initiated an effort to assess the potential impacts of various advanced nuclear fuels on storing, transporting, and disposing of SNF and HLW by requesting data from advanced reactor vendors. DOE is also developing a strategy to identify knowledge gaps and outline areas where further research would contribute to a well-defined disposition pathway for SNF and HLW resulting from advanced reactor operations. This effort will inform DOE decisions concerning how to proceed and how to deal with the impacts. The Board commends DOE for initiating this assessment and strongly endorses the effort.

Thank you again, on behalf of the Board, for the participation of DOE staff and technical experts from the national laboratories at our June and July 2023, and February 2024, fact-finding meetings and at the workshop and Summer Meeting in August 2023. We look forward to continuing our ongoing evaluation of the technical and scientific validity of DOE's activities related to managing and disposing of SNF and HLW.

Sincerely,



Nathan Siu
Chair

Enclosure

cc: Mr. Paul Murray, DOE-NE
Mr. Tim Gunter, DOE-NE
Dr. Erica Bickford, DOE-NE
Ms. Marla Morales, DOE-NE

[18] The *Standard Contract for Disposal of SNF and/or HLW* ("DOE Standard Contract") establishes the terms and conditions under which DOE will make available nuclear waste disposal services to the owners and generators of SNF and HLW. DOE will take title to, transport, and dispose of SNF and/or HLW delivered to DOE by those owners or generators who execute the contract.

Enclosure

International Workshop on Siting of Radioactive Waste Facilities and Summer 2023 Board Meeting

Evaluation Findings, Conclusions, Recommendations, and Observations

This enclosure summarizes U.S. Department of Energy's (DOE's) presentations at the Summer Meeting and the workshop, provides background and details regarding the meeting topics, and presents the Board's evaluation of DOE's activities and the Board's findings, conclusions, and recommendations. [**Topics** (all words are initial uppercase and bold) and subtopics (first word is uppercase) are underlined, *Board findings and conclusions are presented in italics*, and **Board recommendations are presented in bold text]**.

This enclosure also includes an analysis of topics that are outside of DOE's control under the Nuclear Waste Policy Act (NWPA), as amended,[19] but are likely to impact DOE efforts to construct one or more federal interim storage facilities for commercial spent nuclear fuel (SNF) using a consent-based siting process. The Board's analysis and **two observations** (**in bold text**) provide policymakers with information that is relevant to DOE's efforts and the potential for success.

DOE's Activities on Consolidated Interim Storage Facilities for Commercial SNF

As part of its Winter (March 1-2) 2022 meeting, the Board reviewed DOE's activities on the consent-based siting process for federal interim storage facilities for commercial spent nuclear fuel (SNF). The Board found that that there were additional actions that DOE could take to learn from domestic siting experiences and siting processes in other nations and to strengthen its overall consent-based siting effort.[20] The Board also heard an update on DOE's consent-based siting activities at its Spring (March 28) 2023 meeting. The Board commended DOE for starting to look into developing metrics (i.e., ways to measure and assess efforts to engage Tribal nations) to systematically evaluate the extent to which such engagement efforts have been successful, and stated it looked forward to seeing more detailed information about such metrics at future Board meetings.[21] Consistent with its mandate for an ongoing review of DOE's activities, the Board

[19] Hereafter in the enclosure the use of NWPA means the NWPA, as amended, except in direct quotations or where the NWPA of 1982 is noted.

[20] Bahr, J.M. 2022. Board letter to DOE following March 2022 meeting (June 7, 2022). https://www.nwtrb.gov/docs/default-source/correspondence/jmb041.pdf?sfvrsn=4. (last accessed April 4, 2024). DOE response to the Board letter: Huff, K. 2023. DOE Response to the Nuclear Waste Technical Review Board (NWTRB) Report from the NWTRB 2022 Winter Meeting (July 5, 2023). https://www.nwtrb.gov/docs/default-source/correspondence/doe_aug-21-2023.pdf?sfvrsn=6). (last accessed April 4, 2024).

[21] Siu, N. 2023. Board letter to DOE following March 2023 meeting (August 24, 2023). https://www.nwtrb.gov/docs/default-source/correspondence/nos008vf---board-letter-march-28-meeting.pdf?sfvrsn=4. (last accessed April 4, 2024).

utilized the August 2023 workshop and Summer Meeting to continue its review of DOE's consent-based siting activities.[22]

The Board organized its latest review of this topic around the following subtopics.

- Access to scientific and technical information.
- Communication of complex scientific and technical information.
- Building capacity and incorporating scientific and technical information from the disciplines of public health, medicine, emergency management, and health physics.
- Measuring and evaluating progress toward achieving goals.
- Addressing intergenerational issues.

Access to scientific and technical information

In the workshop, DOE staff described how they are incorporating international siting and domestic best practices and lessons learned into DOE's consent-based siting activities. DOE staff stated that during fiscal years 2023 and 2024, they are conducting literature reviews and completing in-depth case studies of international experiences and documenting these along with the status of each country's SNF management program.[23] These "case study" documents provide both insights into the current and historical sociopolitical environment of these countries and basic technical information. DOE staff stated that these case studies and associated single-page summaries ("fact sheets") were developed for use by DOE and national laboratory staff. DOE staff stated that they did not develop the documents with the public in mind and had not intended for the documents to be publicly available.

DOE staff described in the workshop how they are identifying lessons learned in a variety of sectors[24] (non-nuclear as well as nuclear) from previous domestic cases of siting facilities that have encountered a large amount of social scrutiny. The results, to be documented in in six exemplar reports,[25] will reflect a mixture of case studies and interviews from people who were involved. DOE plans to gather best practices and lessons learned from the exemplar studies that could be applicable to its own effort and consolidate that knowledge in a summary report. DOE

[22] The Board's visits over the last 10 years to Sweden, Switzerland, and Canada have also informed our review. For example, in October 2023, the Board visited Ontario Canada to exchange information with key scientific and technical nuclear waste management organizations and a potential repository host community and to gain an understanding of potential activities that the Canadian implementer and DOE may conduct jointly on consent-based siting.

[23] The country reports for fiscal year 2023 address Canada, the United Kingdom, Switzerland, Finland, and Germany.

[24] A sector is an area of the economy in which businesses share the same or related business activity, product, or service.

[25] In 2022, the Board had suggested that DOE look at high-risk, as perceived by the public, facilities, such as a biosafety level 4 facility, as part of their plans for evaluating domestic siting experience. DOE has completed case studies for the Office of the Nuclear Waste Negotiator, a biosafety level 4 facility, and a solar energy project. DOE plans to complete, in fiscal year 2024, exemplar studies in the wind sector, petrochemical manufacturing sector, and another in the nuclear sector (i.e., Western Uranium & Vanadium mill).

staff stated that they did not develop the exemplar reports with the public in mind and had not intended for the documents to be publicly available. In response to questions from the Board, the DOE staff stated that they could consider making the reports public, eventually.

In the workshop, DOE staff described the different facets of environmental justice and how DOE is using best practices and lessons learned from the field. DOE staff indicated that procedural justice, a part of environmental justice, includes the notion of meaningful involvement. Procedural justice addresses the equitable access of stakeholders and entities to the processes of decision making, including provision of access to information. DOE staff stated that it had completed an environmental and energy justice literature review, which is non-public, for its consent-based siting program. In describing its environmental justice efforts in the Summer Meeting, DOE staff discussed the development and use of a digital tool known as CURIE.[26] This resource management database includes access-restricted libraries in which materials are not available to the public. DOE has developed a resource library in CURIE for the consent-based siting consortia that is access restricted but allows DOE and consortia members to add resources to the library. DOE is limiting the materials it is adding to the resource library in CURIE for the consortia to avoid overwhelming the consortia.

The Board commends DOE for its efforts to identify and incorporate lessons learned from domestic and international siting efforts into its consent-based siting program and acknowledges DOE's rapid progress in a short period. However, the Board notes that access to scientific and technical information developed in DOE's studies and information generated by the consortia is valuable not only to DOE but also to the public.

Finding 1: The Board finds that effectively meeting public information needs is an important component of consent-based siting. For interested parties to be informed about and empowered in the siting process,[27] they need consistent and timely access to scientific and technical information. Providing such information will support effective engagement, help inform understanding of the many complex consent-based siting issues, and foster trust between the public and DOE.

Recommendation 1: The Board recommends that consent-based siting-related information that will be produced by DOE and the consent-based siting consortia be made available to the public in as timely a manner as possible.

Communication of complex scientific and technical information

At the workshop, presentations by invited speakers from Canada, Sweden, and Switzerland focused on their country's siting processes and the lessons learned from those activities. The Board observes that in successful siting cases in Sweden and Switzerland, members of the public

[26] CURIE is the Resource Portal for DOE Nuclear Waste Management Information and is at https://curie.pnnl.gov/. (last accessed April 4, 2024)

[27] NWTRB. 2015. *Designing A Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: An Overview and Summary*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. November.

often preferred face-to-face communication and preferred that information come directly from scientists and engineers working on the project rather than from public affairs or public relations staff. Public information specialists certainly had a role to play; but hearing directly from scientists and engineers was an essential component in fostering genuine dialog and understanding and in establishing credibility and trust. As explained by the Swedish and Swiss speakers, scientists and engineers engaged directly with the public, and worked to become more adept at explaining complex scientific and technical information associated with radioactive waste facilities in clear, jargon-free language. The vital communication role played by scientists and engineers in successful siting efforts is consistent with what is also known from research. Scientists tend to rank highly in terms of public trust and confidence (even though there are variations across countries and populations).[28] This means the public looks to individuals with relevant scientific and technical expertise for information, particularly in relation to technically complex topics.[29] Indeed, the International Radiation Protection Association has described direct engagement of technical experts with the public as a best practice. In its benchmarks of good practice, the International Radiation Protection Association advises that communication not be left only to non-specialists; rather, it is particularly important for knowledgeable professionals with scientific and technical expertise about radioactive materials, safety, and risk to engage directly with the public.[30]

Finding 2: The Board finds that the communication of complex scientific and technical information is a crucial part of consent-based siting efforts, and notes that DOE is contemplating various efforts to disseminate information. In successful siting cases for radioactive waste facilities in Sweden and Switzerland, members of the public often preferred communication and information to come directly from scientists and engineers involved in the program rather than from public affairs or public relations staff. To meet this need, some program scientists and engineers engaged directly with the public, and worked to become more adept at explaining complex scientific and technical information about radioactive waste management facilities in clear, jargon-free language. The vital communication role played by scientists and engineers in successful siting efforts is consistent with what is also known from research and experience. The International Radiation Protection Association considers this a best practice.[31]

Recommendation 2: The Board recommends that DOE use successful siting cases for radioactive waste facilities in other countries, results from research, and best practices to explore what training or other efforts would be most helpful in preparing various scientists

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[28] See for example, National Science Board (NSB), National Science Foundation. 2022. "Science and Technology: Public Perceptions, Awareness, and Information Sources." *Science and Engineering Indicators* 2022. NSB-2022-7. Alexandria, VA. https://ncses.nsf.gov/pubs/nsb20227 (last accessed April 4, 2024).

[29] See, for example, Lang, J.T. and W.K. Hallman. 2005. "Who does the public trust? The case of genetically modified food in the United States." *Risk Analysis* 25(5): 1241-1252.

[30] International Radiation Protection Association. 2020. *Practical Guidance for Engagement with the Public on Radiation and Risk*. https://www.irpa.net/members/IRPA%20Guidance%20Public%20Engagement.pdf. (last accessed April 4, 2024).

[31] Ibid.

and engineers associated with the U.S. consolidated interim storage program to be able to engage in sustained and effective dialog with members of the public.

Building capacity and incorporating scientific and technical information from other disciplines

The Board recognizes that DOE is early into the multi-year consent-based siting enterprise. DOE's consent-based siting efforts to date include hiring new federal staff to work on multi-disciplinary issues such as those that intersect with social and behavioral sciences, and environmental justice.[32] DOE has also developed its consent-based siting process document[33] and has funded twelve consent-based siting consortia that serve as information, engagement, and resource hubs. Both DOE's staffing efforts and the consortia are integral parts of building capacity and collaboration that DOE believes it will need to implement its consent-based siting process.

In the Summer Meeting, DOE staff presented an update on its consent-based siting activities and an overview of environmental justice in consent-based siting. DOE staff stated that the consortia (whose participants are located across the nation and many of them associated with universities) will conduct robust engagement activities in their communities and enable mutual learning. The collaboration with communities and building capacity within and between the consortia will occur over the course of 18 to 24 months, which is the period of performance for the cooperative agreements with the individual consortia.[34] DOE staff stated that the consortia resources to be developed are critical in allowing interested communities the opportunity to learn more about nuclear waste, the management of commercial SNF, and the role that a consolidated interim storage facility may have in their community.

DOE staff also described how they are incorporating social science into consent-based siting and developing digital tools for engagement. As of August 2023, the DOE consent-based siting staff included three social scientists (i.e., a psychologist, a cultural anthropologist, and a social scientist) and a physical scientist with a degree in health physics.[35] The DOE staff stated that the

[32] DOE staff described that the development of StoryMaps, one of their digital tools for engagement, has brought the social scientists together with the other technical staff to develop communication products on technical topics that are accessible and appealing to the public. DOE social scientists are working with other technical staff on some of the transportation studies and assessments, including the preparations for a potential package performance demonstration.

[33] DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.

[34] In August 2023, DOE had not finalized any of the cooperative agreements. Currently all consortia have signed agreements and have begun implementing their proposed activities. Under the agreements the consortia will organize, lead, and maintain meaningful, inclusive community and stakeholder engagement processes related to nuclear waste management. The second task required under the agreements is that the consortia will map public values, interests, concerns, and goals to promote and enable effective collaboration and community-driven feedback. Finally, DOE requires the consortia to develop, implement, and report on outcomes, strategies and activities that support mutual learning among the DOE, stakeholders, communities, and experts on nuclear waste-related topics. DOE's intent is to use the information learned from the consent-based siting consortia to revise or adjust its consent-based siting process.

[35] DOE's physical scientist on the consent-based siting team, whose expertise included risk communication, left the agency in September 2023.

three social scientists "cover anthropology, science and technology studies, geography, psychology, behavioral science, science communication, and risk communication which includes risk perception." DOE staff acknowledged that there is considerable research in risk analysis and risk perception and understanding what influences how people perceive risks.

The Board notes that a draft literature review authored by national laboratory staff on social science and SNF that addressed consent-based siting did not appear to include recent studies (such as those on the Fukushima Dai-ichi crisis and its aftermath). These recent studies addressed a range of topics related to risk, risk communication, community engagement, and radiation. For example, in responding to DOE's social science presentation, a Board member explained that considerable new and innovative work about citizen science has been performed in the aftermath of the crisis at Fukushima Dai-ichi.[36] The DOE staff stated that although they were not aware of that literature it could be an exciting avenue to explore. In the Summer Meeting, a Board member also stated that several journals[37] that are directly relevant to the work DOE is conducting are not indexed in social science indices and that DOE could be missing important, relevant work.

Finding 3a: The Board commends DOE for incorporating a wide range of social and behavioral science disciplines into its consent-based siting efforts. At the same time, the Board finds that additional cutting-edge work in radiation risk communication and related topics has taken place in such fields as public health, medicine, emergency management, and health physics. These fields need to regularly interact and communicate with members of the public about radiation, uses of radioactive and nuclear materials and technologies, and radiation safety and health. The Board finds that DOE has not yet fully incorporated this important, additional cutting-edge work in radiation risk communication and related topics into its consent-based siting efforts.

In the Summer Meeting, DOE staff stated they have limited resources and are relying on the staff they have, with support from national laboratory staff with backgrounds in public health, to address knowledge in risk communication and related topics. The Board again notes the importance of communication of complex scientific and technical information to the public in face-to-face situations and the need for DOE to explore training or other efforts that would be most helpful in preparing its scientists and engineers for that type of communication.[38] Having DOE staff expertise in risk communication available to the consent-based siting team could

[36] There is now a growing literature that discusses citizen science, citizen radiation monitoring, citizen engagement, and related topics after the Fukushima Dai-ichi crisis. Examples include: Kenens J. 2020. "Changing perspectives: tracing the evolution of citizen radiation measuring organizations after Fukushima." *Radioprotection* 55(HS2); Brown A. *et al*. 2016. "Safecast: successful citizen-science for radiation measurement and communication after Fukushima." *J. Radiol. Prot.* 36(S82); and van Oudheusden M., J. Kenens, G. Yoshizawa, and N.Mizushima. 2019. *Learning from citizen science after Fukushima: probing the role and potential of citizen science in nuclear science and technology governance in Japan and Belgium*. Brussels: SCK CEN (The Belgian Nuclear Research Centre).

[37] These journals include British Medical Journal, Prehospital and Disaster Medicine, American Journal of Public Health, and Health Physics. The Board notes that DOE's draft report on social science and SNF did not cite any of these journals.

[38] The Board previously recommended that DOE anticipate required personnel needs in the Board's *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward* report. NWTRB 2021. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. April.

better enable DOE to assess its training needs, define and evaluate the support provided by the national laboratories, and facilitate evaluation of the materials developed by the consent-based siting consortia.

Finding 3b: The Board finds that although DOE has been able to successfully increase consent-based siting capacity and staffing, additional sustained resources and personnel (including full-time staff with expertise in such areas as risk communication) would further strengthen the consent-based siting process as it proceeds. By not having such expertise, important and directly relevant work could be missed or repeated unnecessarily by DOE.

Recommendation 3: As DOE continues to assemble needed expertise and information related to consent based siting, the Board recommends that DOE take steps to broaden its approach, such as: a) ensuring a high level of expertise and experience in such areas as risk communication, and b) systematically including technical literature and research from the disciplines of public health, medicine, emergency management, and health physics. Likewise, the Board recommends that when DOE gives public presentations on its consent-based siting activities, insights from these fields and publications describing key sources of information informing project efforts be included in slides.

Measuring and evaluating progress toward achieving goals

At the Board's March 28, 2023, meeting, DOE staff stated that it would be looking into developing metrics (i.e., ways to measure and systematically evaluate Tribal nation engagement and progress) to assess or track the extent to which such engagement efforts have been successful. The Board stated it looked forward to seeing more detailed information about such metrics at future Board meetings.[39] During the workshop and Summer Meeting, invited experts from other countries and DOE staff discussed the topic of measuring and evaluating progress toward achieving goals of siting programs for radioactive waste management facilities. DOE staff stated that in fiscal year 2024, they would be developing evaluation strategies and metrics. DOE's task is challenging because it needs to assess its own efforts, the work conducted by the national laboratories, and the efforts of the consortia. DOE's intent is to use the information learned from the consent-based siting consortia to revise or adjust its consent-based siting process.

Developing an appropriate evaluation strategy will require considerable thought regarding what to assess, what data to gather, what methods to employ (e.g., quantitative, qualitative, mixed), and how to involve stakeholders and other entities, outside experts, and others in the evaluation process. In some cases, evaluation strategies and metrics from international experience may be useful. In other cases, different approaches and methods might be needed for the U.S. context. Evaluations of previous DOE siting and engagement efforts could be useful, as could evaluation-related documents used in other parts of DOE. Other federal agencies, including those that deal with issues related to safety, health, and environment, have well-developed evaluation guides

[39] Siu, N. 2023. Board letter to DOE following March 2023 meeting (August 24, 2023). https://www.nwtrb.gov/docs/default-source/correspondence/nos008vf---board-letter-march-28-meeting.pdf?sfvrsn=4. (last accessed April 4, 2024).

that may be relevant.[40] Since a centrally important component of evaluating a consent-based siting effort involves assessing the effectiveness of engagement efforts, it will be important to consult evaluation literature and handbooks specifically focused on that topic.

Finding 4: The Board finds that as part of successful siting programs in Sweden and other countries, different evaluation approaches, methodologies, and metrics have been employed by each country to help assess the effectiveness of consent-based siting efforts. For example, in Sweden, the implementer collected, analyzed, and reviewed data over an extended time on the percent of the population willing to engage as part of the overall evaluation strategy. DOE described that in fiscal year 2024 it will be looking at potential metrics that could be applied to its communications and to its consent-based siting program. Likewise, the Board finds that such methods and metrics could be used by DOE, for example, to analyze which program-related activities are working well and which ones need to be strengthened, to measure whether consent-based siting program communications are effective, and to assess the extent to which different interested groups are being reached and engaged.

Recommendation 4: As DOE's consent-based siting effort continues to develop, the Board recommends that DOE identify state-of-the-art evaluation approaches, methods, indicators, and metrics that can be utilized to gauge the extent to which key aims are being achieved.

Addressing intergenerational issues

DOE staff stated in both the workshop and Summer Meeting that it is conducting an analysis of intergenerational justice and intergenerational equity.[41] The purpose of this analysis is to identify best practices for understanding these issues and to identify mechanisms for achieving restorative justice while ensuring the well-being of future generations. DOE is also funding the national laboratories to develop guidance and a draft recommendation to DOE for addressing intergenerational justice. DOE is considering a potential intergenerational council in response to public feedback. DOE has also begun to look at the practicalities (e.g., how to recruit people, what ages are optimal, etc.) of including youth in an intergenerational council. The Board commends DOE for its initial efforts to analyze intergenerational justice and equity and to explore the possibility of an intergenerational council.

[40] Clinical and Translational Science Awards Consortium, Community Engagement Key Function Committee, and Task Force on the Principles of Community Engagement. 2011. *Principles of Community Engagement.* Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, NIH publication 11-7782. June. https://stacks.cdc.gov/view/cdc/11699 (last accessed April 4, 2024). For an extensive and detailed compilation of specific tools, resources and instruments for assessing whether engagement is succeeding, whether communities feel engaged, and ways that engagement can be improved see *Assessing Meaningful Community Engagement*. National Academy of Medicine, National Academies of Sciences, Engineering, and Medicine. https://nam.edu/programs/value-science-driven-health-care/assessing-meaningful-community-engagement/ (last accessed April 4, 2024).

[41] DOE (2023) lists and describes the values and principles that will guide their consent-based siting process. DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.

The Canadian implementer, the Nuclear Waste Management Organization (NWMO), relies on several advisory bodies to assist its siting efforts for a geologic repository.[42] One such council, the Council of Knowledge Holders, formerly the Council of Youths and Elders, is focused on Indigenous peoples. It provides counsel on the application of Indigenous knowledge in the implementation of adaptive phased management, the plan for radioactive waste management the Canadian government adopted and that NWMO is implementing. In addition, the council provides advice on issues that could enhance the development and maintenance of good relations with Indigenous communities. In the workshop, DOE staff stated it had signed a bilateral agreement focused on SNF management with NWMO. The purpose of the agreement, a statement of intent, is to support mutual learning, information exchange on consent-based siting processes, science and technology programs, engagement activities, and joint technical studies. This agreement could allow DOE to learn more from NWMO on incorporating youth perspectives in the siting process.

Finding 5: Consent-based siting issues have important implications not only for the present but also for the future (siting could take a decade or more and the transportation of SNF and storage at a sited facility could last decades). Thus, it will be important to understand key intergenerational issues and include the perspectives of younger people in the process. The Board finds that as DOE develops its own consent-based siting process, it would be valuable to further explore the idea of youth advisory boards, intergenerational councils, and other similar mechanisms more fully as ways to include young persons in the process and gain a better understanding of intergenerational aspects of siting decisions.

The Board looks forward to evaluating the scientific and technical validity of DOE's continued progress on the topic of consolidated interim storage facilities for commercial SNF, including its consent-based siting activities. The Board acknowledges DOE's substantial efforts to address the Board's recommendation to learn from domestic siting experiences and siting processes in other nations and to strengthen its overall consent-based siting effort. The Board has also developed observations (immediately below) on topics that are outside of DOE's control under the NWPA but are likely to impact DOE efforts to construct one or more federal interim storage facilities using a consent-based siting process.

Observations on Implementing Consolidated Interim Storage

As stated at the beginning of this letter, the Board's mandate is to evaluate the technical and scientific validity of activities undertaken by DOE. However, as a result of its past and ongoing reviews, the Board has come to recognize two key societal challenges that will likely affect DOE's efforts to successfully implement a consolidated interim storage program. These challenges are: 1) the need for timely progress toward the long-term solution of disposal of SNF and HLW in an underground geologic repository;[43] and 2) the need for a legal and regulatory framework that is fully supportive of a consent-based siting approach, including the satisfactory

[42] NWTRB. 2022. *Survey of National Program for Managing High-Level Radioactive Waste and Spent Nuclear Fuel: 2022 Update*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. July.

[43] NWTRB. 2021. *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. April.

treatment of the key role that states have in decision-making.[44] Solutions to these challenges will likely require budgetary and policy decisions by policymakers.

The Board notes that a geologic repository for SNF and HLW is needed whether a federal consolidated interim storage facility for commercial SNF is part of the integrated waste management system or not. The Board has found that disposal of radioactive waste in deep boreholes does not eliminate the need for a mined, geologic repository.[45] Advanced reactors or recycling facilities also do not eliminate the need for a geologic repository. As described in Advanced Reactor Waste Disposition section of this letter, in section 302(b) of the NWPA, the advance contracting requirement stipulates that DOE can accept for disposal (in a repository) SNF and HLW generated from an advanced reactor's (or from a recycling facility) operation provided the applicant for the U.S. Nuclear Regulatory Commission license for the facility has entered into a contract with the Secretary of Energy.[46] Thus, timely progress toward the long-term solution—disposal in a deep underground repository—is still a matter of urgency.[47]

Others have also noted that timely progress toward disposal in a deep geologic repository is a key issue that will impact DOE's potential for success in its consent-based siting effort. Commenters on DOE's consent-based process[48] and information provided in the workshop highlighted that progress on a geologic disposal program is needed as part of any federal effort on consolidated interim storage of SNF. Regarding the role of a federal consolidated interim storage facility in an integrated waste management system, DOE found that a greater number of people opposed developing federal consolidated interim storage than those who supported moving forward with storage.[49] Many of those opposed cited a concern that such facilities could become de facto permanent disposal sites given the lack of progress in developing a repository. Several commenters also noted that measurable and publicly visible progress toward a repository

[44] NWTRB. 2015. *Designing A Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: Detailed Analysis*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. November.

[45] The Board (NWTB 2016) found that "although deep boreholes might provide a disposal option for certain types of DOE-managed waste, … disposal of radioactive waste in deep boreholes does not eliminate the need for a mined, geologic repository." NWTRB. 2016. *Technical Evaluation of the U.S. Department of Energy Deep Borehole Disposal Research and Development*. Regarding commercial SNF stored in the U.S., the Board (NWTRB 2016) noted that "DOE also has indicated that commercial SNF is not being considered for deep borehole disposal, mainly because of its size".

[46] As DOE described in the Board's Summer Meeting only one entity has provided enough information on its waste characteristics (e.g., form, quantity, packaging, etc.) to allow DOE to state that the U.S. Nuclear Regulatory Commission's applicant is actively and in good faith negotiating with the Secretary of Energy for a contract. That applicant is Kairos Power LLCs in its construction permit application for the Hermes Test Reactor.

[47] NWTRB. 2021. *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. April.

[48] DOE. 2022. *Consent-Based Siting: Request for Information Comment Summary and Analysis*. Washington, DC: U.S. Department of Energy. September. On December 1, 2021, DOE issued a request for information (RFI) on "Using a Consent-Based Siting Process to Identify Federal Interim Storage Facilities" (86 FR 68244). DOE received 225 submissions in response to the RFI from a wide variety of commenters, including Tribal, state, and local governments; non-governmental organizations; members of academia and industry; other stakeholders; and individual commenters.

[49] Ibid.

would alleviate these concerns. Many commenters felt that progress on a repository should be simultaneous with efforts to develop consolidated interim storage. They emphasized that progress on both fronts is critical to restore trust and gain community consent to host a storage facility.[50] At the workshop, Swedish and Swiss experts, whose countries have selected sites for geologic repositories, stated that success in siting a federal consolidated interim storage facility in the U.S. is less likely without an active geologic disposal program or a path to a repository.[51] For example, the Canadian speaker stated that Canada's success was due, in part, to their government assuming the responsibility for final disposal "now, because it's not acceptable to leave the burden of the waste we created to future generations." Also, the Swiss speaker concurred with the Canadian speaker and stressed the importance of addressing the disposal of the SNF now.

The NWPA authorized the DOE to site, construct, and operate a monitored retrievable storage (MRS) facility (equivalent to a federal consolidated interim storage facility) using two alternative paths for siting the facility. Siting could occur by a DOE-directed survey-and-evaluation process [originally specified in Subtitle C of Title I of the NWPA of 1982]. Alternatively, siting could occur through the efforts of the Nuclear Waste Negotiator, whose office was established for that purpose in the Nuclear Waste Policy Amendments Act of 1987.[52] In 1992, the NWPA was amended again and reset the termination date of the Office of the Nuclear Waste Negotiator.[53] Thus, DOE's consent-based siting efforts are limited to the authorities and limitations, in particular, those affecting states and DOE's consultation and cooperation with them, under Subtitle C of Title I of the NWPA.

DOE's current consent-based siting process will have to be consistent with the NWPA.[54] DOE's process does not include states in the decision process for a consent-based sited facility in a potential host community until site selection, some six to ten years after DOE's siting process

[50] Ibid.

[51] The Swiss consultant's report to the Board also addressed this topic. *Short report containing observations and suggestions for improvements in the U.S. Department of Energy's (DOE) consent-based siting process for one or more consolidated interim storage facilities for spent nuclear fuel*. https://www.nwtrb.gov/docs/default-source/meetings/2023/august/zuidema_report.pdf?sfvrsn=4 (last accessed April 4, 2024).

[52] DOE. 1991. *Preliminary Site Requirements and Considerations for a Monitored Retrievable Storage Facility*. https://curie.pnnl.gov/system/files/documents/not%20yet%20assigned/MRS_Preliminary_Site_Requirements.pdf (last accessed April 4, 2024).

[53] The Office shall cease to exist not later than 30 days after the date 7 years after the date of the enactment of the Nuclear Waste Policy Amendments Act of 1987. P.L. 102–486, 106 Stat. 2923 (1992).

[54] "Current law, including Subtitle C of Title I of the NWPA of 1982, as amended, allows the Department to proceed with a consent-based siting process, negotiate an agreement with a host community, and design and seek a license for an interim storage facility. … The consent-based siting process will follow applicable provisions in the NWPA concerning Tribes, states, and affected units of local government." DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.

started.[55] Under Section 146 of the NWPA, state participation in a consolidated interim storage facility siting decision is limited to an allowance to submit a notice of disapproval to Congress.

The Board notes the nation's past lack of success in siting, constructing, and operating a consolidated interim storage facility or a repository for SNF and HLW is generally understood—for example by DOE, the Blue Ribbon Commission on America's Nuclear Future and the Board—to be related to an inadequate accounting of the pivotal role and power that states have in decision-making within their borders. In 1990, DOE stated in its briefing paper for the Nuclear Waste Negotiator, the failed "MRS siting experience at Oak Ridge illustrates the need for any discussions with a potential host to include both the local community (or Tribe) **and** [bold in the original] the State, as well as other affected stakeholders."[56] In the August 2023 workshop, DOE staff described lessons learned from the efforts of the Office of the Nuclear Waste Negotiator. DOE staff described that creating a process that shifts agency to states and provides funding to enable the shift will increase the chance of success.[57] The Blue Ribbon Commission on America's Nuclear Future stated that it believed "that states and tribes should retain—or where appropriate, be delegated—direct authority over aspects of regulation, permitting, and operations where oversight below the federal level can be exercised effectively and in a way that is helpful in protecting the interests and gaining the confidence of affected communities and citizens."[58] In its analysis of past siting efforts for deep geologic repositories, the Board[59] addressed the pivotal role and power that states have in decision-making within their borders and how strong forms of consent-based siting do not find a hospitable environment in the United States. The Board also discussed the difference between the consultation and cooperation approach adopted in the NWPA and a consultation and concurrence approach that would be

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[55] See Figure 1 and Tables 2-6 in DOE (2023). Nonetheless, "throughout the consent-based siting process, DOE will also seek to engage and communicate with Tribes and states adjacent to the host." DOE. 2023. *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*. Washington, DC: U.S. Department of Energy. April.

[56] DOE also noted that the "Supreme Court let stand without review the U.S. Court of Appeals decision that NWPA did not require DOE to consult with any state before DOE submits the proposal [proposed site for MRS] to Congress." DOE also stated that "recognizing the difficulty of DOE-directed siting through national or regional screening, the DOE prefers an MRS facility that is sited through the efforts of the Nuclear Waste Negotiator." DOE noted that a negotiated site would avoid the institutional issues [dealing with states and Tribes] associated with a DOE-directed siting process. DOE. 1990. *MRS Siting Briefing*. https://curie.pnnl.gov/system/files/documents/not%20yet%20assigned/siting%20history.pdf (last accessed April 4, 2024).

[57] The Board notes that a DOE-funded draft report on the lesson learned characterized this concept as that state-level elected officials need to be able to 'win' in the eyes of their constituents, which means having some element of control over the process and make gains for the state.

[58] Blue Ribbon Commission on America's Nuclear Future. 2012. *Report to the Secretary of Energy*. Washington, DC. The Commission focused on an independent organization implementing a consent-based siting program and stated that "a new waste management organization must find ways to address state concerns while at the same time capitalizing on local support for proposed facilities." The Commission also stated that "it will be important to define the roles, responsibilities, and authorities of host state, tribal, and local governments both throughout the siting and licensing process and once a facility is operational."

[59] NWTRB. 2015. *Designing A Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: Detailed Analysis*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. November.

more suited for the development of a consent-based siting process.[60] The Board notes that consultation and concurrence is likely to be more successful based upon domestic history and international experiences of nuclear waste described in the workshop. Based on past experiences, the Board believes these limitations—the lack of a repository program and a legal and regulatory framework that is inconsistent with obtaining consent from states—likely will impact DOE's potential success in siting, constructing, and operating a federal consolidated interim storage facility.

In keeping with the Board's technical mandate, the Board takes no position on whether a new effort should be undertaken to site either the country's first or second repository or whether to, or how to implement a consent-based siting approach; policymakers will make those decisions. The Board offers the following two observations that can inform Congressional decision-making regarding a path forward on SNF and HLW management and disposal *if* policymakers decide to move forward.

Observation 1: Information from the Board's past and recent reviews (including the experiences from other countries) shows that timely progress on a geologic disposal program for SNF and HLW is needed now to provide confidence that storage of SNF at a federal consolidated storage facility will be interim and not permanent. Such confidence will be necessary for consent from states, Tribes, and communities.

Observation 2: If a consent-based siting approach is used for a federal consolidated interim storage facility or a repository, a consultation and concurrence approach with states and Tribes, rather than the consultation and cooperation approach currently embodied in the NWPA will likely need to be explored both in terms of the timing (for example, when does consultation and concurrence begin and end) and extent (for example, what issues are subject to concurrence and who are the responsible concurring parties).

High Burnup SNF

DOE's HBF R&D has focused on better understanding the characteristics of HBF, including the fuel's cladding, to determine the performance and potential degradation of HBF during extended storage and subsequent transportation. DOE's efforts include the High Burnup Spent Fuel Data Project (or "Demo Project") that includes a demonstration cask ("demo cask") that stores HBF assemblies from pressurized water reactors. The project also includes detailed examinations of 25 HBF "sister rods" (aka sibling pins) withdrawn from assemblies in the demo cask or from assemblies similar to those in the cask.

At the Board's August 2023 Summer Meeting, national laboratory staff described DOE's gap analysis to support extended storage and transportation,[61] DOE's storage and transportation 5-

[60] Ibid. Metlay (2013) explores further the concept of consultation and concurrence. Metlay, D. 2013. *Consent-Based Siting: What Have We Learned?* Radwaste Solutions, Vol. 20, No. 3, pp. 28-36. https://www.nwtrb.gov/docs/default-source/staff/dsm-radwaste.pdf?sfvrsn=6 (last accessed April 4, 2024).

[61] Teague, M., S. Saltzstein, B. Hanson, K. Sorenson, and G. Freeze. 2019. *Gap Analysis to Guide DOE R&D in Supporting Extended Storage and Transportation of Spent Nuclear Fuel: An FY2019 Assessment*. SAND2019-15479R. Sandia National Laboratories. Albuquerque, NM. December.

year R&D plan,[62] and DOE's Demo Project. The presentation focused on DOE's HBF sibling pin test campaign. The Phase I testing[63] of sibling pins is ongoing, but largely complete, and DOE completed an extensive multi-modal transportation test with surrogate SNF. Key conclusions include 1) the cladding temperatures and hoop stresses in the HBF rods examined are too low to cause potentially damaging radial hydride formation within the cladding and 2) the mechanical loads expected during transportation are well within the capacity of the fuel cladding to resist degradation. As a result, many of the information gaps on issues of potential importance to HBF performance during storage and transportation can be closed.

The Board notes that DOE is well on the way to completing Phase I of its efforts to address issues related to the long-term storage and transportation of HBF. DOE has made substantial and beneficial progress in this regard and has essentially closed out many issues previously believed to be important. However, the Board notes that DOE has not addressed all the Board's 2021 recommendations on HBF.[64]

The national laboratory staff stated that as a follow-on to the Phase I testing, DOE and the national laboratories are proposing additional (Phase II) testing to gather additional data from the remaining HBF sibling pins. A national laboratory speaker described the Draft Phase II test priorities and prioritization approach. DOE funded development of, and the national laboratories have completed, a Phase II test plan.[65] The speaker described that the national laboratories reassessed gaps from the existing gap analysis on extended storage and transportation to help determine priorities for Phase II testing. One factor that the investigators considered in determining priorities for the Phase II program was testing to higher temperatures (to address potential industry actions to load hotter SNF for storage, which would raise overall cask and fuel temperature). A second factor, in which the U.S. Nuclear Regulatory Commission staff expressed interest, was addressing potential annealing and creep in SNF cladding because Phase I test results indicated reduced cladding yield strengths.

The Board held a follow-up technical fact-finding meeting with DOE and national laboratory staff on February 28, 2024, related to DOE's HBF R&D. The Board understands from discussions at the fact-finding meeting that DOE may soon make significant changes to its HBF storage and transportation R&D program. The Board also understands that the start of HBF Phase II testing is now on hold. The Board thanks DOE for discussing its high burnup SNF R&D and planning effort for its future R&D at the fact-finding meeting on February 28, 2024. The Board will provide, in a separate letter, the Board's assessment of the status of DOE's

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[62] Saltzstein, S., B. Hanson, G. Freeze, and K. Sorenson. 2020. *Spent Fuel and Waste Science and Technology Storage and Transportation 5-Year R&D Plan*. SAND2020-9310R. Sandia National Laboratories. Albuquerque, NM. August.

[63] S. Saltzstein et al., *Visualization of the High Burnup Spent Fuel Rod Phase 1 Test Plan*, SAND2018-8042-O, 2018.

[64] NWTRB. 2021. *Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Spent Nuclear Fuel During Extended Storage and Transportation*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. July.

[65] Bignell, J. et. al. 2023. *High-Burnup Spent Fuel Data Project: Sister Rod Final Phase II Test Plan*. Albuquerque, New Mexico: Sandia National Laboratories. September https://www.osti.gov/servlets/purl/2204271 (last accessed April 4, 2024). At the time of the Summer Meeting, the report was still in draft form and not yet public.

current R&D efforts relative to the Board's 2021 recommendations on HBF.[66] The Board's updated assessment of DOE's HBF R&D could help DOE in its ongoing program reprioritization.

Other SNF topics

During the discussion of DOE's HBF R&D at the Board's August 2023 Summer Meeting, the Board raised other issues that are applicable to all commercial SNF, not just HBF. Previously the Board has addressed DOE's efforts related to potential repackaging of SNF from current containers into different packages and post-closure repository evaluations of potential criticality related to SNF disposal. At the Board's March 1-2, 2022, meeting, national laboratory staff described DOE's SNF cladding degradation modeling efforts applicable to a geological repository environment. DOE is developing the cladding degradation model, in part, to support post-closure repository evaluations of potential criticality related to SNF disposal in dual-purpose (storage and transportation) canisters. The Board noted that degradation of cladding, SNF assembly hardware (e.g., grid spacers), and baskets within a dual-purpose canister will affect the potential for criticality and that short-term testing indicates that the grid spacers would degrade faster than cladding. At the meeting, DOE recognized that partial grid collapse may occur for horizontally emplaced dual-purpose canisters, which could permanently obviate criticality. The Board observed that this partial grid collapse scenario deserves attention because it could reduce the probability of criticality, but that DOE could need additional knowledge of grid material properties and stresses.[67]

Fuel rod assembly mechanical behavior could affect other aspects of the management of SNF, such as potential repackaging of SNF from current containers into different packages. The Board recently completed an evaluation of DOE's R&D on the disposition of commercial SNF in dual-purpose (storage and transportation) canisters.[68] The evaluation addressed repackaging of SNF from current containers (e.g., dual-purpose canisters) into different packages and post-closure repository evaluations of potential criticality. In that report, the Board noted that using a risk approach, which considers both the probability and potential consequences, rather than solely focusing on detailed analyses of consequences could allow DOE to determine whether such detailed analyses are needed.[69] The Board notes that considering both the probability and consequences can be a basis for defining the scope of DOE's high burn SNF R&D program and individual activities.

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[66] NWTRB. 2021. *Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Spent Nuclear Fuel During Extended Storage and Transportation*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. July.

[67] Bahr, J.M. 2022. Board letter to Dr. Kathryn Huff with comments from March 2022 Board meeting (June 7, 2022), available at: https://www.nwtrb.gov/docs/default-source/correspondence/jmb041.pdf?sfvrsn=4 (last accessed April 4, 2024).

[68] NWTRB. 2024. *Evaluation of the U.S. Department of Energy Research and Development Activities on the Disposition of Commercial Spent Nuclear Fuel in Dual-Purpose Canisters*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. February.

[69] Bahr (2022) more fully discusses this approach. Bahr, J.M. 2022. Board letter to DOE following March 2022 meeting (June 7, 2022). https://www.nwtrb.gov/docs/default-source/correspondence/jmb041.pdf?sfvrsn=4. (last accessed April 4, 2024).

As discussed in the February 2024 fact-finding meeting, one source of information for fuel rod assembly mechanical behavior could be industry sources (e.g., fuel assembly vendors). The Board also notes that DOE's planned transport of the demo cask to a hot cell facility in 2027 and subsequent examination of HBF offer another opportunity to obtain data on fuel assembly mechanical behavior because the demo cask contains complete SNF assemblies.

Advanced Reactor Waste Disposition

In its May 12-13, 2021, public meeting the Board reviewed DOE's R&D activities related to advanced nuclear fuels for light water reactors, including accident tolerant fuels ("advanced nuclear fuels" henceforth), and the impact of these fuels on SNF management and disposal. By that point, DOE had completed a preliminary, high-level, R&D gap analysis regarding the performance of advanced fuels [including metallic and TRISO (tri-structural isotropic) fuels during storage and transportation].[70] At the meeting, DOE staff stated that significantly different fuel systems (e.g., TRISO, metallic fuels) may require a new storage, transportation, and disposal container design. The Board recommended that DOE expand the scope of its efforts beyond storage and transportation to include disposal of SNF resulting from the use of advanced nuclear fuels in the next update to DOE's gap analysis report for SNF management.[71]

More recently, DOE's advanced reactor waste disposition R&D efforts accelerated due to dedicated funding in fiscal years 2022 and 2023. At the Board's Summer Meeting, DOE staff described how they are addressing back-end management of SNF and HLW from advanced reactors. DOE is seeking information from advanced reactor developers necessary to address regulatory and legal issues (such as, with the Standard Contract) and to identify storage, transportation, and disposal R&D gaps related to the SNF and HLW generated by advanced reactors. DOE is pursuing two efforts to address the waste from advanced reactors.

First, section 302(b) of the NWPA is the advance contracting requirement related to the disposal of SNF and HLW generated from the reactor's operation that involves the Secretary of Energy.[72]

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[70] Honnold, P. et. al. 2021. *High Level Gap Analysis for Accident Tolerant and Advanced Fuels for Storage and Transportation*. Albuquerque, New Mexico: Sandia National Laboratories. April https://www.osti.gov/servlets/purl/1813674 (last accessed April 4, 2024).

[71] Bahr, J.M. 2022. Board letter to DOE following May 2021 meeting (August 12, 2021). https://www.nwtrb.gov/docs/default-source/correspondence/jmb035.pdf?sfvrsn=6. (last accessed April 4, 2024). DOE responded to the Board letter. Griffith, A. 2022. DOE Response to the Nuclear Waste Technical Review Board (NWTRB) Comments and Recommendations on Advanced Nuclear Fuels and Accident Tolerant Fuels Spring 2021 NWTRB Meeting (April 7, 2022). https://www.nwtrb.gov/docs/default-source/correspondence/doe04072022.pdf?sfvrsn=6. (last accessed April 4, 2024).

[72] "(1) (A) The Commission shall not issue or renew a license to any person to use a utilization or production facility under the authority of section 103 or 104 of the Atomic Energy Act of 1954 (42 USC 2133, 2134) unless– (i) such person has entered into a contract with the Secretary under this section; or (ii) the Secretary affirms in writing that such person is actively and in good faith negotiating with the Secretary for a contract under this section. (B) The Commission, as it deems necessary or appropriate, may require as a precondition to the issuance or renewal of a license under section 103 or 104 of the Atomic Energy Act of 1954 (42 USC 2133, 2134) that the applicant for such license shall have entered into an agreement with the Secretary for the disposal of high-level radioactive waste and spent nuclear fuel that may result from the use of such license."

As DOE staff described it, DOE will need enough data, describing the characteristics of both the initial fuel and the discharged SNF and HLW and SNF and HLW operations (e.g., fuel irradiation time and storage canister design), from a potential applicant to allow DOE to determine whether to enter such a contract. DOE's Office of Nuclear Energy is developing a report for each new reactor design that is based on proprietary data provided by the reactor vendor. Each report will address back-end management of SNF and HLW for each reactor and the report will be provided to DOE's Office of General Counsel (OGC) for review and action (e.g., OGC can decide to send a letter to the applicant affirming that it is actively and in good faith negotiating with the Secretary for a contract—the applicant can then use the DOE letter in the U.S. Nuclear Regulatory Commission licensing process). DOE staff stated it needs four to six months to develop a report that contains the technical assessment of the feasibility of storage, transportation, and disposal of the advanced reactor's fuel and HLW, if any.

Second, DOE is developing a report that addresses advanced reactors SNF and wastes,[73] including the storage, transportation, and disposal of SNF and HLW from TRISO- and metallic-fueled reactors and molten salt reactors. The national laboratory staff described an effort to develop a detailed R&D gap analysis for accident tolerant fuels, high burn/high enrichment fuels, and advanced reactor SNF and waste forms for storage and transportation in fiscal year 2024 and beyond. The national laboratories plan to conduct a features, events, and processes analysis, at the same time, for the same materials to identify the R&D gaps for disposal.

Finding 6: DOE has initiated an effort to assess the potential impacts of various advanced nuclear fuels on storing, transporting, and disposing of SNF and HLW by requesting data from advanced reactor vendors. DOE is also developing a strategy to identify knowledge gaps and outline areas where further research would contribute to a well-defined disposition pathway for SNF and HLW resulting from advanced reactor operations. This effort will inform DOE decisions concerning how to proceed and how to deal with the impacts. The Board commends DOE for initiating this assessment and strongly endorses this effort.

[73] Matteo, E. et al. 2023. *Advanced Reactors Spent Fuel and Waste Streams Disposition Strategies*. Albuquerque, New Mexico: Sandia National Laboratories. June.