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US DOE Progress on Implementing US National Academy of Sciences Recommendations for Spent Nuclear Fuel Transportation

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Abstract

In 2006, the National Research Council of the United States' National Academy of Sciences (NAS) issued the report, *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States* (NAS, 2006). The foremost finding of the report was that there were “no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States.” However, it made a number of recommendations to improve safety, communicate risk, and conduct planning and other activities in anticipation of a large-scale transport campaign for spent nuclear fuel (SNF) and high-level radioactive waste (HLW). The Blue Ribbon Commission on America's Nuclear Future (BRC), formed by the Secretary of Energy at the request of the President to conduct a comprehensive review of the back end of the nuclear fuel cycle and recommend a new plan, concluded that with respect to transportation issues, the NAS recommendations that had not yet been implemented should be revisited and addressed as appropriate. This paper discusses the NAS recommendations and the current status regarding their implementation, with a focus on actions being taken by DOE.

Introduction

In anticipation of future shipments of large quantities of spent nuclear fuel (SNF) and high-level radioactive waste (HLW), the National Academy of Sciences (NAS) initiated a study into the safe transport of SNF and HLW. In 2006, they reported their findings in the publication entitled *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States* (NAS, 2006). Included in the findings were fourteen recommendations for reducing risks from transportation of SNF and HLW.

The Blue Ribbon Commission on America's Nuclear Future (BRC) was convened at the request of the President to review policies for managing the back end of the fuel cycle and to recommend a new strategy. The BRC issued its Report to the Secretary of Energy in January 2012 (BRC, 2012). In

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addressing transportation issues, the BRC referred to the conclusion of the 2006 NAS report that there are “no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States.” The BRC also noted that the NAS study made a number of recommendations to improve safety, communicate risk, and conduct planning and other activities in anticipation of a large-scale transport campaign for SNF and HLW. The BRC report further noted that a number of these recommendations have been adopted at least in part by various federal agencies. The BRC expressed the opinion that the NAS recommendations that have not yet been implemented should be revisited and addressed as appropriate. This paper discusses the progress that the US Department of Energy (DOE) has made in adopting the recommendations of the NAS.

The Recommendations

The NAS made fourteen recommendations for the transportation of SNF and HLW. This section presents each recommendation or a summary thereof, followed by a discussion of DOE’s progress on implementation.

The foremost finding of the NAS is as follows:

“The committee could identify no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport by highway (for small-quantity shipments) and by rail (for large-quantity shipments) is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health, and environmental consequences when conducted with strict adherence to existing regulations. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs that will require expeditious resolution as described in this report. Moreover, the challenges of sustained implementation should not be underestimated” (NAS, 2006).

With this principal finding in mind, the recommendations and steps taken by DOE to implement them follow. Some recommendations are under the authority of other federal agencies. Actions taken by agencies other than DOE to implement the NAS recommendations are outside the scope of this paper.

1. Transportation Security

Recommendation: “An independent examination of the security of spent fuel and high-level waste transportation should be carried out prior to the commencement of large-quantity shipments to a federal repository or to interim storage. This examination should be carried out by a technically knowledgeable group that is independent of the government and free from institutional and financial conflicts of interest. This group should be given full access to the necessary classified documents and Safeguards Information to carry out this task. The findings and recommendations from this examination should be made available to the public to the fullest extent possible” (NAS 2006).

Discussion: No actions have been taken to convene an independent group of technically knowledgeable experts separate from the government or industry to review transportation security issues. However, DOE is cognizant of security concerns, and has made strides to ensure heightened security of future SNF and HLW shipments. The *DOE Radioactive Material Transportation Practices Manual* (DOE, 2008), most recently updated in 2008, requires that DOE shipments of SNF and HLW conform to or exceed the level of protection of the US Nuclear Regulatory Commission's (NRC) requirements for transportation security contained in Title 10 of the Code of Federal Regulations (10 CFR) Part 73, which is titled "Physical Protection of Plants and Materials."

2. Routing Hazards

Recommendation: "Transportation planners and managers should undertake detailed surveys of transportation routes to identify potential hazards that could lead to or exacerbate extreme accidents involving very long duration, fully engulfing fires. Planners and managers should also take steps to avoid or mitigate such hazards before the commencement of shipments or shipping campaigns" (NAS, 2006).

Discussion: Because a destination for an ISF or repository for SNF and HLW has not yet been determined, transportation routes have not yet been identified; therefore it is not yet possible to implement this recommendation. However, DOE is currently developing a route analysis tool, the Stakeholder Tool for Assessing Radioactive Transportation (START), so that once a destination becomes available, DOE will have the technological capacity to support route evaluations. Using geographic information systems data, START will be able to identify potential hazards, such as tunnels and links of routes with historically high accident frequency, along transportation routes (Abkowitz, 2016).

3. Social Risks

Recommendation: "Transportation implementers should take early and proactive steps to establish formal mechanisms for gathering high-quality and diverse advice about social risks and their management on an ongoing basis" (NAS, 2006).

Discussion: DOE's National Transportation Stakeholders Forum (NTSF) is the mechanism through which DOE engages at a national level with states, Tribes, federal agencies and other interested stakeholders about the Department's shipments of radioactive material. As part of the NTSF, DOE's Office of Nuclear Energy (NE) has established several ad hoc working groups to address particular pertinent issues. Relevant activities include working through questions and outstanding issues relating to DOE's policy and procedures to implement Section 180(c) of the Nuclear Waste Policy Act (NWPA) and facilitating dialogue between DOE and transportation stakeholders regarding rail transportation

and routing to advance understanding and identify issues or questions prior to shipments. DOE-NE has met with these working groups in concert with annual NTSF meetings, at standalone meetings a few times per year, and through several web-based meetings throughout the year. DOE resumed financial support of and regular interactions with state regional groups (SRGs) in 2012, with a priority of these interactions being to address public concerns of the risk involved in SNF transportation. The SRGs recommended that DOE assemble a list of reports documenting studies on transportation risk perception. In response to that recommendation, a risk perception bibliography was composed, including over 130 references dating from 2013 back to 1977.

4. Preventing Fires

Recommendation: “The Nuclear Regulatory Commission should build on recent progress in understanding package performance in very long duration fires. To this end, the agency should undertake additional analyses of very long duration fire scenarios that bound expected real-world accident conditions for a representative set of package designs that are likely to be used in future large quantity shipping programs” (NAS, 2006).

Discussion: This recommendation is directed toward the NRC rather than DOE. While a detailed discussion regarding this recommendation is beyond the scope of this paper, it should be noted that the NRC has examined four actual transportation accidents involving severe fires and analyzed the expected effects of these accidents on SNF casks. Accident scenarios involved a fire in a rail tunnel in 2001, fires in roadway tunnels in 1982 and 2007, and a fire in a multi-level roadway interchange in 2007. Reports documenting the analysis of each accident were released in 2007, 2009, and 2015; a document summarizing these analyses, *A Compendium of Spent Fuel Transportation Package Response Analyses to Severe Fire Accident Scenarios, Draft Report for Comment* (NRC, 2016), was released for public comment in January 2016. On a related note, DOE is considering the possibility of making shipments of SNF or HLW to an ISF or repository via dedicated trains. This could further reduce the risk of large fires involving casks containing such material, as rail cars containing flammable or combustible materials would be restricted from the consist of SNF and/or HLW railcars (Federal Railroad Administration, 2005).

5. Package Testing

Recommendation: “Full-scale package testing should continue to be used as part of integrated analytical, computer simulation, scale-model, and testing programs to validate package performance. Deliberate full-scale testing of packages to destruction should not be required as part of this integrated analysis or for compliance demonstrations” (NAS, 2006).

Discussion: In accordance with Section 180 of the Nuclear Waste Policy Act of 1982 (NWPA), as amended, all SNF or HLW would be transported to a storage facility or repository under subtitle A or

subtitle C in packages certified by the NRC for such purposes. The NRC certifies packages in accordance with its requirements in 10 CFR Part 71. Compliance with NRC requirements for certification is demonstrated by subjecting a transportation cask or a scale model to a series of tests designed to simulate adverse conditions during normal conditions of transport and during hypothetical accident conditions.

The BRC report notes that the NRC had planned a package performance study (PPS), which would subject an actual transportation cask to accident conditions more severe than the hypothetical accident conditions described in 10 CFR Part 71 but, in accordance with the NAS recommendation, would not test to failure of the package. Casks are generally not subjected to the full battery of tests, but scale model testing and computational analysis is instead used to demonstrate the ability of a cask to meet the regulations. According to the BRC report, the program was stopped due to the halting of plans for Yucca Mountain, and also due to the study's high cost.

A report (Durbin et al., 2014) containing a proposed path forward for a PPS was submitted to the DOE in 2014, suggesting that a new PPS could proceed as long as public interest in it continued. Furthermore, if this path forward were to be adopted, only those components and phases of the study considered valuable to the public would be conducted. For example, if modeling is sufficient to demonstrate confidence in SNF and HLW packaging, then plans for the actual accident testing could be removed; otherwise, the modeling would be used to inform the accident tests. Whether this approach to a new PPS will be adopted by either NRC, DOE, or both has yet to be determined. The report does not propose roles for the NRC or DOE in a new PPS, however, it notes that when the first PPS was being outlined in 2003, the NRC planned to be the lead agency involved in full-scale package testing, and that the DOE planned to provide a portion of the funding for the study.

6. State and Tribal Involvement

Recommendation: “The Department of Energy should continue to ensure the systematic, effective involvement of states and tribal governments in its decisions involving routing and scheduling of foreign and DOE research reactor spent fuel shipments” (NAS, 2006).

Discussion: In making this recommendation, NAS found that the existing procedure for routing and transporting SNF from foreign and domestic research reactors was adequate and reasonable. Indeed, in developing a proposed routing procedure for future commercial SNF shipments, experiences of the research reactor SNF shipping campaigns were studied.

DOE works with states and Tribes through cooperative agreements with SRGs and other entities to engage in transportation planning. In addition, NE is participating in working groups of the NTSF to explore issues such as developing a process for identifying routes, and refining a proposed policy for

providing funds and technical assistance under Section 180(c) of the NWPA to states and Tribes for training local public safety officials. NE has also established the NE Transportation Core Group, a small group of tribal and state representatives (many of whom also participate in the NTSF), that meets twice per year to hear updates on NE's transportation planning for future shipments of SNF and HLW, provide feedback on such initiatives, and discuss outstanding issues and next steps.

7. Routing Regulation Compliance

Recommendation: "DOT should ensure that states that designate routes for shipment of spent nuclear fuel rigorously comply with its regulatory requirement that such designations be supported by sound risk assessments. DOT and DOE should ensure that all potentially affected states are aware of and prepared to fulfill their responsibilities regarding highway route designations" (NAS, 2006).

Discussion: As mentioned in Section 2, DOE is continuing to develop an enhanced routing tool, START. One functional requirement is that potential routes identified through START must be in compliance with applicable routing regulations (Abkowitz, 2016). States and Tribes are being trained on the use of the tool for planning, and it is expected that START will be able to be used in conjunction with future applications under a Section 180(c) financial assistance program for state and tribal funding for training along routes. DOE is considering a standard routing methodology in which federal, state, tribal, and carrier input would be used to help determine SNF shipment routes, and a step to confirm compliance with regulations would be included in such a process.

For highway shipments of SNF and HLW, a DOE standard routing methodology would follow the US Department of Transportation's (DOT) requirements. The DOT requires in 49 CFR 397.101 that carriers use routes that minimize radiological risk, considering available information on accident rates, transit time, population density and activities, and the time of day and the day of week during which transportation will occur. The DOT further requires the use of preferred routes including Interstate System highways and bypasses and beltways around cities. In addition, pursuant to 49 CFR 397.103, state and tribal routing agencies may identify different preferred routes if necessary to reduce transportation risks. DOT guidance (DOT, 1992) specifies a process for evaluating and selecting routes to minimize transportation risks and to enhance public safety.

8. Rail Transportation

Recommendation: "DOE should fully implement its mostly rail decision by ... obtaining the needed rail packages and conveyances, and working with commercial spent fuel owners to ensure that facilities are available at plants to support this option. These steps should be completed before DOE commences the large-quantity shipment of spent fuel and high-level waste to a federal repository to avoid the need to procure infrastructure and construct facilities to support an extended truck transportation program. DOE should also examine the feasibility of further reducing its needs for cross-country truck shipments

of spent fuel through the expanded use of intermodal transportation (i.e., combining heavy-haul truck, legal-weight truck, and barge) to allow the shipment of rail packages from plants that do not have direct rail access” (NAS, 2006).

Discussion: DOE is making progress on preparing for future rail shipments of SNF and HLW. The development of a railcar in compliance with Association of American Railroads (AAR) Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material*, is advancing under a contract for the design and prototype fabrication of cask and buffer railcars entered into in August 2015. Since the railcar development is expected to take seven to nine years from conceptual design through prototype fabrication, testing, and approval, it is important for DOE to stay on schedule so that railcars will be available when a storage facility opens. Obtaining the necessary rail transportation casks is an area of current and future study. Many transportation casks have already been developed and certified, and some are certified for the shipment of high burnup fuel and/or damaged fuel assemblies. Additionally, a cost analysis is necessary to help determine whether transportation casks should be purchased or leased.

A report on the shutdown sites, “Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites,” updated in 2015 (Maheras et al., 2015), identifies infrastructure and modal options at the shutdown nuclear power plant sites. The large size casks that would be used would require rail, barge, heavy-haul truck, or a combination of these in order to move the stored fuel canisters off site. Barge and heavy-haul trucks will likely need to be used in some locations to bring SNF shipments to a point where they can be transferred to rail, as rail is expected be the primary mode of SNF transportation due to the large size and weight of the SNF packages. As suggested by the NAS, this would eliminate the need for an extended truck transportation program, which would involve a larger number of shipments of SNF and therefore higher risks of transportation accidents and a greater potential for radiological exposure. In 2015, DOE began conducting preliminary de-inventorying evaluations specific to each shutdown site’s requirements, and that work is ongoing.

9. Route Selections

Recommendation: “DOE should identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository as soon as practicable to support state, tribal, and local planning, especially for emergency responder preparedness. DOE should follow the practices of its foreign research reactor spent fuel transport program of involving states and Tribes in these route selections to obtain access to their familiarity with accident rates, traffic and road conditions, and emergency responder preparedness within their jurisdictions. Involvement by states and tribes may improve the public acceptability of route selections and may reduce conflicts that can lead to program delays” (NAS, 2006).

Discussion: Recognizing the importance of the selection of modes and routes for transport of SNF and HLW, DOE is considering a possible standard route selection methodology. Such a methodology would be based on recommendations from the NAS and BRC. Furthermore, it would build on lessons learned from past shipping campaigns, including the Three Mile Island Unit 2 core debris shipments to Idaho National Laboratory, the Foreign Research Reactor cross country shipping program, and shipments to the Waste Isolation Pilot Plant. DOE's development of a standard route selection methodology is expected to take into consideration the following attributes: that planning should begin long in advance of shipments; that a routing process must be clearly defined and readily adaptable if and when new information becomes available; that advanced computational tools for logistics and databases should be taken advantage of; that working cooperatively with states and Tribes is essential; that carriers and logistics providers must participate in route planning; and that preparations should be made to build public trust.

It should further be noted that since this recommendation was published by the NAS in 2006, the US DOT's Pipeline and Hazardous Materials Safety Administration promulgated a rail routing regulation for transport of hazardous materials in 49 CFR 172.820. The regulation includes requirements for selecting and evaluating routes using 27 different safety and security factors, identified in Appendix D to 49 CFR Part 172, such as transit time, the presence of passenger train traffic, and the number and types of grade crossings over the route. Any rail routes used for SNF and HLW transport would have to comply with this regulation.

10. Dedicated Trains

Recommendation: "DOE should fully implement its dedicated train decision before commencing the large-quantity shipment of spent fuel and high-level waste to a federal repository to avoid the need for a stopgap shipping program using general trains" (NAS, 2006).

Discussion: Although no official policy decisions have been made on the subject of dedicated train service, DOE anticipates that the primary mode of transportation for SNF and HLW to waste management facilities such as a future ISF or repository will be by rail, with the possibility of using dedicated train service. Rail transportation is being considered due to certain safety and security considerations and operational efficiency, and also due to the large mass (75 to 200 tons each) of the packages being transported, which would be too large and heavy for a highway-based shipping campaign. In addition, DOE is planning for all rail cask cars, buffer cars, and security escort cars used in transporting SNF and HLW to be designed to meet AAR's Standard S-2043. Meeting the AAR S-2043 standard requires that all non-locomotive cars in a rail consist meet the S-2043 design specification, therefore it is expected that SNF and HLW will only be transported in train consists with other S-2043 compliant railcars. These railcars will include extra safety features, which are not used in normal freight rail service, such as continuous equipment and performance monitoring and

electronically controlled pneumatic braking systems. Current DOE planning efforts underway for the large-scale transport of SNF and HLW are consistent with this recommendation.

11. Shutdown Site Prioritization

Recommendation: “DOE should negotiate with commercial spent fuel owners to ship older fuel first to a federal repository or federal interim storage, except in cases (if any) where spent fuel storage risks at specific plants dictate the need for more immediate shipments of younger fuel. Should these negotiations prove to be ineffective, Congress should consider legislative remedies. Within the context of its current contracts with commercial spent fuel owners, DOE should initiate transport through a pilot program involving relatively short, logistically simple movements of older fuel from closed reactors to demonstrate the ability to carry out its responsibilities in a safe and operationally effective manner. DOE should use the lessons learned from this pilot activity to initiate its full-scale transportation program from operating reactors” (NAS, 2006).

Discussion: Current DOE planning is focused on shipping SNF from shutdown sites to a pilot ISF. Accordingly, DOE transportation planning work is currently underway to analyze those shutdown sites. A detailed report (Maheras et al., 2015) enumerates the SNF inventory at each of the thirteen shutdown civilian reactor sites, and it also includes a study of the near-site infrastructure (rail, road, and/or barge facilities), complete with some past history of previous shipping campaigns (e.g., how the reactor vessel was moved from the site during decommissioning). As of this writing in August 2016, five sites have been the subjects of a more thorough investigation in order to compile a site-specific de-inventory evaluation, including hardware and equipment needs, emergency planning, and security requirements. DOE currently intends to develop de-inventory evaluation reports for each shutdown site over the next several years.

12. Section 180(c) Activities

Recommendation: “DOE should begin immediately to execute its emergency responder preparedness responsibilities defined in Section 180(c) of the Nuclear Waste Policy Act” (NAS, 2006).

Discussion: DOE-NE has been discussing with stakeholders its proposed policy for implementing NWSA Section 180(c). DOE established an ad hoc working group under the NTSF in order to identify and address issues related to implementation of Section 180(c) which were of importance to stakeholders and in need of resolution prior to the commencement of SNF shipments. A policy implementation exercise was launched in December 2014 in order to simulate the proposed process for states and Tribes to apply for and receive federal assistance for training public safety personnel in localities to be affected by SNF shipments; nine state and tribal representatives participated. The policy implementation exercise included the development, by the participating states and Tribes, of mock training grant applications, a review of the application by a mock Merit Review Panel, an assessment

of allowable activities, and discussion of the potential grant negotiation process. Recently completed, the exercise will provide lessons learned on the Section 180(c) process and help improve the process from state, tribal, and DOE perspectives. This is an important step for DOE to maintain its collaboration with stakeholders by establishing a Section 180(c) policy amenable to states, Tribes, and DOE.

13. Classification of Information

Recommendation: “The Department of Energy, Department of Homeland Security, Department of Transportation, and Nuclear Regulatory Commission should promptly complete the job of developing, applying, and disclosing consistent, reasonable, and understandable criteria for protecting sensitive information about spent fuel and high-level waste transportation. They should also commit to the open sharing of information that does not require such protection and should facilitate timely access to such information: for example, by posting it on readily accessible Web sites” (NAS, 2006).

Discussion: DOE plans to revisit this recommendation in order to ensure that policies and procedures are in place for the protection of sensitive information and the sharing of necessary materials between federal agencies, state, tribal, and local authorities, and with the public, as appropriate.

14. Organizational Structure

Recommendation: “The Secretary of Energy and the US Congress should examine options for changing the organizational structure of the Department of Energy’s program for transporting spent fuel and high-level waste to a federal repository. The primary objectives in modifying the structure should be to give the transportation program greater planning authority; greater budgetary flexibility to make the multiyear commitments necessary to plan for, procure, and construct the necessary transportation infrastructure; and greater flexibility to support an expanding future mission to transport spent fuel and high-level waste for interim storage or reprocessing. Whatever structure is selected, the organization should place a strong emphasis on operational safety and reliability and should be responsive to social concerns” (NAS, 2006).

Discussion: At this time, no changes have been made to the organizational structure of DOE to give greater planning authority and budgetary flexibility to a transportation program for shipping SNF and HLW to a future ISF or repository. Whether a new organization for the management of SNF and HLW is a federal government corporation or an independent government agency, the establishment of any organization independent from DOE would require new legislation from Congress.

Conclusions

As discussed above, DOE has made progress in implementing many of the recommendations made by the NAS in its report *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level*

Radioactive Waste in the United States but in some cases, more work is needed to completely address the NAS recommendations. In many cases, the recommendations would be implemented by continuation of DOE's current activities related to transportation planning including stakeholder engagement, the consideration of the use of dedicated trains to ship the majority of SNF by rail, and plans to follow the appropriate safety and security requirements of the DOT and NRC. Furthermore, DOE would act to implement other recommendations by continuing to develop railcars and equipment to transport SNF and HLW along railways in compliance with AAR Standard S-2043; continuing to work with states and Tribes to improve the proposed policy to implement NWSA Section 180(c); proceeding to adopt lessons learned from social risk studies; and using the tools and procedures it has developed to identify potential routes for SNF and HLW shipments. In order to fully implement some of the recommendations, DOE would need to re-examine or expand its efforts, including reviewing its policies and procedures for protecting sensitive information and sharing information, as appropriate, with other federal agencies, with state, tribal, and local authorities, and with the public.

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