Overview of the DOE Nuclear Fuels Storage and Transportation Planning Project – 15444[a]

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ABSTRACT

The US Department of Energy (DOE) Office of Nuclear Energy is conducting planning activities within the Nuclear Fuels Storage and Transportation Planning Project (NFST) to lay the groundwork for implementing interim storage, including associated transportation, per the Administration's *Strategy for the Management and Disposal of Used*[b] *Nuclear Fuel and High-Level Radioactive Waste*, and to develop a foundation for a new nuclear waste management organization. The purpose of the NFST is to make progress on this important national issue within existing legislative and budgetary authorizations. The objective of the NFST is to develop and begin implementation of an integrated plan to (1) implement interim storage; (2) improve the overall integration of storage as a planned part of the waste management system; (3) prepare for the large-scale transportation of spent nuclear fuel and high-level radioactive waste, with an initial focus on removing SNF from the shutdown reactor sites; and (4) develop foundational information, resources, and capabilities needed to support the aforementioned objectives and future implementation decisions and actions. An over-arching goal is to develop options for decision-makers on the design of an integrated waste management system. The planning activities are divided into four major topical areas: (1) Consent-Based Siting, (2) Storage, (3) Transportation, and (4) Strategic Crosscuts. This paper provides an overview of the NFST and its activities.

INTRODUCTION

The Nuclear Waste Policy Act of 1982 (NWPA), as amended, requires the federal government to receive spent nuclear fuel (SNF) and high-level radioactive waste (HLW) from waste generators for ultimate disposition. In the meantime, the amount of SNF stored at operating and shutdown reactor sites continues to increase by ~2,000 metric tons of heavy metal (MTHM) annually, as illustrated in Fig. 1.

In 2010, the Secretary of Energy chartered the Blue Ribbon Commission on America's Nuclear Future (BRC) to conduct a comprehensive review and recommend a plan of action for the back end of the nuclear fuel cycle: namely the management and disposal of the nation's SNF and HLW. In January 2012 the BRC issued its final report [2], which included a recommended strategy with the following eight key elements:

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[b] Note that the terms "used" and "spent" are used interchangeably by various organizations to describe nuclear fuel that has been irradiated in a nuclear reactor.

1. A new, consent-based approach to siting future nuclear waste management facilities.
2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3. Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
4. Prompt efforts to develop one or more geologic disposal facilities.
5. Prompt efforts to develop one or more consolidated storage facilities.
6. Prompt efforts to prepare for the eventual large-scale transport of SNF and HLW to storage and disposal facilities when such facilities become available.
7. Support for continued US innovation in nuclear energy technology and for workforce development.
8. Active US leadership in international efforts to address safety, waste management, nonproliferation, and security concerns.

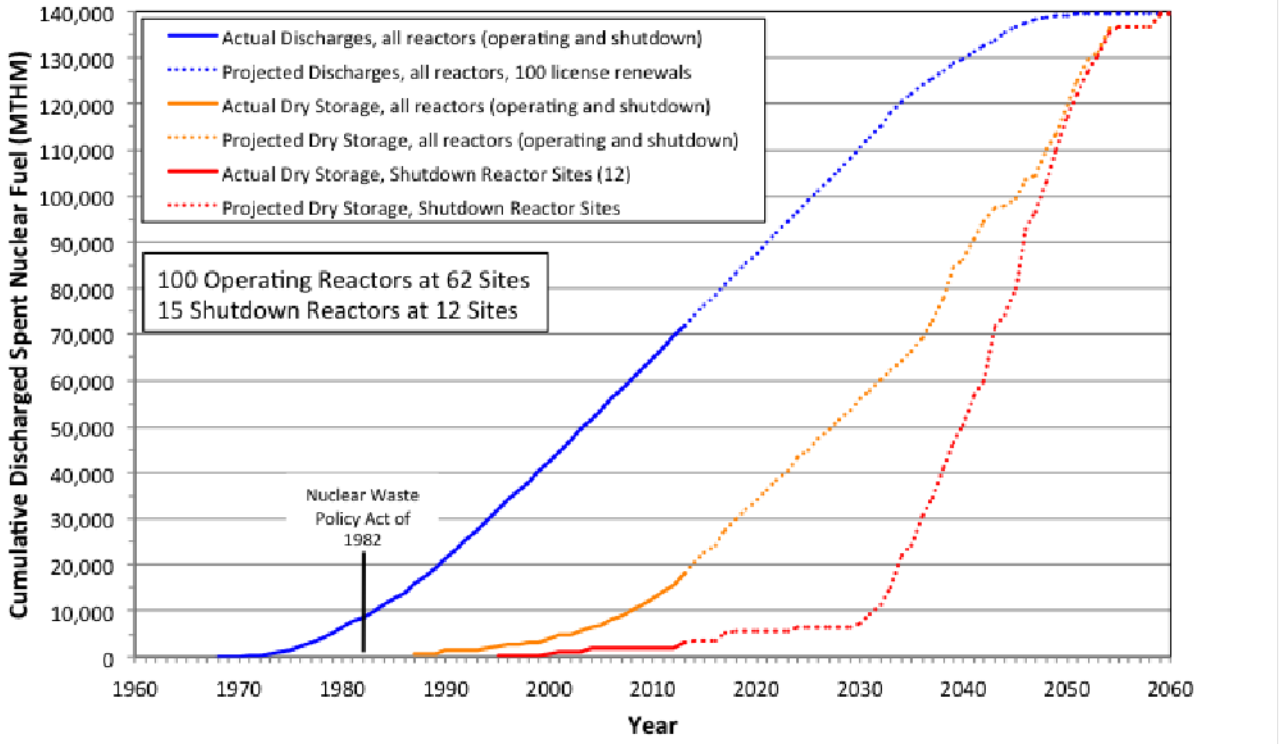

Fig. 1. Historical and projected commercial SNF Discharges.

In January of 2013, the Administration released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (*Strategy*), [3] which serves as a statement of the Administration's policy regarding the importance of addressing the disposition of SNF and HLW; lays out the overall design of a system to address the issue; outlines the reforms needed to implement such a system; and represents the Administration's response to the BRC's recommendations. The *Strategy* "endorses the key principles that underpin the BRC's recommendations" and "translates many of the BRC's principles into an actionable framework within which the Administration and Congress can build a national program for the management and disposal of the nation's used nuclear fuel and high-level radioactive waste."

As stated in the *Strategy*,

> *This Strategy includes a phased, adaptive, and consent-based approach to siting and implementing a comprehensive management and disposal system. At its core, this strategy endorses a waste management system containing a pilot interim storage facility; a larger, full-scale interim storage facility; and a geologic repository in a timeframe that demonstrates the federal commitment to addressing the nuclear waste issue, builds capability to implement a program to meet that commitment, and prioritizes the acceptance of fuel from shut-down reactors. A consent-based siting process could result in more than one storage facility and/or repository, depending on the outcome of discussions with host communities … . As a starting place, this Strategy is focused on just one of each facility.*
>
> *With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:*
> - *Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;*
> - *Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and*
> - *Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048.*

In conjunction with the development of the Administration's *Strategy*, the US DOE Office of Nuclear Energy (DOE-NE) established the Nuclear Fuels Storage and Transportation Planning Project (NFST) on October 1, 2012. The NFST mission and objectives, project structure, and recent activities and accomplishments are presented herein.

NUCLEAR FUELS STORAGE AND TRANSPORTATION MISSION AND OBJECTIVES

The mission of the NFST is to lay the groundwork for implementing interim storage, including associated transportation, per the Administration's *Strategy*. within existing legislative and budgetary authorizations, while the Administration and Congress work together on legislative changes to the nuclear waste management program. An over-arching goal is to develop options for decision-makers on the design of an integrated waste management system.

The near-term objectives of the NFST are to:

- develop and maintain an integrated plan to accomplish the *Strategy* goals;
- improve integration of storage as a planned part of the waste management system, including evaluating standardization of dry cask storage systems;
- develop and evaluate design options for an integrated waste management system;
- develop and apply systems analyses to provide quantitative estimates of system impacts of utility actions and inform future decisions;
- prepare for the large-scale transportation of SNF and HLW, with an initial focus on removing SNF from the shutdown reactor sites; and
- establish and maintain a unified and integrated SNF database and analysis system to characterize the input to the waste management system.

The longer-term objectives[c] are to:

- site, design and license, construct, and begin operations of a pilot interim storage facility (ISF) with an initial focus on accepting SNF from shutdown reactor sites;
- develop transportation infrastructure and capabilities to facilitate the acceptance of SNF at a pilot ISF; and
- site and license a larger ISF with sufficient capacity to provide flexibility in the waste management system and allow for acceptance of enough SNF to reduce expected government liabilities.

The NFST activities are aligned with the key principles that underpin the BRC recommendations and are prioritized and executed such that they will provide a foundation for a new nuclear waste management organization. Within DOE-NE, the NFST activities are coordinated with other Office of Fuel Cycle Technologies programs, in particular the Used Fuel Disposition Research and Development (UFD R&D) campaign [4] that conducts research and development activities pertaining to the extended storage and subsequent transportation of SNF and to the permanent disposal of commercial SNF and HLW.

NFST PROJECT STRUCTURE, ACTIVITIES, AND ACCOMPLISHMENTS

NFST activities are divided into four major topical areas: (1) Consent-Based Siting, (2) Storage, (3) Transportation, and (4) Strategic Crosscuts. Activities and accomplishments in each area are described below, and the detailed project structure is provided in Fig. 2.

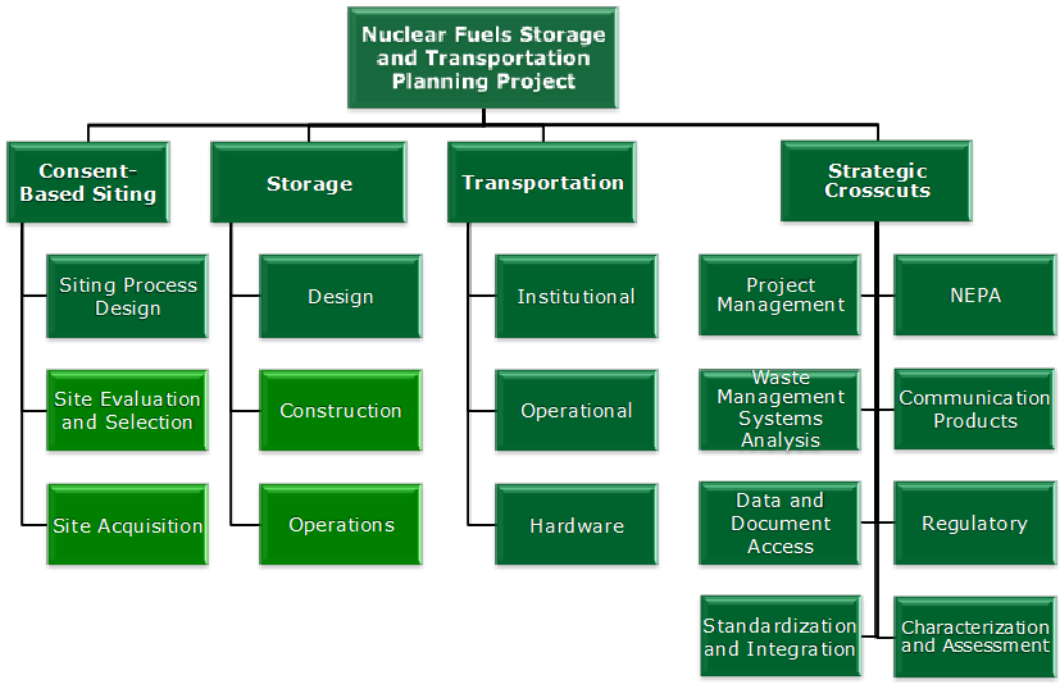

Fig. 2. NFST project structure (elements in lighter shading are inactive at this time).

[c] Per the Administration's *Strategy*, legislation is required to enable full implementation of the longer-term objectives.

Consent-Based Siting

The objective is to support establishment of a publicly accepted consent-based siting process to identify one or more viable sites. The primary focus is currently on developing information that would support a consent-based siting process.

The Administration's *Strategy* endorses a siting process that is consent based, transparent, phased, adaptive, standards and science based, and governed by legally binding agreements between the federal government and host jurisdictions. To support development of the consent-based siting process, NFST is conducting public surveys and associated analysis of public preferences related to siting, characterization, and operation of radioactive waste management facilities for storage and disposal. Specifically, NFST is evaluating public preferences related to storage at decommissioned sites, centralized storage, community acceptance of disposal, and features necessary for consent-based siting of new facilities. To ensure that future siting efforts are informed by past experience, the Siting Experience Database (SED) was developed and provides an archive of documented experience relating to nuclear waste facility siting efforts (accessible at www.curie.ornl.gov). The SED includes over 700 documents relating to nuclear waste storage and disposal siting efforts in the US and abroad, and US efforts to site advanced fuel cycle facilities. NFST continues to maintain and expand the SED with information and documents as they become available.

Storage

The objective is to lay the groundwork for implementation of interim storage as a planned part of the waste management system, with an initial focus on a pilot ISF accepting SNF from shutdown reactor sites[d]. The primary focus is currently on developing and evaluating interim storage design options, including design concepts to support development of a Topical Safety Analysis Report for eventual submittal to the NRC. This is a key activity that can be performed now to help reduce uncertainties and mitigate potential schedule risks associated with full implementation in the future.

NFST is identifying and evaluating alternative generic design concepts for receiving, storing, and handling SNF canisters to enable systems analyses needed to provide quantitative estimates of the system benefits and/or impacts associated with interim storage. This includes developing generic facility and cask system design characteristics data, such as cost, operational attributes, and system dependencies, for various approaches to developing and operating generic storage and fuel-handling facilities, as well as the supporting transportation system.

The design and operation of an ISF, both in a pilot phase and in an expanded phase, depend on how the SNF will be managed at and accepted from the reactor sites. A range of different design concepts could be utilized. It is expected that a future ISF would be deployed in phases, and as such, modular design concepts would be necessary. Thus, a range of alternative design concepts needs to be developed to provide information for use in evaluating the concepts within an integrated system analysis framework. The design concepts and accompanying waste management system analysis will provide

[d] The approach described in this paper does not in any way affect the responsibilities of the parties as defined in the Standard Contract for the Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (10 CFR Part 961). A modification of the Standard Contract would have to be agreed to in order for the US Government to accept SNF in dual-purpose canisters. As the Standard Contract provides, the U.S. Government will not accept canistered fuel without a modification to the Standard Contract (10 CFR Part 961, Article VI.A.1. (a), Appendix E).

- a range of viable design concepts for input into a future design selection;
- a range of design alternatives to inform the development of an environmental impact statement; and
- the basis for defining an ISF concept to initiate the consent-based siting process.

NFST has sought industry input relative to interim storage design concepts, as well as the costs and impacts of opening storage canisters. Most recently, NFST is managing work to develop and evaluate a suite of generic modular design alternatives for the receipt and storage of SNF in canisters at an ISF. Concepts being evaluated for storage include (1) horizontal and vertical storage systems currently licensed and in use at reactor sites, (2) universal above- and below-grade vaults, (3) universal above-grade overpacks, and (4) universal below-grade systems. CBI is also developing and evaluating generic design concepts for dry storage canister and cask handling at an ISF. The cask-handling building is envisioned to be a facility that receives transportation casks and uses the appropriate transfer cask to transfer the canister to a storage configuration. It may be more efficient and reduce personnel exposure if these operations were conducted remotely in a shielded facility. The current work is examining alternative cask-handling methods and configurations for various possible acceptance rates.

NFST is also developing initial concepts for bare fuel receipt and storage. Items of interest include cost, concept of operations (including time and motion studies), and worker dose assessments to provide foundational data for systems analysis studies.

Transportation

The objective is to prepare for the large-scale transportation of SNF and HLW to facilitate the acceptance of SNF at a pilot ISF, with an initial focus on accepting SNF from shutdown reactor sites. The primary focus is currently on making progress on long lead-time, destination-independent aspects of the transportation infrastructure.

Transportation activities are divided into three primary elements: (1) Institutional, which involves the establishment of relationships with federal, state, and tribal entities to develop policies and agreements on transportation system operations, responsibilities, and funding to provide training for local public safety officials in preparation for SNF transport; (2) Operational, which involves planning for the activities to operate the transportation system; and 3) Hardware, which involves planning for the development and/or acquisition of all physical items required to operate the transportation system (e.g., casks and ancillary equipment, railcars, and heavy-haul trucks).

Institutional transportation activities are currently focused on collaborating with stakeholders through state regional groups and tribal representatives to develop a revised NWPA Section 180(c) policy, which requires that technical assistance and funds be provided to states for training public safety officials of appropriate units of local government and to Native American tribes through whose jurisdictions SNF would be transported; developing a new National Transportation Plan, which will describe how DOE intends to develop and implement a safe, secure, and efficient transportation system and how stakeholder collaboration will contribute to the development of that transportation system; and performing preliminary routing studies, which includes evaluating potential routes from shutdown reactors to the national rail network, regardless of final destination, and developing a routing determination methodology for stakeholder interactions.

Operational transportation activities have primarily been focused on assessing needs, issues, and actions required to remove the SNF and greater than class C (GTCC) low-level radioactive waste from the

shutdown reactor sites [5]; developing a new transportation routing capability – the Stakeholder Tool for Assessing Radioactive Transportation (START); and developing transportation cask-specific models and evaluating aspects and uncertainties that may impact the transportability of loaded canisters [6], such as fuel condition, thermal load, vacuum drying conditions, criticality safety, and dose rates, with emphasis on loaded casks at the shutdown sites. Additional activities include assessing past work associated with the design of a full-scale rail cask severe accident test to develop a path forward relative to a possible package performance study.

Hardware transportation activities include planning for design, testing, and acquisition of railcars certified per the Association of American Railroads (AAR) Standard S-2043, which provides performance specifications for trains used to carry SNF and HLW [7], determining railcar and cask fleet operations and maintenance activities necessary to operate the transportation system, and performing systems studies to determine hardware needs and inform decisions related to the procurement or leasing of railcars, casks, and ancillary equipment. Related to the AAR Standard S-2043, activities have included documenting the AAR Standard S-2043-related information including standard development and use histories and implementation requirements, developing systems requirements for AAR Standard S-2043 compliant railcars, and issuing a request for information (RFI) / sources sought notice (SSN) [8] seeking information and sources for the following potential project: Railcar Design, Testing, and Approval for Transportation of High-Level Radioactive Material (HLRM). The purposes of this RFI / SSN are (1) to solicit ideas from all sources on how DOE should acquire the capability to transport casks of commercial SNF, (2) to determine if any small businesses are available to perform the work contemplated by DOE and described herein, (3) to obtain feedback on the draft statement of work, and (4) to obtain industry feedback on the proposed acquisition strategy for this procurement.

Strategic Crosscuts

The objective in this area is to perform required functions and activities to support Storage, Transportation, and Consent-Based Siting objectives. Primary activity areas include Project Management, Waste Management Systems Analysis, Characterization and Assessment, Data and Document Access, Standardization and Integration, and Regulatory.

Waste Management Systems Analysis involves the development and application of waste management systems analysis tools and data to inform future decisions. Analysis activities [9] are being performed to provide quantitative estimates of the impacts of utility and federal actions on the waste management system; the cost, benefits, and impacts of having one or more ISFs; and the impacts of different storage design options, packaging, transportation throughput, schedules, etc. This area also serves to establish the functional and operational requirements for the storage and transportation components of the waste management system. The analysis activities are also being used to identify opportunities for better integration of storage into the waste management system, including standardization of dry cask storage, transportation, and disposal systems and alternative storage options at an ISF to increase flexibility in the waste management system. In addition to maintaining and applying legacy system analysis tools, a Next Generation System Analysis Model (NGSAM) is being developed that will (1) be more readily sustainable and maintainable in the future, (2) be flexible for use by a broader set of users, (3) take advantage of advanced simulation techniques, such as agent-based simulation, (4) provide advanced capabilities not currently available, (5) leverage existing logistics and transportation simulation models developed for other applications, and (6) link with the Used Nuclear Fuel Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS) described below.

Characterization and Assessment involves establishing a unified, comprehensive SNF database and

integrated analysis system, referred to as UNF-ST&DARDS, [6] to characterize the input to the waste management system; provide a credible, controlled data source for key information; assess issues and uncertainties related to the extended storage and transportability of loaded canisters; support safety confidence and R&D prioritization; and provide a foundational data and analysis capability resource for the future. UNF-ST&DARDS currently includes five main types of data: (1) fuel assembly discharge information from the Energy Information Administration; (2) fuel assembly design data; (3) reactor-specific operation data; (4) cask design and loading data; and (5) infrastructure and logistics-related data to support systems analyses. The integrated analysis capabilities include assembly depletion and decay and cask criticality and shielding via the SCALE code system [10] and cask thermal analysis via the COBRA-SFS code [11]. Activities under way include identifying data sets and sources for inclusion to support SNF characterization activities; maintaining, developing, and enhancing SNF characterization activities to meet the needs of a variety of database users; integrating schema to facilitate data interface with waste management system architecture analysis tools, such as NGSAM; developing and incorporating SNF and GTCC inventory projections; updating and supplementing important SNF information previously documented in the Characteristics Data Base [12]; collecting and integrating SNF discharge data as it becomes available; and determining realistic safety margins for loaded casks, with a focus on shutdown reactor sites.

Data and Document Access involves development and maintenance of a collaborative SNF document and data access system, the Centralized Used Fuel Resource for Information Exchange (CURIE: curie.ornl.gov). CURIE maintains a calendar of meetings relevant to the SNF community, an SNF-related image gallery, SNF-related documents, and external links to databases and websites. It also maintains reactor- and site-specific information, which is spatially displayed using a map to illustrate dry and wet storage in the US. Most of CURIE is publicly accessible, with over 2200 documents and the SED. CURIE is a national resource that provides usable, collaborative documents and data accessible to industry, vendor, federal, and laboratory partners.

Standardization and Integration involves activities for evaluating and, if feasible, implementing standardization within the nuclear waste management system. This includes standardization of storage, transportation, and disposal canisters (STADs) and standardization of storage and transportation overpacks for the variety of dry storage canisters currently in use. NFST has sought industry input relative to the feasibility, issues, and benefits of standardization. In collaboration with the UFD R&D campaign and in consultation with industry, the current focus is on conducting a quantitative assessment and comparison of relevant options to establish the basis for future policy decision-making relative to the potential benefits and impacts associated with deviating from the current industry practice of loading large dual-purpose canisters. Activities also include generic design and operational studies for small (four pressurized-water reactor assemblies / nine boiling-water reactor assemblies) STAD systems.

Limited Regulatory activities are focused on identifying regulatory requirements and associated emerging issues. They include identifying licensing approaches; reviewing existing transportation cask Certificates of Compliance to identify items for confirmation and/or resolution prior to transportation, with priority on the systems that may be used to clear SNF from the shutdown reactor sites; reviewing existing storage cask licenses to summarize their range of relevant licensing conditions and parameters and identify potential issues associated with their use at an ISF, with priority on the systems currently used at the shutdown reactor sites; and reviewing existing licensing documents for similar facilities and systems for applicable lessons learned.

CONCLUSIONS

Working under the direction of DOE-NE, NFST is laying the groundwork for implementing interim storage, including associated transportation, per the Administration's *Strategy*. The NFST activities are aligned with the *Strategy* and will provide a foundation for a new nuclear waste management organization. The NFST activities are conducted by staff from DOE-NE, multiple national laboratories, industry contractors, vendors, and universities. NFST is making progress on this important national issue, within existing legislative and budgetary authorizations, while the Administration and Congress work together on legislative changes to enable full implementation of the Administration's *Strategy*.

REFERENCES

1. Nuclear Waste Policy Act of 1982, as amended.
2. *Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy*, January 2012.
3. *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, January 2013.
4. P. N. SWIFT, J. T. BIRKHOLZER, W. J. BOYLE, T. C. GUNTER, N. B. LARSON, R. J. MACKINNON, K. A. MCMAHON, W. M. NUTT, and K. B. SORENSON, "Overview of the United States Department of Energy's Used Fuel Disposition Research and Development Campaign," *International High-Level Radioactive Waste Management Conference*, Albuquerque, NM, USA, April 28–May 2, 2013.
5. *Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites*, FCRD-NFST-2013-000238, Rev. 1, September 2013.
6. J. M. SCAGLIONE, J. L. PETERSON, K. BANERJEE, K. R. ROBB, and R. A. LEFEBVRE, "Integrated Data and Analysis System For Commercial Used Nuclear Fuel Safety Assessments," *Proceedings of the WM2014 Conference*, Phoenix, AZ, March 2–6, 2014 (paper 14657).
7. Performance Specification for Trains Used to Carry High-Level Radioactive Material, Standard S-2043, *Manual of Standards and Recommended Practices, Section C, Car Construction Fundamentals and Details*, Association of American Railroads, Washington, DC.
8. Request for Information / Sources Sought Notice for Railcars for Transportation of High-Level Radioactive Material, DE-SOL-0006863, www.FedConnect.net.
9. W. NUTT, E. MORRIS, F. PUIG, R. HOWARD, J. JARRELL, R. JOSEPH III, and T. COTTON, "Waste Management system Architecture Evaluations," *Proceedings of the WM2014 Conference*, March 2–6, 2014, Phoenix, AZ (paper 14564).
10. *SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design*, ORNL/TM-2005/39, Version 6.1, Radiation Safety Information Computational Center at Oak Ridge National Laboratory, 2011.
11. *COBRA-SFS: A Thermal-Hydraulic Code for Spent Fuel Storage and Transportation Casks*, PNL-10782, 1995.
12. *Characteristics of Potential Repository Wastes*, DOE/RW-0184-R1, Vol. 1, US Department of Energy, Office of Civilian Radioactive Waste Management, Washington, DC, 1992.