Summary of Consolidated Interim Storage Advantages and Disadvantages from an Integrated Systems Perspective from Prior Reports and Studies

Spent Fuel and Waste Disposition

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This is a technical paper that does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961) [1].

To the extent discussions or recommendations in this paper conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this paper in no manner supersedes, overrides, or amends the Standard Contract.

This paper reflects technical work which could support future decision making by DOE. No inferences should be drawn from this paper regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository.

EXECUTIVE SUMMARY

The question of whether centralized storage of civilian spent nuclear fuel (SNF) should be part of the federal waste management system as an intermediate step before permanent disposal has been debated for more than four decades. Centralized storage facilities were included as a potential component of the U.S. spent fuel management system in the Nuclear Waste Policy Act of 1982 (NWPA), but the NWPA did not identify these facilities as being essential. At the time the NWPA was enacted, it was expected that a permanent repository would be available around the turn of the century to meet the commitment that was made to start accepting waste by that time. For several reasons, a permanent repository was not available at that stage.

This report summarizes or directly quotes statements in prior reports and studies regarding the advantages and disadvantages of including a consolidated interim storage facility (ISF) as part of an integrated waste management system. This report does not contain any new analysis or conclusions and should not be construed as endorsing any view expressed in those reports. This report should not be construed as reflecting the views of the Department of Energy.

Storing SNF before disposal is a functional requirement for an integrated waste management system. As described below, the reports and studies summarized or quoted in this report have identified potential benefits that could be obtained by adding a consolidated ISF to the waste management system, including (1) earlier acceptance of fuel by the federal government, (2) reduction in the number of unintended long-term storage sites, (3) added system flexibility and opportunity for better integration, and (4) near-term development and demonstration of institutional and technical infrastructures for large-scale management of SNF. Other reports and studies and in some cases the same reports and studies have identified potential disadvantages to including an ISF to the waste management system, including (1) potential adverse impacts on development of a repository, (2) additional transportation of SNF, and (3) upfront economic investment to establish the consolidated storage capability. This report presents a summary by the authors of the views expressed in prior reports and studies regarding these advantages and disadvantages.

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ACRONYMS

BRC	Blue Ribbon Commission on America's Nuclear Future
CFR	Code of Federal Regulation
DOE	Department of Energy
DTS	Dry transfer system
EPA	Environmental Protection Agency
FCRD	Fuel Cycle Research and Development
FES	Federal Emergency Storage
HLW	High-level radioactive waste
IEA	International Energy Agency
ISF	Interim storage facility
ISFSI	Independent spent fuel storage installations
MRS	Monitored retrievable storage
MTU	Metric tons of uranium
NFST	Nuclear Fuels Storage and Transportation Planning Project
NRC	Nuclear Regulatory Commission
NRDC	Natural Resources Defense Council
NWPA	Nuclear Waste Policy Act
NWTRB	Nuclear Waste Technical Review Board
ORNL	Oak Ridge National Laboratory
SNF	Spent nuclear fuel
UFIS	User-Funded Interim Storage

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SUMMARY OF CONSOLIDATED INTERIM STORAGE ADVANTAGES AND DISADVANTAGES FROM AN INTEGRATED SYSTEMS PERSPECTIVE FROM PRIOR REPORTS AND STUDIES

1. BACKGROUND

The question of whether centralized storage of civilian spent nuclear fuel (SNF) should be part of the federal waste management system as an intermediate step before permanent disposal has been debated for more than four decades. It was a central topic at issue in Congress when the Nuclear Waste Policy Act of 1982 (NWPA) was being developed. The debate was resolved in favor of focusing on permanent disposal in repositories, with a centralized storage (Monitored Retrievable Storage or MRS) facility potentially available as a complement to but not a substitute for repositories.[1] Section 141 of the NWPA directed the U.S. Department of Energy (DOE) to study the feasibility and the need for an MRS facility and to submit a proposal to Congress for construction of one or more such facilities. Such a facility was to accommodate high-level radioactive waste (HLW) and SNF, allow continuous monitoring, management, and maintenance of these materials, provide for the ready retrieval of these wastes for further processing or disposal, and safely store these wastes for as long as may be necessary. The NWPA specified that the disposal of HLW and SNF in a repository "should proceed regardless of any construction" of an MRS facility.

In 1987, DOE proposed construction of an MRS facility at a site in Tennessee.[2] The principal functions of the proposed facility were to be to receive SNF from nuclear reactors, prepare it for emplacement in a repository, and serve as the central receiving station for the waste management system. The MRS facility was to provide temporary storage for a limited quantity of SNF. DOE's schedule called for this facility to start receiving SNF in 1998, consistent with the schedule specified in the NWPA. When the NWPA was enacted, it was expected that a permanent repository would be available around the turn of the century to meet the commitment that was made to start accepting waste by that time.[3] However, the MRS proposal noted that the date for the start of operations at the first repository was moved from January 31, 1998 to 2003 to allow time to carry out necessary technical program activities and to provide additional opportunity for consultation and cooperation with affected states and Indian tribes. Thus, the MRS facility

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[1] U.S. Congress Office of Technology Assessment 1985, 101.

[2] U.S. Department of Energy 1987a, 1–6.

[3] U.S. House of Representatives Committee on Interior and Insular Affairs 1982, 59. The report on HR3809 made it clear that the contractual commitment—in section 124 of the bill—was expected to be met by a repository. Section 124 is a subsection of the repository subtitle A– "Repositories for disposal of high-level waste and spent nuclear fuel": "Paragraph (4)(B) makes the Secretary responsible for disposing of high level waste or spent nuclear fuel as provided under this subtitle in permanent disposal facilities, beginning not later than January 1998, in return for the payment of fees established by this section."

U.S. House of Representatives Committee on Interior and Insular Affairs 1982, 31. The repository program in the act was expected to ensure a repository would be available to meet the schedule in the bill: "A broad site survey program is included to evaluate a deverse (sic) number of potential repository sites in various geologic media, both to improve the quality of the sites finally developed and to protect the program from delay and the appearance of failure which could result from abandonment of a site."

U.S. House of Representatives Committee on Interior and Insular Affairs 1982, 40. "A commitment to a permanent repository program, and a detailed program and schedule leading to operation of such a repository, also included in H.R. 3809, render unnecessary consideration of whether expanded spent fuel storage at reactor sites will create de facto permanent disposal sites."

would be critical to the DOE's ability to accept waste for disposal in 1998.[4] The DOE proposal also included linkages to the repository-development schedule, based on recommendations of the Oak Ridge community.[5]

The Nuclear Waste Policy Amendments Act of 1987 focused all repository siting efforts on Yucca Mountain in Nevada, authorized construction of an MRS facility, and nullified DOE's recommendation of an MRS site in Tennessee. The act linked the MRS tightly to the repository with the result that many of the benefits of an MRS could not be realized,[6] and it created a Monitored Retrievable Storage Review Commission (MRS Review Commission) to report to Congress on whether such a facility was needed.[7] The MRS Review Commission's report,[8] delivered in November of 1989, did not resolve the issue. The MRS Review Commission concluded that:

> …the MRS as presently described in the law, which links the capacity and schedule of operation of the MRS to a permanent geologic repository, cannot be justified, [but that] while no single factor would favor an MRS over the No-MRS option, cumulatively the advantages of an MRS would justify the building of an MRS if: (1) there were no linkages between the MRS and the repository; (2) the MRS could be constructed at an early date; and (3) the opening of the repository were delayed considerably beyond its presently scheduled date of operation.[9]

In 1989, DOE reported to Congress that the repository would not be available until 2010 and that in the face of the "schedule delays and the uncertainties inherent in the development of a geologic repository …an aggressive program to develop an integrated MRS facility for spent fuel" was needed for timely compliance with federal obligations.[10,11] The report also concluded that the tight linkages between the MRS and the repository established in the 1987 NWPA amendments needed modification, either through legislation or through an agreement with an MRS host obtained by the Office of the United States Nuclear Waste Negotiator (an office created by the 1987 amendments).[12] In making this recommendation, DOE noted that:

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[4] U.S. Department of Energy 1987a, 2. "Thus, the MRS facility would be critical to the DOE's ability to accept waste for disposal in 1998."

[5] Department of Energy 1987a, 5.

[6] Monitored Retrievable Storage Review Commission 1989, 95. "The existing linkages, particularly those that tie the MRS schedule to that of the repository, keep pressure on the repository program but severely limit the flexibility of the waste management system….As the foregoing analysis of DOE's postulated benefits shows, the existing statutory linkages significantly reduce the benefits associated with an MRS."

[7] U.S. Congress 2020, 130. In 2020, Congress directed DOE to proceed under the existing provisions of the NWPA which relate to a monitored retrievable storage (MRS) facility as defined and delimited in that Act: "Within available funds in this account for interim storage, the Department is directed to move forward under existing authority to identify a site for a federal interim storage facility. The Department is further directed to use a consent-based approach when undertaking these activities. The Department is reminded that the Nuclear Waste Policy Act provides for a wide variety of activities that may take place prior to the limitation in section 141(g)."

[8] Monitored Retrievable Storage Review Commission 1989.

[9] Monitored Retrievable Storage Review Commission 1989, iii. Letter of Transmittal.

[10] U.S. Department of Energy 1989b, 17, x.

[11] U.S. Nuclear Regulatory Commission 1990, 38500–38501. The NRC noted in its 1990 update to the Waste Confidence Decision that the NWPAA's decision to characterize potential repository sites sequentially (starting with Yucca Mountain) instead of simultaneously as required in the NWPA of 1982 meant that "there could be considerable delay while characterization was completed at another site or slate of sites if the initially chosen site was found inadequate." In the 1990 update, "[t]he Commission raised the concern as early as April 1987 that under a program of single-site characterization, there could be considerable delay while characterization was completed at another site or slate of sites if the initially chosen site was found inadequate. By terminating site characterization at alternative sites to the Yucca Mountain site, the NWPAA has had the effect of increasing the potential delay in repository availability if the Yucca Mountain site proves unsuitable."

[12] U.S. Department of Energy 1989b, 18.

> Other highly industrialized countries in which nuclear power plays a prominent role, such as Sweden, Germany, and France, are providing centralized interim storage facilities while pursuing repository-development programs. This has allowed these countries to provide near-term management for the spent fuel and to conduct their repository programs at a pace not dictated by unrealistic waste-acceptance objectives. The DOE believes that a similar approach should be considered in the United States.[13]

However, no legislation was adopted, and the negotiator's siting process was terminated while still underway. Subsequent attempts by Congress to enact legislation directing establishment of a central storage facility in Nevada were unsuccessful.[14] In 2008, DOE issued a report required by Congress describing a demonstration of the interim storage of SNF from decommissioned nuclear power reactor sites.[15] The report concluded that if Congress authorized and funded DOE to perform interim storage, it would provide an additional option for accepting commercial SNF that could prove beneficial if Yucca Mountain was delayed due to licensing, litigation, lack of funding, or other causes. [16] However, this option would only be provided if the legislation adequately addressed key issues including removal of the linkage to the repository and funding reform to avoid competition for limited budget resources between storage, transportation, disposal, and other priorities.[17]

By 2009, the timeline for opening Yucca Mountain had already slipped to 2020,[18] stalled by reduced funding from Congress, along with public and legal opposition. It was determined that Yucca Mountain was not a workable solution..[19,20,21] The 2013 *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (2013 *Strategy*),[22] proposed consent-based siting of pilot and larger consolidated interim storage facilities (ISFs) expected to be sited and operating by 2021 and 2025, respectively. Siting of these facilities would be accompanied by development of a geologic repository that would be sited by 2026 and in operation by 2048. In its earlier report, the Blue Ribbon Commission on America's Nuclear Future (BRC or the Commission) observed that "given the present situation, developing consolidated storage capacity could be the fastest and surest path for the federal government to begin performing under existing contracts and to ultimately achieve waste acceptance rates that can

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[13] U.S. Department of Energy 1989b, 16.

[14] Holt 1998, 7–9.

[15] U.S. Department of Energy 2008.

[16] U.S. Department of Energy 2008, iv.

[17] U.S. Department of Energy 2008, iii.

[18] U.S. Department of Energy 2009, 1. This was an optimum schedule predicated on the timely enactment of land withdrawal legislation, licensing approvals, and issuance of all necessary federal and state permits, as well as absence of litigation-related delays: "This PDS anticipates that the repository will be operational by 2020. This schedule is predicated upon the enactment of legislation, similar to previous legislation submitted to Congress that addresses funding reform and permanent land withdrawal. This schedule also assumes appropriations by the Congress consistent with optimum Project execution, the issuance of an NRC construction authorization consistent with the three-year period specified in the NWPA for the licensing proceeding with an opportunity for a fourth year if needed, and the subsequent timely issuance by the NRC of a receive and possess license. This schedule is also dependent on a complete and timely submission by the DOE of all necessary applications to the relevant agencies, the timely issuance of all other necessary authorizations and permits, and the absence of litigation-related delays."

[19] Moniz 2013.

[20] Moniz 2014.

[21] U.S. Department of Energy 2015a, 5: "The path to a first and second repository as envisioned under the NWPA has been significantly more controversial, costly, and delayed than was anticipated in 1985. When the Act was amended in 1987 to focus on a single repository site at Yucca Mountain, it reflected a growing frustration in Congress over the increasing cost and delay. There was a strong belief at the time that focusing on a single site would alleviate these issues. That did not prove to be the case—cost escalation and delays continued, while state opposition and legal challenges mounted. In 2009, with the timeline for opening a repository pushed back by two decades, and no end to opposition in sight, the Department determined the site to be unworkable. There have been no funds appropriated for work at the site since fiscal year 2010."

[22] U.S. Department of Energy 2013.

stop the further growth of taxpayer liability."[23] The BRC recommended "a new, consent-based approach to siting future nuclear waste management facilities."[24] In December 2015, DOE announced the initiation of a consultative process to obtain input from the public on important considerations in designing a consent-based siting process for both storage facilities and repositories.[25] In 2015, DOE began developing a consent-based process for siting storage or disposal facilities collaboratively with members of the public, communities, stakeholders, and governments at the Tribal, State, and local levels. Subsequently, in the Consolidated Appropriations Act, 2021, Congress appropriated funds to the Department for interim storage activities.[26] In a December 2021 Federal Register notice, DOE's Office of Nuclear Energy requested information on how to site Federal facilities for the temporary, consolidated storage of spent nuclear fuel using a consent-based approach.[27] In 2022, DOE issued a funding opportunity announcement (FOA) to provide resources for communities interested in learning more about consent-based siting, management of spent nuclear fuel, and interim storage facility siting considerations.[28] That same year, a paper was released that summarized the comments received from the request for information.[29]

2. PURPOSE

Since the NWPA was enacted, the need for ISFs as part of the federal waste management system has been analyzed and documented in numerous reports and studies. This current report summarizes the advantages and disadvantages as described in those reports of incorporating an ISF into the waste management system. These reports include: DOE reports and studies (see list below) supporting the Department's 1985 proposal to develop an MRS facility (which first identified many of the benefits and costs discussed in this report), along with several extensive reviews of the need for interim storage in the U.S. waste management system by key independent review groups:

DOE reports:

- *Monitored Retrievable Storage Submission to Congress: Volume I, The Proposal*, March 1987, DOE/RW-0035/1-Vol.1-Rev.1.[30]

  This document is DOE's official response to the requirements of NWPA Sect. 141.[31]

- *The DOE Position on the MRS Facility*, June 1989, DOE/RW-0239.[32]

  This report served as input to MRS Review Commission deliberations.

- *Additional Information on Monitored Retrievable Storage*, November 1987, DOE/RW-0166.[33]

[23] Blue Ribbon Commission on America's Nuclear Future 2012, 37.

[24] Blue Ribbon Commission on America's Nuclear Future 2012, vii.

[25] U.S. Department of Energy 2015b.

[26] Consolidated Appropriations Act, 2021 (Public Law 116-260), 2020.

[27] U.S. Department of Energy Federal Register 2021.

[28] U.S. Department of Energy FOA 2022c.

[29] U.S. Department of Energy 2022b.

[30] U.S. Department of Energy 1987a.

[31] U.S. Department of Energy 1987a, iii. In response to Section 141 of the Nuclear Waste Policy Act of 1982, the U.S. Department of Energy hereby submits a proposal for the construction of a facility for monitored retrievable storage (MRS).

[32] U.S. Department of Energy 1989a.

[33] U.S. Department of Energy 1987c.

This report responded to questions[34] that had been raised by the General Accounting Office and others about the need for an MRS facility.

- *Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program*, November 29, 1989, DOE/RW-0247.[35]

  This document presents a reassessment of the repository schedule, showing a significant slip for the expected start of repository operations—from the year 2003 to approximately 2010[36] and supporting modification of the statutory linkages between the MRS and the repository either through congressional action or the efforts of Nuclear Waste Negotiator to achieve a negotiated agreement for a site for an MRS facility.[37]

Independent reviews:

- *Nuclear Waste: Is There a Need for Federal Interim Storage?* Report of the Monitored Retrievable Storage Review Commission, November 1, 1989.[38]

  The Nuclear Waste Policy Amendments Act of 1987 established the MRS Review Commission "to prepare a report on the need for an MRS as a part of a national nuclear waste management system" and to "make a recommendation to Congress as to whether such a facility should be included in the national nuclear waste management system." As part of its charge to "review the status and adequacy of the [Energy] Secretary's evaluation of the system's advantages and disadvantages of bringing such a facility into the national nuclear waste disposal system," the MRS Review Commission evaluated the DOE MRS proposal and position on the MRS facility listed above, as well as nine system studies DOE conducted to help the MRS Review Commission in its evaluation.

- *Disposal and Storage of Spent Nuclear Fuel — Finding the Right Balance.* A Report to Congress and the Secretary of Energy by the Nuclear Waste Technical Review Board, March 1996.[39]

  The Nuclear Waste Technical Review Board (NWTRB) was established by the Nuclear Waste Policy Amendments Act of 1987 to "evaluate the technical and scientific validity of activities undertaken by the Secretary [of Energy]" after passage of the amendments. During congressional consideration of several legislative proposals to proceed with the development of an ISF at the proposed repository site at Yucca Mountain, Nevada, the NWTRB submitted this special report on the issues concerning the relationship between storage and disposal.

- *Report to the Secretary of Energy by the Blue Ribbon Commission on America's Nuclear Future*, January 2012.[40]

[34] U.S. Department of Energy 1987c, 1. "Since the DOE developed the MRS proposal for the Congress, a number of questions have been raised by the General Accounting Office (GAO), the State of Tennessee, and others concerning the need for the MRS facility and the feasibility of achieving comparable performance for the overall waste management system without an MRS facility. This report was prepared to provide additional information to address these questions."

[35] U.S. Department of Energy 1989b.

[36] U.S. Department of Energy 1989b, vii.

[37] U.S. Department of Energy 1989b, 18.

[38] Monitored Retrievable Storage Review Commission 1989.

[39] Nuclear Waste Technical Review Board 1996.

[40] Blue Ribbon Commission on America's Nuclear Future 2012.

In 2009, DOE determined that developing the proposed repository at Yucca Mountain, Nevada, would not be a workable solution due to continued public and legal opposition.[41] In 2010, Secretary of Energy Chu chartered the BRC to conduct a comprehensive review and recommend a new plan of action for management and disposal of the nation's SNF and HLW. This report contains the final findings and recommendations.

- *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, January 2013.[42]

  This document presents the strategy issued by the Administration in 2013 in response to the BRC's final report and recommendations. It is "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel and high-level radioactive waste from civilian nuclear power generation, defense, national security, and other activities."[43]

Sections 3 and 4 of this report present the findings of these and other reports and studies and summarize the advantages and disadvantages of ISFs that have been identified in referenced reports and studies. In this report, an *advantage* is a benefit or positive characteristic provided by an integrated waste management system with an ISF compared to an integrated waste management system without an ISF. A *disadvantage* is a negative characteristic associated with an integrated waste management system that includes an ISF compared to an integrated waste management system without an ISF. Detailed discussions of each advantage and disadvantage are provided in Appendices A and B.

3. KEY ADVANTAGES OF AN INTERIM STORAGE FACILITY

This section summarizes the advantages of an ISF as documented in various reports and studies. Additional details are in Appendix A.

3.1 Providing for Earlier Federal Acceptance of SNF

Many of the reports cited in this section have concluded that an ISF may be the most expeditious and most certain way for the federal government to begin meeting its ethical, statutory, and contractual obligations to accept SNF for ultimate disposal. In 1989, DOE reported to Congress[44] that the repository would not be available until 2010, and the "schedule delays and the uncertainties inherent in the development of a geologic repository" have necessitated "an aggressive program to develop an integrated MRS facility for spent fuel" to ensure timely performance to meet the federal obligations.[45]

[41] U.S. Department of Energy 2015a, 5. "The path to a first and second repository as envisioned under the NWPA has been significantly more controversial, costly, and delayed than was anticipated in 1985. When the Act was amended in 1987 to focus on a single repository site at Yucca Mountain, it reflected a growing frustration in Congress over the increasing cost and delay. There was a strong belief at the time that focusing on a single site would alleviate these issues. That did not prove to be the case—cost escalation and delays continued, while state opposition and legal challenges mounted. In 2009, with the timeline for opening a repository pushed back by two decades, and no end to opposition in sight, the Department determined the site to be unworkable. There have been no funds appropriated for work at the site since fiscal year 2010."

[42] U.S. Department of Energy 2013.

[43] U.S. Department of Energy 2013, 1.

[44] U.S. Department of Energy 1989b.

[45] U.S. Department of Energy 1989b, 17, x.

In its final report, the BRC emphasized the ethical position embodied in the NWPA[46] that the generations who created the SNF and HLW and benefited from the national defense and commercial nuclear power activities that produced them have an obligation to ensure that the entire burden of providing for their management and disposal does not fall to future generations.[47] Reviewing the delays in the U.S. waste management program to date, the BRC concluded that meeting that commitment "means mustering, without further delay, the financial, programmatic, institutional, and political wherewithal to implement a functional system to manage these materials that provides for their safe transportation, consolidated storage, and disposal." [48] The BRC observed that "given the present situation, developing consolidated storage capacity could be the fastest and surest path for the federal government to begin performing under existing contracts and to ultimately achieve waste acceptance rates that can stop the further growth of taxpayer liability." [49] The BRC recommended "a new, consent-based approach to siting future nuclear waste management facilities."[50] Siting and operating a consolidated storage facility would help restore trust and confidence in the intention and ability of the federal government to meet its waste management obligations.[51]

Several studies have noted that initiation of waste acceptance using a central storage facility would begin the fulfillment of government contractual responsibilities and reduction of taxpayer payments for damages.[52,53] In 2014, DOE estimated that the cumulative liability resulting from failure to begin SNF acceptance in 1998 would be $27.1 billion, assuming that waste acceptance begins in 2021 consistent with the schedule for implementation of storage facilities in the 2013 *Strategy* document.[54] Deducting the amount paid as of September 30, 2014, under settlements and as a result of final judgments, a total of $4.5 billion, the remaining liability was estimated to be approximately $22.6 billion. By the end of Fiscal Year (FY) 2022, the total liability estimate had risen to $41.1 billion.[55] The liability estimate is contingent upon Congress amending the NWPA and providing adequate ongoing appropriations. Deducting an amount paid of $10.1 billion under settlements and as a result of final judgments, the remaining liability was estimated to be approximately $31.0 billion, representing an average increase in estimated remaining liability of about $1.05 billion per year since September 30, 2014.

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[46] U.S. House of Representatives 1982, 29. "The Committee strongly recommends that the focus of the Federal waste management program remain, as it is today, on the development of facilities for the disposal of high level nuclear waste which do not rely on human monitoring and maintenance to keep the wastes from entering the biosphere. As has been emphasized and reiterated over the lifetime of the Federal nuclear program, high level wastes should not be a burden on future generations, and must be disposed of by those who benefited from the energy derived from the nuclear activities which created the wastes."

[47] Blue Ribbon Commission on America's Nuclear Future 2012, 6.

[48] Blue Ribbon Commission on America's Nuclear Future 2012, 6.

[49] Blue Ribbon Commission on America's Nuclear Future 2012, 37.

[50] Blue Ribbon Commission on America's Nuclear Future 2012, viii.

[51] Blue Ribbon Commission on America's Nuclear Future 2012, 40. "Trust and confidence in the federal government's basic commitment and competence to deliver on its waste management obligations have all but completely eroded since 1987. Restoring that trust and confidence must be the government's first priority and is essential for getting all aspects of the nation's nuclear waste program back on track. In this context, demonstrating that it is possible to muster the policy direction, technical expertise, and institutional competence needed to site and operate one or more consolidated storage facilities (while also vigorously pursuing final disposal capability) would by itself be enormously valuable."

[52] Blue Ribbon Commission on America's Nuclear Future 2012, 37. "Given the present situation, developing consolidated storage capacity could be the fastest and surest path for the federal government to begin performing under existing contracts and to ultimately achieve waste acceptance rates that can stop the further growth of taxpayer liability."

[53] Government Accountability Office 2009, 30. "Finally, if DOE uses centralized facilities to store commercial spent nuclear fuel, this alternative could allow DOE to fulfill its obligation to take custody of the commercial spent nuclear fuel until a long-term strategy is implemented. As a result, DOE could curtail its liabilities to the electric power companies, potentially saving the government up to $500 million per year after 2020, as estimated by DOE."

[54] U.S. Department of Energy 2014, 77.

[55] U.S. Department of Energy 2022a, 120.

3.2 Reducing the Number of Unintended Long-Term Storage Locations

An ISF would provide an alternative to the continued unintended and unplanned growth of an ad hoc[56,57] decentralized, long-term storage system at reactor sites by default.[58,59] In the absence of reliable projections for the availability of a federal facility to begin accepting SNF, and without explicit federal guidance about storage methods, utilities have been left to address their interim storage needs on an individual basis using options deemed best for their particular needs.[60] This has led to a proliferation of diverse storage systems at 70 reactor sites across the country. The diversity continues to increase as dry storage design improvements are made, with a trend toward increasingly large storage canisters. While this reduces near-term costs and impacts on reactor operations, the large canisters may require very long-term cooling after reactor shutdown (many decades or even more than a century) before they could be disposed of directly in a geologic repository without reopening and repackaging the fuel, the objective of ongoing DOE research activities.[61] This consideration supports recommendations for moving the canisters to centralized storage before any issues that might affect the ability to transport them from the reactor sites might arise.[62] Another often-cited benefit of an ISF is that it would provide the ability to remove SNF from reactor sites after shutdown and reactor decommissioning, as cited by the MRS Review

[56] Blue Ribbon Commission on America's Nuclear Future 2012, 32. "Current arrangements for the storage of SNF in the United States, however, have evolved in an ad hoc fashion."

[57] Government Accountability Office 2021, 32. "The United States currently has an ad hoc system for managing spent nuclear fuel. Specifically, there is no standardized strategy for storing fuel on-site at reactors and no standard storage canister."

[58] Blue Ribbon Commission on America's Nuclear Future 2012, 33. "Chapter 3 of this report describes how the current situation—in which the vast majority of spent fuel is still being stored at the reactor sites where it was generated— arose by default as the U.S. government first decided not to pursue reprocessing and then fell further and further behind in developing a disposal repository."

[59] Stanford University and George Washington University 2018, 4. "When policy makers contemplated nuclear waste disposal in the U.S. Nuclear Waste Policy Act of 1982, they envisioned a straightforward process: storing spent fuel in pools at reactors for no more than a few years and then transporting the spent fuel to a geologic repository starting in 1998. More than 35 years later, an ad hoc system for managing spent fuel has replaced this strategy, with no geologic repository in sight. The current situation exists without clear and consistent incentives on how best to manage spent fuel at reactor sites, without agreement on the necessity of centralized storage, and without consent from a host community or state for the site of a final geologic repository. As a result, there are no standardized waste management strategies at reactors, no standard waste packages, and no plan for transportation of the spent fuel from reactor sites to either interim storage or a geologic repository. Hence, it is nearly impossible to assure the compatibility of waste package design with storage or repository requirements. Spent fuel is stored using a variety of different technologies that directly impact how and when final disposal can happen. Instead of a planned, coherent system, we have the confusion of an unplanned, less than optimal system, with each player only focused on their own small piece of the larger system. This is not a situation that builds public confidence."

[60] U.S. Department of Energy 1987c, 17. "The DOE does not take explicit action to influence the methods used by the utilities to solve their spent-fuel-storage problems. It is expected that each utility with a storage problem will choose from available options of dry storage and possibly in-pool consolidation the option it deems best for its particular needs."

[61] Nuclear Waste Technical Review Board 2021, A-4. "The figure [Figure A-2] shows that, in order to meet the waste package thermal power limit for an unbackfilled repository in hydrologically unsaturated hard rock, a waste package with 32 PWR assemblies having a burnup of 40 GWd/MT would require an aging time of < 50 years (Point A) prior to emplacement to reduce thermal power so that temperature limits are met. Longer aging times would be required for the other repository concepts illustrated in Figure A-2: 50 years for a backfilled repository in salt (Point B), 150 years for a backfilled repository in hydrologically saturated argillite (Point C), and > 200 years for a backfilled repository in hydrologically saturated hard rock (Point D). The largest DPCs currently in use can hold 37 PWR assemblies or 89 BWR assemblies, which emit more heat and, thus, will require longer aging times than the 32-PWR waste package evaluated in Figure A-2."

[62] Carlsen and BradyRaap 2012, 24. "Fundamentally, the U.S. should assume that UNF will be moved before the ability to transport is lost. Timely UNF transport reduces the risk with storage at dispersed locations without the financial burden associated with repackaging (either wet or dry). To fully benefit from repackaging and remediation capabilities at a centralized facility, the UNF management strategy must ensure that packages are transported before repackaging becomes necessary."

Commission,[63] the NWTRB,[64] the BRC,[65] and the 2013 *Strategy*[66] as well as other groups.[67,68,69,70,71,72] This will allow those sites to be fully decommissioned and put to other beneficial uses.[73] During the congressional deliberations leading up to passage of the NWPA, the House Committee on Interior and Insular Affairs also recognized MRS facilities as an important backup in the event of failure or serious delay in the repository program past the point at which reactors began to be decommissioned.[74] In addition, by reducing the number of sites that store SNF, the expensive replication of the efforts and costs

[63] Monitored Retrievable Storage Review Commission 1989, xvi. "Although the Commission does not find any single factor that would cause it to favor one alternative, it believes that, cumulatively, there are a number of advantages that would justify a central storage facility not limited in capacity nor linked to the repository schedule and operation. These advantages include … storage for spent fuel from shutdown reactors…"

[64] Nuclear Waste Technical Review Board 1996, xii-xiii. "The Board recommends that during the next several years generic planning for a centralized storage facility and for a supporting transportation infrastructure begin at a funding level modest enough to avoid competition with the repository program. From a technical, operational, and fiscal perspective, 2010 is the key milestone for storage. Therefore, plans should be made to have this storage facility operating at full capacity (able to accept 3,000 metric tons/year for 30 years) by about 2010. This will allow the federal government to remove the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur."

[65] Blue Ribbon Commission on America's Nuclear Future 2012, xii. "The arguments in favor of consolidated storage are strongest for "stranded" spent fuel from shutdown plant sites. Stranded fuel should be first in line for transfer to a consolidated facility so that these plant sites can be completely decommissioned and put to other beneficial uses."

[66] U.S. Department of Energy 2013, 5. "This system would initially be focused on acceptance of used nuclear fuel from shut-down reactors; such fuel provides an opportunity to build waste handling capability as well as to relieve surrounding communities and utility contract holders of the burdens associated with long-term storage of used nuclear fuel at a shut-down reactor."

U.S. Department of Energy 2013, 6. "Consistent with legislation recently under consideration in Congress, the Administration supports the development of a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites. Acceptance of used nuclear fuel from shut-down reactors provides a unique opportunity to build and demonstrate the capability to safely transport and store used nuclear fuel, and therefore to make progress on demonstrating the federal commitment to addressing the used nuclear fuel issue. A pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation."

[67] Cochran 2005, Slide 12. "NRDC'S Preferred Solution: …Allow away-from-reactor spent fuel storage for decommissioned reactors."

[68] American Physical Society 2007, Executive Summary. "Consolidated storage could facilitate the decommissioning of sites with reactors that have been shut down."

[69] National Commission on Energy Policy 2007, 7. "Require the Secretary of Energy to take possession of and/or remove fuel from reactor sites that have been, or are in the process of being fully decommissioned."

[70] Keystone Center 2007, 16. "The NJFF group also agrees that centralized interim storage is a reasonable alternative for managing waste from decommissioned plant sites and could become cost-effective for operating reactors in the future."

[71] Massachusetts Institute of Technology 2011, 48. "The possibility of storage for a century, which is longer than the anticipated operating lifetimes of nuclear reactors, suggests that the United States should move toward centralized SNF storage sites—starting with SNF from decommissioned reactor sites and in support of a long-term SNF management strategy."

[72] Stanford University and George Washington University 2018, 5. "The Standard Contract should be revised under the new organization to include planned removal of spent fuel first from shutdown plants."

[73] Blue Ribbon Commission on America's Nuclear Future 2012, xii.

[74] U.S. House of Representatives 1982, 44. "Monitored Retrievable Storage may be required in the event of failure or long-term delay of the repository development program. Indeed, this need for insurance that some safe technology will be available when nuclear reactors begin being decommissioned is the Committee's primary basis for recommendation of the detailed planning for an MRS program included in the Committee amendment to H.R. 3809."

of guarding the fuel at multiple small sites will be avoided.[75,76,77] Finally, if an ISF is sited using a consent-based process as endorsed by multiple sources[78,79,80,81] and directed by Congress in 2020,[82] then removing fuel from shutdown sites will result in the SNF management system becoming more consent-based as fuel is moved from sites, where consent for long-term storage was never sought or granted to a willing host community that has negotiated the terms and conditions of hosting the facility.[83]

3.3 Increased System Flexibility and Integration

An ISF would add flexibility and operational alternatives to an integrated waste management system that includes a repository. The ISF would provide an effective buffer to accommodate variations and concerns with loading and storage operations at reactor sites or repository(s).[84] The 1987 DOE MRS proposal noted that by separating the acceptance of SNF at reactors from emplacement in the repository and adding significant operational storage capacity to the system, an MRS facility "would produce identifiable improvements in the manageability of the system and allow the DOE to better accommodate the circumstances of the future."[85] An ISF would provide capabilities and opportunities to deal with unexpected developments that would be challenging to manage at shutdown or at operating reactor sites.[86] According to reports and studies supporting U.S. Nuclear Regulatory Commission's (NRC's) Continued

[75] Blue Ribbon Commission on America's Nuclear Future 2012, 35.

[76] Keystone Center 2007, 79. "A centralized facility that took all the spent fuel from decommissioned reactors would reduce the number of spent fuel installations, provide for consolidated and more efficient oversight of the waste, and allow the decommissioned sites to be reclaimed for other purposes."

[77] Massachusetts Institute of Technology 2011, 50. "*For decommissioned sites, our economic modeling of the net present value—comparing at reactor storage with centralized storage at a number of reference locations in the east, west and mid-west—show significant advantages for consolidation at centralized sites. This is due largely to the cessation of government payments for spent fuel storage at shutdown sites once cleared of spent fuel. A second important result is the relative indifference of costs to site location despite the significant real distance between sites.* Transportation costs are not a major cost driver. This implies that policy makers have wide flexibility in siting a central facility, a flexibility that should come in handy considering past experience."

[78] Blue Ribbon Commission on America's Nuclear Future 2012, vii–ix.

[79] U.S. Department of Energy 2013. 1. "This Strategy includes a phased, adaptive, and consent-based approach to siting and implementing a comprehensive management and disposal system."

[80] Government Accountability Office 2021, 24.

[81] Stanford University and George Washington University 2018, 6. "The Steering Committee recommends the adoption of a consent-based siting process that (1) establishes strong bonds of trust between localities, tribes, and states on the one hand and the implementer and that (2) fairly reallocates power among the parties."

[82] U.S. Congress 2020. 130. "Within available funds in this account for interim storage, the Department is directed to move forward under existing authority to identify a site for a federal interim storage facility. The Department is further directed to use a consent-based approach when undertaking these activities."

[83] Blue Ribbon Commission on America's Nuclear Future 2012, 35. "Moreover, these communities were never asked about, and never contemplated or consented to, the conversion of these reactor sites into indefinite long-term storage facilities. As a result, they generally also did not have an opportunity to negotiate for rights of participation or incentives and benefits of the sort that would likely be available to the host community of a dedicated storage facility."

[84] U.S. Department of Energy 1989a, 13. "An MRS facility could add flexibility by insulating reactors from the effects of slippages in the schedule for repository development and operation. The extent of such insulation would depend on the linkages between the MRS facility and the repository. Flexibility during site characterization can be accomplished only with an MRS facility that can be constructed before the selection of the repository site. That would require modification or elimination of the linkages in the Amendments Act."

[85] U.S. Department of Energy 1987a, 3-4.

[86] Blue Ribbon Commission on America's Nuclear Future 2012, 39. "Such facilities could also offer enhanced remote handling capabilities, thereby reducing the potential for worker exposures. This capability could be particularly important if changes in the condition of the spent fuel over time make it necessary to open storage containers and repackage the fuel before moving it elsewhere for disposition. Dry storage facilities at shutdown reactors without pools do not have any of the fuel handling and recovery capabilities that would be provided in a consolidated facility—in effect, these facilities are simply well-guarded parking lots for storage casks. If fuel at these sites needed repackaging, a new fuel handling facility would have to be constructed at considerable time and expense."

Storage Rule (10 CFR Part 51, §51.23), confidence in the long-term safety of dry storage is based in part on confidence that SNF could be safely retrieved from dry casks for inspection or repackaging if necessary,[87] and this could be done more effectively and safely at a central storage site.[88] In addition to providing reliability improvements and buffer storage, an ISF would provide opportunities for better integration of storage with disposal and transportation functions, system standardization, and exploration of technical challenges in the integrated waste management system.[89,90] The BRC concluded[91] "[a] federal facility with spent fuel receipt, handling and storage capabilities can support other valuable activities that would benefit the waste management system. These include long-term monitoring and periodic inspection of dry storage systems and work on improved storage methods."

3.4 Near-Term Development and Demonstration of Institutional and Technical Infrastructures for Large-Scale Management of SNF

As indicated below, several studies concluded that the development of an ISF would be the first step in the development of an integrated waste management system, and it would demonstrate the federal government's ability to move forward to meet its SNF obligations. The MRS Review Commission noted "both early acceptance of spent fuel and demonstrating progress towards disposal of spent fuel would enhance confidence in the waste management program and these two means of achieving confidence are not necessarily incompatible."[92] The BRC concluded "siting and developing one or more consolidated storage facilities would improve prospects for a successful repository program."[93] In addition to demonstrating a technical solution, an ISF would provide experience working with host communities. Specifically, the 2013 *Strategy* stated "[a] pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation."[94] In summary, inclusion of an ISF in the waste management system would allow many of the first-of-a-kind technical and institutional challenges of

[87] U.S. Nuclear Regulatory Commission 2014, xxxi. "To guide its analysis, the NRC also relied on certain assumptions regarding the storage of spent fuel…A DTS [dry transfer system] would be built at each ISFSI location for fuel repackaging…A DTS would enable retrieval of spent fuel for inspection or repackaging without the need to return the spent fuel to a spent fuel pool."

[88] Carlsen and BradyRaap 2012, 24. "A key objective is to ensure that UNF is transported to its final destination, or a destination with the necessary repackaging capabilities, before the need for repackaging arises. Although presently small, the likelihood of the need for a DTS [dry transfer system] to enable retrieval of UNF for inspection or repackaging will increase as the duration and quantity of fuel in dry storage increases. Stored fuel will eventually require remediation and/or repackaging for transport. Any large-scale repackaging operations that may eventually be necessary can be more safely and effectively conducted at a consolidated facility."

[89] Monitored Retrievable Storage Review Commission 1989, 92. "The Commission finds that if standardization is not mandated by the Federal government, an MRS facility that accepts waste early could promote standardization by reducing the variety of spent fuel forms and packages to be handled and could limit the number of reactors providing storage for other than intact, un-packaged spent fuel."

[90] Blue Ribbon Commission on America's Nuclear Future 2012, 39. "Finally, a consolidated storage facility could provide flexible, safe, and cost-effective waste handling services (i.e., repackaging or sorting of fuel for final disposal) and could facilitate the standardization of cask systems. This in turn could reduce the need for extensive handling at many reactor sites and make it possible to use more cost-effective storage systems at a central facility."

[91] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

[92] Monitored Retrievable Storage Review Commission 1989, 96.

[93] Blue Ribbon Commission on America's Nuclear Future 2012, 38.

[94] U.S. Department of Energy 2013, 6.

consolidated waste management and disposal to be addressed in advance of development of a repository instead of leaving them all to be faced for the first time at the first repository site.[95]

4. KEY DISADVANTAGES OF AN INTERIM STORAGE FACILITY

With any significant action, there is always potential for negative impacts on specific activities or stakeholders. The three main disadvantages of an ISF identified in the cited summarized reports and studies are (1) potential adverse impacts on a repository, (2) increased transportation of SNF and the added risks associated with additional handling of SNF, and (3) the potentially significant costs of designing, licensing, constructing, and operating an ISF.

4.1 Potential Adverse Impacts on Development of a Repository

Many of these reports and studies have noted that developing an ISF would reduce the urgency to provide permanent disposal in geologic repositories and would become a de facto repository by default.[96,97,98] While multiple reports support parallel development of interim storage facilities (ISF) and repositories,[99,100,101,102] the appropriate linkage between the two has been debated since DOE proposed such a linkage in 1987 to assure the communities that would be affected by an MRS facility in Tennessee

[95] U.S. Department of Energy 1989a, 22–23. "The DOE also believes that an MRS facility can play an important role in a stepwise process for the development of the waste-management system. Analyses that simply compare the operational characteristics of MRS and no-MRS systems tend to overlook the importance of proceeding with an MRS facility as a strategic step toward a repository. Whether or not there is an MRS facility in the waste-management system, much in the way of resources and a large amount of human ingenuity will be dedicated during the next two decades to managing spent fuel before it is emplaced in a repository. If those efforts were made by utilities in providing at-reactor storage at approximately 70 separate reactor sites, it would provide little learning experience that would help the DOE in meeting the technical, regulatory, and institutional challenges of developing and operating a Federal waste-management system capable of accepting, transporting, and handling large quantities of high-level waste and spent fuel at high annual rates. If the efforts were exerted by the DOE in developing and operating an MRS facility, much of that experience would directly increase the likelihood of timely and reliable operation of the Federal waste-management system."

[96] U.S. House of Representatives 1982, 42. "The objection most often raised to the concept of large-scale, long-term MRS storage is that it is not compatible with, and may be destructive of, a national or societal goal to dispose permanently of high-level radioactive wastes…Once waste is loaded into an MRS facility, barring a serious accident, the cost of moving the radioactive material and decommissioning the MRS in funds and human exposure would outweigh the advantage of relocating the waste underground to a permanent repository."

[97] U.S. Department of Energy 1987a, 5. "Some potential adverse programmatic effects have also been postulated by various parties, but most are perceived and avoidable rather than inevitable. The one most often cited is concern that an MRS facility would diminish the resolve to develop a geologic repository.

[98] Blue Ribbon Commission on America's Nuclear Future 2012, 39–40. "The Commission has also heard and considered arguments against proceeding with consolidated storage. Of these, the most important objection and one that will need to be thoughtfully addressed is the concern that any consolidated storage facility could become a de facto disposal facility and—by reducing the pressure to find a long-term solution—thwart progress toward developing the deep geologic disposal capacity that will ultimately be needed. This is not a new concern; it is why the 1987 NWPA Amendments explicitly tied the construction of an MRS facility to progress on a first repository and set capacity limits for the MRS facility so that it could not accommodate all the spent fuel in need of disposal."

[99] Blue Ribbon Commission on America's Nuclear Future 2012.

[100] U.S. Department of Energy 2013.

[101] Nuclear Waste Technical Review Board 1996, xiii. "Because siting a centralized storage facility may be extremely difficult without a viable disposal program, if the site at Yucca Mountain proves unacceptable for repository development, the Board recommends that other potential sites for both disposal and centralized storage be considered."

[102] Government Accountability Office 2021, 24. "Nearly all of the experts we interviewed said the United States should initiate a new siting process that would apply to the siting, development, and construction of consolidated interim storage facilities and permanent geologic repositories for commercial spent nuclear fuel. Most of these experts said the United States should use a consent-based siting process."

that the spent fuel would be removed.[103] The 1987 DOE Monitored Retrievable Storage Submission to Congress t stated that an ISF would serve as a buffer between reactor sites and the repository, providing flexibility in the repository-development schedule by insulating repository development from pressures for acceptance of SNF and thereby allowing adjustments in that schedule without at-reactor impacts.[104] This inherent flexibility has also been identified as a potential disadvantage due to concerns that there will be reduced priority and resources given to repository development.[105,106,107,108] Repository development is vital since the ISF per se does not provide a complete solution to the waste management problem.[109,110] For additional perspectives from past reports on linkages between an ISF and a repository related to this potential disadvantage, see Appendix B.1-3.

[103] U.S. Department of Energy 1987a, 27. "Earlier efforts to provide Federal storage facilities have raised the concern that the ready availability of Federal storage would make it easy for the nation to defer the difficult political decisions required to site a geologic repository. Conversely, the history of the waste-management program suggests that the credibility of any interim storage measures will be suspect unless there is confidence that a permanent repository will be available within a reasonable period of time. To dispel doubts about the resolve to develop a repository, the DOE proposes a direct linkage of MRS operations to the development of a repository. Specifically, the DOE proposes that waste acceptance at the MRS facility be precluded until a construction authorization for the first repository is received from the Nuclear Regulatory Commission. In addition, the DOE recommends that the storage capacity of the MRS facility be limited to 15,000 MTU. This capacity is sufficient to offset potential storage shortfalls at reactors for approximately 5 years, but it is less than one-third of the spent-fuel inventory expected by the year 2000."

[104] U.S. Department of Energy 1987a, 23. "The inclusion of significant storage capability at the MRS facility would provide a system buffer that would allow the unloading of reactor storage pools to be independent of the loading of the repository. This system-buffer capability is important because the optimal rates and sequences for unloading the individual reactor storage pools will differ from waste-acceptance rates conducive to an efficient loading of the repository."

[105] U.S. Department of Energy 1987a, 27. "The perceived and potential programmatic impacts of adding an MRS facility are the weakening of resolve to develop a repository, the potential for diverting the resources needed to develop a repository, and the enlargement of the system to be implemented."

[106] U.S. Senate Committee on Energy and Natural Resources and Committee on Environment and Public Works 1981, 25. "Finally, an unlimited monitored retrievable storage facility may well divert resources and effort from the primary need to develop a permanent disposal solution as soon as possible."

[107] U.S. House of Representatives 1982, 42: "Once waste is loaded into an MRS facility, barring a serious accident, the cost of moving the radioactive material and decommissioning the MRS in funds and human exposure would outweigh the advantage of relocating the waste underground to a permanent repository."

[108] Government Accountability Office 2021, 31. "In addition, most of the experts we interviewed said that in order for a consolidated interim storage facility to be viable, the United States would need to have a plan for a permanent geologic repository…In addition to the legal limitations on siting a federal consolidated interim storage facility before siting a geologic repository, many experts raised concerns that efforts to site and develop a consolidated interim storage facility would distract from efforts to site and develop a permanent geologic repository."

[109] U.S. Senate Committee on Energy and Natural Resources and Committee on Environment and Public Works 1981, 25. Even Senate supporters of the MRS thought so. "The changes to title V included in the Committee amendment would assure that these needs are met, and that the directions in the bill that monitored, retrievable storage cannot serve as a substitute for permanent disposal in a geologic repository are carried out. In that regard, the Committee believes that there are a number of serious disadvantages to a large-scale system of monitored, retrievable storage facilities that is intended to serve as an alternative to geologic disposal in a repository. First, the development of a permanent disposal system that is capable of containing the nuclear waste for the substantial periods of time during which these wastes remain hazardous is essential to establishing public confidence that there exists a solution to the nuclear waste problem. A system, such as monitored, retrievable storage, that must rely on continued monitoring throughout the lifetime of the facility and the repeated replacement of the facility itself over time cannot provide public confidence that the nuclear waste problem has been solved. Such a solution can be provided, however, through the use of geologic repositories that include the use of stable, geologic formations as an additional barrier to the release of the waste and that thereby eliminate the need for long-term monitoring and replacement of the facility."

[110] U.S. House of Representatives 1982, 42. "The objection most often raised to the concept of large-scale, long-term MRS storage is that it is not compatible with, and may be destructive of, a national or societal goal to dispose permanently of high-level radioactive wastes."

4.2 Additional Transportation of SNF

The BRC report pointed out that one of the main arguments against proceeding with consolidated storage was that it would require additional handling of SNF and HLW, increasing safety and security risks, as well as costs.[111] As noted by the NRC in NUREG-2125,[112] "The risks associated with SNF transportation come from the radiation that the spent fuel emits, which is attenuated—but not eliminated—by the transportation casks shielding and the possibility of the release of some quantity of radioactive material during a severe accident. This investigation shows that the risk from the radiation emitted from the casks is a small fraction of naturally occurring background radiation and the risk from accidental release of radioactive material is several orders of magnitude less." An assessment of consolidated interim storage by the American Physical Society that specifically looked at transportation risks related to moving spent fuel twice concluded that "consolidating the waste from operating nuclear reactors would likely not significantly change the overall risks associated with the storage of spent fuel."[113] The MRS Commission evaluated both radiological and non-radiological risks for waste management systems and concluded that the differences were so small that they should not affect the choice of systems.[114] In addition, recent analysis has shown that though the costs associated with transportation will increase, they are not substantial when compared to total systems costs, and the incremental costs of transporting fuel twice are insignificant in the larger picture (see Appendix A). Additional transportation of SNF is expected unless an ISF and a repository can be collocated at a single site through a consent-based process. Non-radiological risks associated with transportation accidents would be expected to increase proportionally to the amount of distance traveled.

4.3 Up-front Economic Investment

Whether an ISF would increase the total costs of a nuclear waste system has been discussed by a number of studies over the past 20 years.[115] DOE's 1987 MRS proposal estimated that inclusion of an MRS facility would increase system costs by about 5 percent, an amount that was considered to be small in comparison with the benefits.[116] In the long run, total costs of the storage facility would be offset to some extent by the reduction of at-reactor costs for managing SNF in dry storage at multiple sites. The MRS Review Commission concluded that the cost differences between an MRS and no-MRS system decreased the longer a repository was delayed and added that in any case "the uncertainty apparent in the cost data suggests it would not be prudent to base decisions primarily on what is currently perceived to be the

[111] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

[112] U.S. Nuclear Regulatory Commission 2012, iii.

[113] American Physical Society 2007, 5–6. "With respect to transportation risks, an interim consolidated site would require spent fuel to be moved twice rather than once. The fuel would be moved from operating reactors to the consolidated site, and then from the consolidated site to the permanent repository. The additional transport adds risk. However, the transportation safety risks (as distinct from security risks) are so low that the overall risk increase is likely to be insubstantial as long as transportation programs operate with care and in adherence to applicable regulations. Similarly, as security risk information becomes publicly available, it is likely that it will not add substantially to the overall risks. Consequently, consolidating the waste from operating nuclear reactors would likely not significantly change the overall risks associated with the storage of spent fuel."

[114] Monitored Retrievable Storage Review Commission 1989, 52. "The Commission finds that the estimates of the radiological effects of transporting spent fuel are small, and the difference between the estimates for different alternatives is not large enough to make transportation effects significant in choosing between alternatives."

Monitored Retrievable Storage Review Commission 1989, 53. "The Commission finds that the non-radiological risks associated with the alternatives are small and that differences among them are insignificant in determining the need for an MRS."

[115] Jarrell et al. 2016.

[116] U.S. Department of Energy 1987a, 4–5.

lowest cost strategy." [117] One contractor report concluded that the bulk of the cost avoidances would not occur for multiple decades, so assumptions about inflation, escalation, and discount rates have a significant effect on potential economic impacts of an ISF.[118] The same contractor report further concluded that while system-wide cost avoidance could be significant, it would not offset the initial investment in an ISF for multiple decades.[119]

5. CONCLUSIONS

This report summarizes key advantages and disadvantages that have been identified in reports and studies by DOE, Congress, the Blue Ribbon Commission, by DOE contractors and others of the impacts of including an ISF as part of an integrated waste management system. The studies referenced and summarized in this report have identified a range of benefits that could be obtained by adding a consolidated ISF to the waste management system, including (1) earlier acceptance of fuel by the federal government, (2) reduction in the number of unintended long-term storage sites, (3) added system flexibility and opportunity for better integration, and (4) near-term development and demonstration of institutional and technical infrastructures for large-scale management of SNF. Reports and studies referenced and summarized in the report have identified potential disadvantages to deployment of an ISF, including (1) potential adverse impacts on development of a repository, (2) additional transportation of SNF, and (3) up-front economic investment to establish the consolidated storage capability. Additional information on these advantages and disadvantages as identified in prior reports and studies is provided in the appendices to this report.

[117] Monitored Retrievable Storage Review Commission 1989, 74. "The Commission finds that the costs of building and operating an MRS are greater than the savings in reactor storage costs if the repository starts according to current DOE schedules or is subject to a modest delay. If the MRS [sic. Should be "repository"] is delayed beyond 2013, when the cost delaying the removal of spent fuel from shutdown reactors begins to accumulate, then the cost differences between a No-MRS and unlinked MRS system become negligible. Since the criteria that the Commission used to evaluate the desirability of including a monitored retrievable storage facility in the national spent fuel management and disposal system are not limited to lowest cost, these data do not demonstrate conclusively that a No-MRS strategy is to be preferred, even if one is optimistic about the repository schedule. Moreover, the uncertainty apparent in the cost data suggests it would not be prudent to base decisions primarily on what is currently perceived to be the lowest cost strategy."

[118] Jarrell et al. 2016.

[119] Jarrell et al. 2016, iv–v.

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APPENDIX A

Detailed Discussions of the Advantages and Disadvantages of Including an ISF in the Integrated Waste Management System

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APPENDIX A
Detailed Discussions of the Advantages and Disadvantages of Including an ISF in the Integrated Waste Management System

A-1. ADVANTAGES OF INCLUDING INTERIM STORAGE FACILITIES

There are several advantages associated with developing an ISF. These advantages are discussed in detail in this section.

A-1.1 Earlier Federal Acceptance of SNF

In the Nuclear Waste Policy Act (NWPA), Congress found that "high-level radioactive waste and spent nuclear fuel have become major subjects of public concern, and appropriate precautions may be taken to ensure that such waste and spent fuel do not adversely affect the public health and safety and the environment for this or future generations."[1] To address this concern, Congress enacted in the NWPA a clear federal commitment to provide for the safe disposal of HLW and SNF and established a schedule for developing geologic repositories for that purpose, along with a contractual fee-for-service mechanism to ensure that waste owners and generators would pay for it instead of putting the burden on others. The contracts established under the Act required the federal government to begin accepting SNF from nuclear utilities by 1998; this requirement was not met. The BRC emphasized the ethical position embodied in the NWPA[2] that the generations who created the SNF and HLW and benefited from the national defense and commercial nuclear power activities that produced them have an obligation to ensure that the entire burden of providing for their management and disposal does not fall to future generations.[3] The BRC reviewed the delays in the U.S. waste program to date and concluded that meeting this commitment "means mustering, without further delay, the financial, programmatic, institutional, and political wherewithal to implement a functional system to manage these materials that provides for their safe transportation, consolidated storage, and disposal."[4] Many of the reports cited later in this section have concluded that an ISF may be the most expeditious and most certain way for the federal government to begin meeting its ethical, statutory, and contractual obligations to accept SNF for ultimate disposal. The supporting arguments are discussed further in subsections A-1.1.1 and A-1.1.2 below.

A-1.1.1 Development of consolidated storage capacity is the fastest way to begin acceptance of SNF

While the NWPA as originally enacted in 1983 provided for consideration of an optional ISF (the Monitored Retrievable Storage [MRS] facility), the Act assumed that the federal obligation to begin accepting SNF or HLW by 1998 could be met by timely implementation of a robust, aggressive repository siting program. The repository siting program was an important basis of the NRC's 1994 determination that a repository would be available in the 2007–2009 timeframe. This was stipulated in the NRC's first Waste Confidence Rule, and it allowed for normal programmatic delays. However, as early as

[1] Nuclear Waste Policy Act of 1982, § 111(a)(7); 42 U.S.C. § 10131(a)(7).

[2] U.S. House of Representatives 1982, 29. "The Committee strongly recommends that the focus of the Federal waste management program remain, as it is today, on the development of facilities for the disposal of high level nuclear waste which do not rely on human monitoring and maintenance to keep the wastes from entering the biosphere. As has been emphasized and reiterated over the lifetime of the Federal nuclear program, high level wastes should not be a burden on future generations, and must be disposed of by those who benefited from the energy derived from the nuclear activities which created the wastes."

[3] Blue Ribbon Commission on America's Nuclear Future 2012, 6.

[4] Blue Ribbon Commission on America's Nuclear Future 2012, 6.

1987, DOE had already concluded that delays in the repository program meant that implementation of an MRS facility was needed to begin accepting waste in 1998.[5] The potential for further repository delays was increased by the 1987 Nuclear Waste Policy Amendments Act, which eliminated the robust parallel site evaluation program of the Act as originally enacted in 1983 and replaced it with a repository siting program focused on Yucca Mountain, an approach that NRC had warned would greatly increase the uncertainty in the repository schedule.[6] In 1989, DOE reported to Congress that the repository would not be available until 2010, and that due to "schedule delays and the uncertainties inherent in the development of a geologic repository," "an aggressive program to develop an integrated MRS facility for spent fuel" [7] was needed for timely fulfillment of the federal obligations. The report concluded that an MRS facility could be developed rapidly "because it [would] make maximum use of technologies that have been proved and because it has fewer licensing uncertainties than a geologic repository." [8] The report also concluded that the tight linkages between the MRS and the repository established in the 1987 amendments should be modified through legislation or an agreement with an MRS host obtained by the nuclear waste negotiator.[9] However, no legislation was adopted, and the negotiator process was terminated in 1994 while still underway. In 2008, DOE issued a report, requested by Congress, demonstrating the interim storage of SNF from decommissioned nuclear power reactor sites.[10] The report concluded that if Congress authorized and funded DOE to perform interim storage, it would provide an additional option for accepting commercial SNF that could prove beneficial if Yucca Mountain experienced delays due to licensing, litigation, lack of funding, or other causes, but only if the enabling legislation adequately addressed funding reform to avoid competition for limited budget resources between storage, transportation, disposal, and other priorities [11].

By 2009, the timeline for opening Yucca Mountain had already slipped to 2020,[12] stalled by public protest and legal opposition with seemingly no end in sight.[13] This led to the determination that Yucca Mountain is not a workable solution and that a new consent-based approach could gain the necessary

[5] U.S. Department of Energy 1987a, 2. "Thus, the MRS facility would be critical to the DOE's ability to accept waste for disposal in 1998."

[6] U.S. Nuclear Regulatory Commission 1990, 38500–38501. According to the NRC in its 1990 update to the Waste Confidence Decision, the NWPAA, in effect, directed DOE to characterize potential repository sites sequentially (starting with Yucca Mountain) instead of simultaneously as required in the NWPA as originally enacted in 1983, and that this meant that "there could be considerable delay while characterization was completed at another site or slate of sites if the initially chosen site was found inadequate." In the 1990 update, "[t]he Commission raised the concern as early as April 1987 that under a program of single-site characterization, there could be considerable delay while characterization was completed at another site or slate of sites if the initially chosen site was found inadequate. By terminating site characterization at alternative sites to the Yucca Mountain site, the NWPAA has had the effect of increasing the potential delay in repository availability if the Yucca Mountain site proves unsuitable."

[7] U.S. Department of Energy 1989b, 17, x.

[8] U.S. Department of Energy 1989b, 17.

[9] U.S. Department of Energy 1989b, 18.

[10] U.S. Department of Energy 2008.

[11] U.S. Department of Energy 2008, iii.

[12] U.S. Department of Energy 2009, 1. This was an optimum schedule predicated on the timely enactment of land withdrawal legislation, licensing approvals, and issuance of all necessary federal and state permits, as well as absence of litigation-related delays. "This PDS anticipates that the repository will be operational by 2020. This schedule is predicated upon the enactment of legislation, similar to previous legislation submitted to Congress that addresses funding reform and permanent land withdrawal. This schedule also assumes appropriations by the Congress consistent with optimum Project execution, the issuance of an NRC construction authorization consistent with the three-year period specified in the NWPA for the licensing proceeding with an opportunity for a fourth year if needed, and the subsequent timely issuance by the NRC of a receive and possess license. This schedule is also dependent on a complete and timely submission by the DOE of all necessary applications to the relevant agencies, the timely issuance of all other necessary authorizations and permits, and the absence of litigation-related delays."

[13] U.S. Department of Energy 2015a, 5. "In 2009, with the timeline for opening a repository pushed back by two decades, and no end to opposition in sight, the Department determined the site to be unworkable."

public acceptance.[14,15,16] The 2013 *Strategy* [17] proposed consent-based siting and operation of pilot storage facilities by 2021 and larger storage facilities by 2025, accompanied by the development of a geologic repository planned to be sited by 2026 and in operation by 2048. In its earlier report, the BRC observed that "[g]iven the present situation, developing consolidated storage capacity could be the fastest and surest path for the federal government to begin performing under existing contracts and to ultimately achieve waste acceptance rates that can stop the further growth of taxpayer liability" and recommended "a new, consent-based approach to siting future nuclear waste management facilities."[18] As the BRC observed, experiences in other countries provide a basis for confidence in the consent-based approach.[19] In December 2015, DOE announced the initiation of a consultative process to obtain input from the public on important considerations in designing a consent-based siting process for both storage facilities and repositories.[20]

A-1.1.2 Initiation of waste acceptance would begin the fulfillment of government contractual responsibilities and reduction of taxpayer payments for damages

Federal taxpayers pay damages to utilities for continued failure to accept SNF for disposal starting in 1998, with the projected amount increasing as the delay in acceptance extends. A key part of the NWPA is a contractual fee-for-service arrangement in which the federal government is obligated to dispose of SNF and HLW from civilian nuclear activities, while the generators and owners of those materials are responsible for the associated costs. Contracts define a fee on nuclear-generated electricity in exchange for a federal commitment to begin accepting waste in 1998. The federal government did not meet that contractual obligation, and "as a result of litigation by contract holders, the government was found in partial breach of contract, and is now liable for damages to some utilities to cover [certain] costs of on-site, at-reactor storage."[21] In 2014, DOE estimated that the cumulative liability resulting from failure to begin SNF acceptance in 1998 would be $27.1 billion, assuming that waste acceptance begins in 2021 consistent with the schedule for implementation of storage facilities in the 2013 Strategy document.[22] Deducting the amount paid as of September 30, 2014, under settlements and as a result of final judgments, a total of $4.5 billion, the remaining liability was estimated to be approximately $22.6 billion. By the end of FY 2022, the total liability estimate had risen to $41.1 billion [23]. The liability estimate is contingent upon Congress amending the NWPA and providing adequate ongoing appropriations.. Deducting an amount paid of $10.1 billion under settlements and as a result of final judgments, the remaining liability was estimated to be approximately $31.0 billion, representing an average increase in

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[14] Moniz 2013.

[15] Moniz 2014.

[16] U.S. Department of Energy 2015a, 5–6. "The path to a first and second repository as envisioned under the NWPA has been significantly more controversial, costly, and delayed than was anticipated in 1985. When the Act was amended in 1987 to focus on a single repository site at Yucca Mountain, it reflected a growing frustration in Congress over the increasing cost and delay. There was a strong belief at the time that focusing on a single site would alleviate these issues. That did not prove to be the case—cost escalation and delays continued, while state opposition and legal challenges mounted. In 2009, with the timeline for opening a repository pushed back by two decades, and no end to opposition in sight, the Department determined the site to be unworkable. There have been no funds appropriated for work at the site since fiscal year 2010."

[17] U.S. Department of Energy 2013.

[18] Blue Ribbon Commission on America's Nuclear Future 2012, 37, vii.

[19] Blue Ribbon Commission on America's Nuclear Future 2012, ix. "Based on a review of successful siting processes in the United States and abroad— including most notably the siting of a disposal facility for transuranic radioactive waste, the Waste Isolation Pilot Plant (WIPP) in New Mexico, and recent positive outcomes in Finland, France, Spain and Sweden— we believe this type of approach can provide the flexibility and sustain the public trust and confidence needed to see controversial facilities through to completion."

[20] U.S. Department of Energy 2015b.

[21] U.S. Department of Energy 2013, 3.

[22] U.S. Department of Energy 2014, 77.

[23] U.S. Department of Energy 2022, 120.

estimated remaining liability of about $1.05 billion per year since September 30, 2014. The 2013 *Strategy* pointed out that interim storage would provide "the opportunity to move expeditiously to fulfill government contractual responsibilities,"[24] and that "the sooner that legislation enables progress on implementing this Strategy, the lower the ultimate cost will be to the taxpayers."[25]

A-1.1.3 Ability to take near-term action on the front end of the integrated waste management system

DOE's 1987 MRS proposal identified that early implementation of the "front end" of the waste management system would be a major step in the overall development of an integrated waste management system:

> The MRS facility would allow the DOE to separate a major part of the waste-management process (acceptance, transportation from the reactor sites, consolidation, and sealing in canisters) from uncertainties about the repository and to proceed immediately with detailed planning for, and implementation of, that part. This would provide the utilities with a firmer basis for planning the transfer of spent fuel to the DOE. The development of the transportation system would also be advanced because the approval of the MRS facility would allow specific routing, logistics, and equipment requirements for shipments from reactors to be determined up to 8 years earlier. The early accomplishment of these separable steps of the waste-management process would significantly enhance confidence in the schedule for the operation of the total system. Moreover, the facility would provide a focal point for early system integration[26].

The BRC noted the value of consolidated storage in separating waste acceptance from the repository schedule: "[d]eveloping consolidated storage capacity would allow the federal government to begin the orderly transfer of spent fuel from reactor sites to safe and secure centralized facilities independent of the schedule for operating a permanent repository."[27]

A-1.2 Reduction in Number of Unintended Long-Term Storage Locations

An ISF would provide a needed alternative to the continued unintended, unplanned growth of an ad hoc [28,29] decentralized, long-term storage system at reactor sites by default[30]. SNF will continue to be stored at each reactor site while the reactor is operating and for at least a few years after it has shut down to allow removal of SNF from the pools. At the time of the BRC report, SNF was being stored at nine sites that no longer had an operating reactor. There have been several unexpected early shutdowns since

[24] U.S. Department of Energy 2013, 5.

[25] U.S. Government Publishing Office 2015, 394.

[26] U.S. Department of Energy 1987a, 3.

[27] Blue Ribbon Commission on America's Nuclear Future 2012, xii.

[28] Blue Ribbon Commission on America's Nuclear Future 2012, 32. "Current arrangements for the storage of SNF in the United States, however, have evolved in an ad hoc fashion."

[29] U.S. Government Accountability Office, 2021 32. "The United States currently has an ad hoc system for managing spent nuclear fuel. Specifically, there is no standardized strategy for storing fuel on-site at reactors and no standard storage canister."

[30] Stanford University and George Washington University 2018, 4.

the BRC report,[31] and a larger wave of shutdowns is expected by some starting in around 2030 as reactors reach the end of their licensed lives, as shown in Fig. A-1.

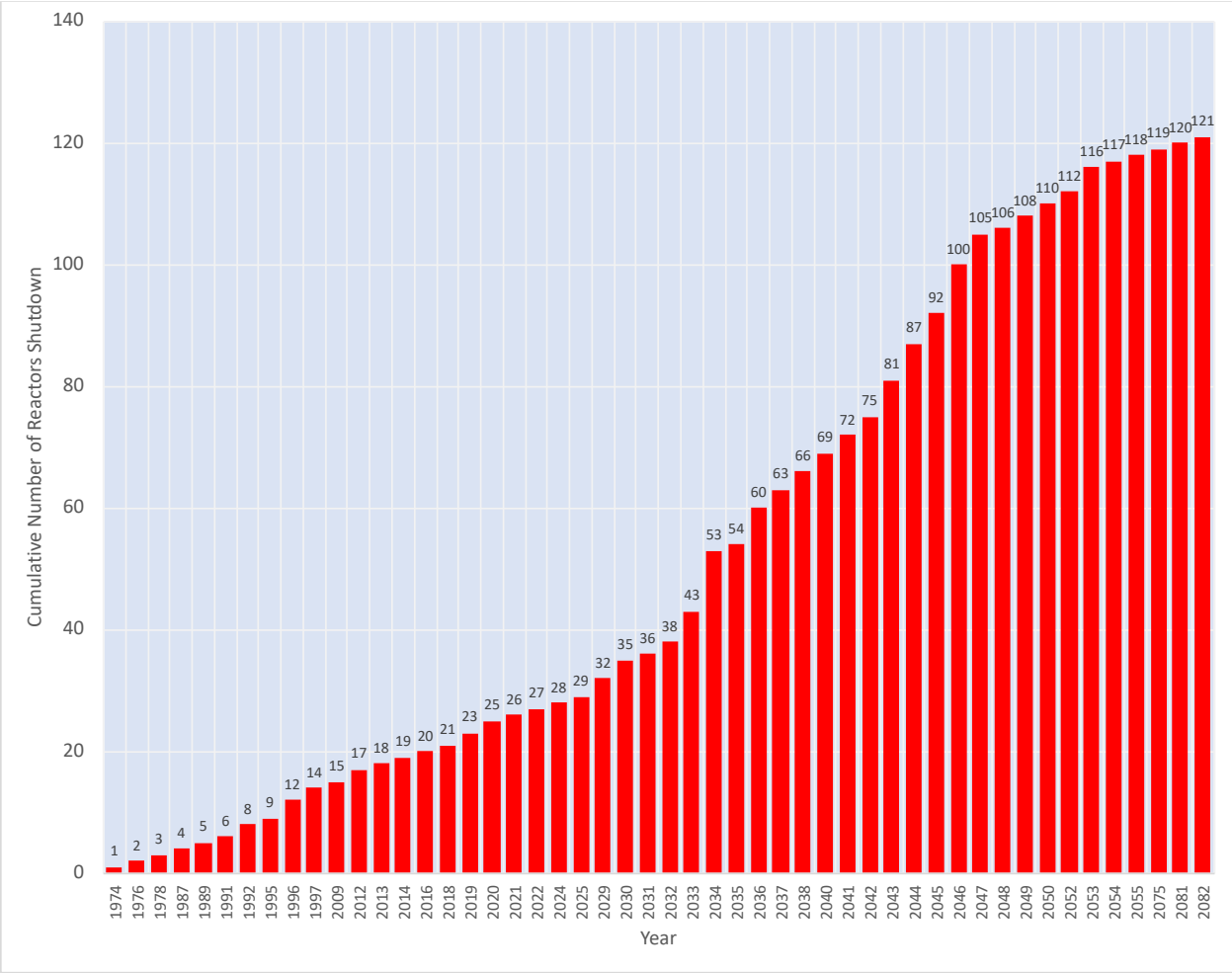

Fig. A-1. Number of shutdown reactors (actual through 2021 and predicted after 2021).[32]

Without anywhere else to take the SNF, the amount of SNF in dry storage will rapidly increase at shutdown sites as the reactor pools are emptied to facilitate decommissioning.

In the absence of reliable projections of the availability of a federal facility being able to begin accepting SNF and without explicit federal guidance about storage methods, utilities have responded to their interim storage needs on an individual basis using options deemed best for their particular needs.[33] This has led to a proliferation of storage systems at 70 reactor sites across the country. The diversity continues to increase as design improvements are made, with a trend toward increasingly large storage canisters. While this reduces near-term costs and impacts on reactor operations the large canisters may

[31] As of June 30, 2021, 26 reactors have been shut down: Big Rock Point; Haddam Neck; Humboldt Bay 3; La Crosse; Maine Yankee; Rancho Seco; Trojan; Yankee Rowe; Zion 1 and 2; Dresden 1; Duane Arnold; Crystal River 3; Fort Calhoun; Indian Point 1, 2, and 3; Kewaunee; Millstone 1; Oyster Creek; Pilgrim; San Onofre 1, 2, and 3; Three Mile Island 1; and Vermont Yankee. In addition, three reactors have announced early shutdown dates: Palisades, Diablo, and Canyon 1 and 2.

[32] Peters, S., D. Vinson, and J. Carter 2021.

[33] U.S. Department of Energy 1987c, 17. "The DOE does not take explicit action to influence the methods used by the utilities to solve their spent-fuel-storage problems. It is expected that each utility with a storage problem will choose from available options of dry storage and possibly in-pool consolidation the option it deems best for its particular needs."

require very long-term cooling after reactor shutdown (many decades or even more than a century) before they could be disposed of directly in a geologic repository without reopening and repackaging the fuel, the objective of ongoing DOE research activities.[34]

Another often-cited benefit of an ISF is that it would provide the ability to remove SNF from reactor sites after shutdown and reactor decommissioning, as cited by the MRS Review Commission,[35] the NWTRB,[36] the BRC,[37] and the 2013 *Strategy*[38] as well as other groups.[39,40,41,42,43,44] During the congressional deliberations leading up to passage of the NWPA, the House Committee on Interior and

[34] Nuclear Waste Technical Review Board 2021, A-4. "The figure [Figure A-2] shows that, in order to meet the waste package thermal power limit for an unbackfilled repository in hydrologically unsaturated hard rock, a waste package with 32 PWR assemblies having a burnup of 40 GWd/MT would require an aging time of < 50 years (Point A) prior to emplacement to reduce thermal power so that temperature limits are met. Longer aging times would be required for the other repository concepts illustrated in Figure A-2: 50 years for a backfilled repository in salt (Point B), 150 years for a backfilled repository in hydrologically saturated argillite (Point C), and > 200 years for a backfilled repository in hydrologically saturated hard rock (Point D). The largest DPCs currently in use can hold 37 PWR assemblies or 89 BWR assemblies, which emit more heat and, thus, will require longer aging times than the 32-PWR waste package evaluated in Figure A-2."

[35] Monitored Retrievable Storage Review Commission 1989, xvi. "Although the Commission does not find any single factor that would cause it to favor one alternative, it believes that, cumulatively, there are a number of advantages that would justify a central storage facility not limited in capacity nor linked to the repository schedule and operation. These advantages include…storage for spent fuel from shutdown reactors…"

[36] Nuclear Waste Technical Review Board 1996, xii-xiii. "The Board recommends that during the next several years generic planning for a centralized storage facility and for a supporting transportation infrastructure begin at a funding level modest enough to avoid competition with the repository program. From a technical, operational, and fiscal perspective, 2010 is the key milestone for storage. Therefore, plans should be made to have this storage facility operating at full capacity (able to accept 3,000 metric tons/year for 30 years) by about 2010. This will allow the federal government to remove the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur."

[37] Blue Ribbon Commission on America's Nuclear Future 2012, xii. "The arguments in favor of consolidated storage are strongest for "stranded" spent fuel from shutdown plant sites. Stranded fuel should be first in line for transfer to a consolidated facility so that these plant sites can be completely decommissioned and put to other beneficial uses."

[38] U.S. Department of Energy 2013, 5. "This system would initially be focused on acceptance of used nuclear fuel from shut-down reactors; such fuel provides an opportunity to build waste handling capability as well as to relieve surrounding communities and utility contract holders of the burdens associated with long-term storage of used nuclear fuel at a shut-down reactor."

U.S. Department of Energy 2013, 6. "Consistent with legislation recently under consideration in Congress, the Administration supports the development of a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites. Acceptance of used nuclear fuel from shut-down reactors provides a unique opportunity to build and demonstrate the capability to safely transport and store used nuclear fuel, and therefore to make progress on demonstrating the federal commitment to addressing the used nuclear fuel issue. A pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation."

[39] Cochran. 2005, Slide 12. "NRDC's Preferred Solution…Allow away-from-reactor spent fuel storage for decommissioned reactors."

[40] American Physical Society 2007. Executive Summary. "Consolidated storage could facilitate the decommissioning of sites with reactors that have been shut down."

[41] National Commission on Energy Policy 2007, 7. "Require the Secretary of Energy to take possession of and/or remove fuel from reactor sites that have been, or are in the process of being fully decommissioned."

[42] Keystone Center 2007, 16. "The NJFF group also agrees that centralized interim storage is a reasonable alternative for managing waste from decommissioned plant sites and could become cost-effective for operating reactors in the future."

[43] Massachusetts Institute of Technology 2011, 48. "The possibility of storage for a century, which is longer than the anticipated operating lifetimes of nuclear reactors, suggests that the United States should move toward centralized SNF storage sites—starting with SNF from decommissioned reactor sites and in support of a long-term SNF management strategy."

[44] Stanford University and George Washington University 2018, 5. "The Standard Contract should be revised under the new organization to include planned removal of spent fuel first from shutdown plants."

Insular Affairs also recognized MRS facilities as an important backup in the event of failure or serious delay in the repository program past the point at which reactors began to be decommissioned.[45]

Establishing an ISF as soon as possible instead of continued growth of a highly decentralized default storage system has several benefits which are outlined in the subsections below (A-1.2.1 to A-1.2.6).

A-1.2.1 Reducing the footprint of the SNF management system

The footprint of the integrated waste management system would be significantly reduced by allowing reactor sites to be fully decommissioned, thus reducing the number of locations where SNF is stored. Fig. A-2 through Fig. A-5 show how rapidly an unintended, unplanned, and highly decentralized collection of small storage sites would evolve if movement of SNF from reactor sites is delayed. Each blue circle represents a shutdown reactor site. The larger the circle, the more SNF is projected to be stored at the site. The darker the green shading of the states with the shutdown sites, the greater the total of SNF projected to be stored at shutdown sites in the state. While there would only be a small number of shutdown sites with SNF scattered around the country by 2030, there would be a dramatic increase by 2040 as more and more reactors reach the ends of their lives. By 2050, there could be 60 or more former reactor sites with nothing on the site preventing the site from being repurposed except SNF in dry storage.

Within about 5 years of startup, operation of a pilot storage facility could reduce the net number of dry storage sites by nine simply by moving SNF already in dry casks at sites shut down by 2008 to a central facility.[46] In a 1995 special report on interim storage, the NWTRB concluded:

> …commercial spent fuel storage needs will change markedly beginning around 2010. Until then, approximately 15,000 metric tons of new storage capacity will be needed at reactor sites. But beginning around 2010, large amounts of dry-cask storage will be required to allow removal of spent fuel from the storage pools of reactors that are being shut down. It is at this time that a federal storage facility operating at full scale will be most useful. A centralized facility will relieve utilities of the need to build new dry-storage capacity at shutdown reactors while accommodating any future institutional or technical uncertainties associated with the long-term storage of spent fuel.[47]

[45] U.S. House of Representatives 1982, 44. “Monitored Retrievable Storage may be required in the event of failure or long-term delay of the repository development program. Indeed, this need for insurance that some safe technology will be available when nuclear reactors begin being decommissioned is the Committee’s primary basis for recommendation of the detailed planning for an MRS program included in the Committee amendment to H.R. 3809.”

[46] U.S. Department of Energy 2008.

[47] Nuclear Waste Technical Review Board 1996, ix.

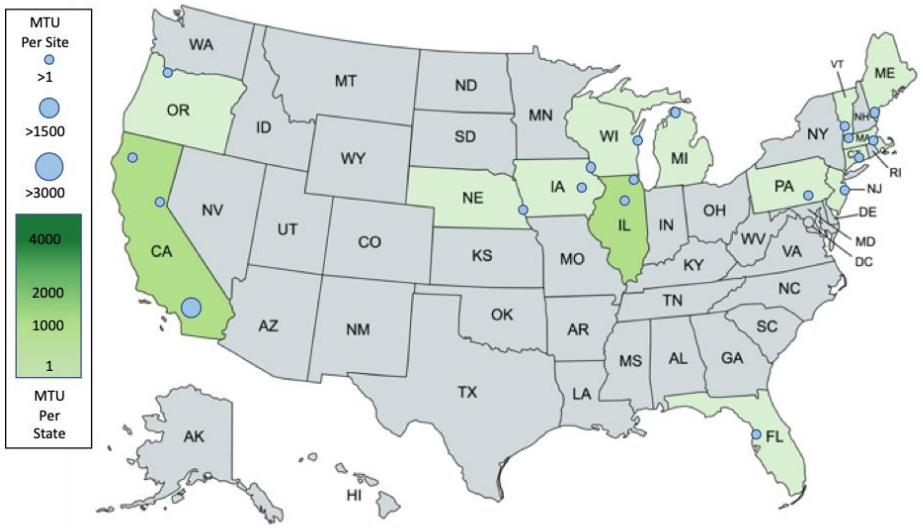

Fig. A-2. Shutdown reactor sites with SNF in storage in 2020.[48]

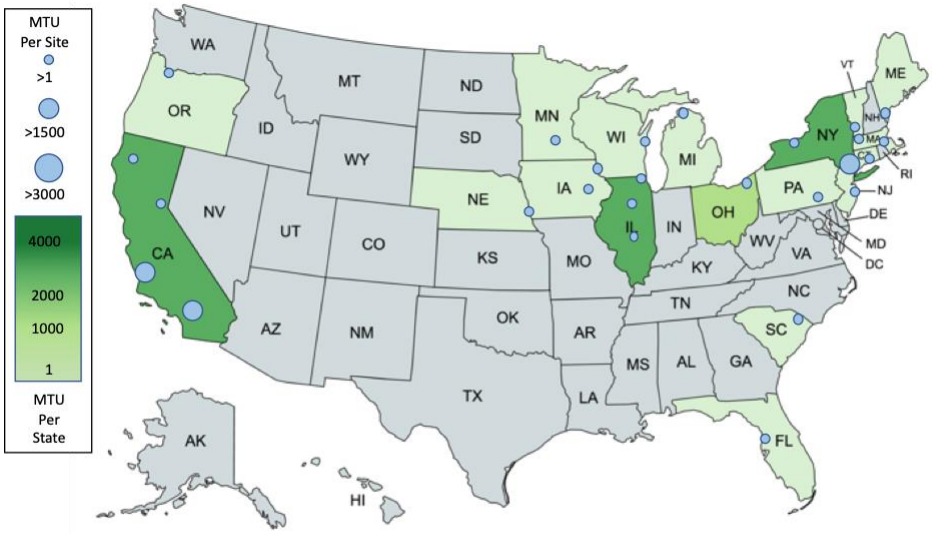

Fig. A-3. Shutdown reactor sites with SNF in storage in 2030 if waste acceptance is deferred.

[48] Peters, S., D. Vinson, and J. Carter 2021.

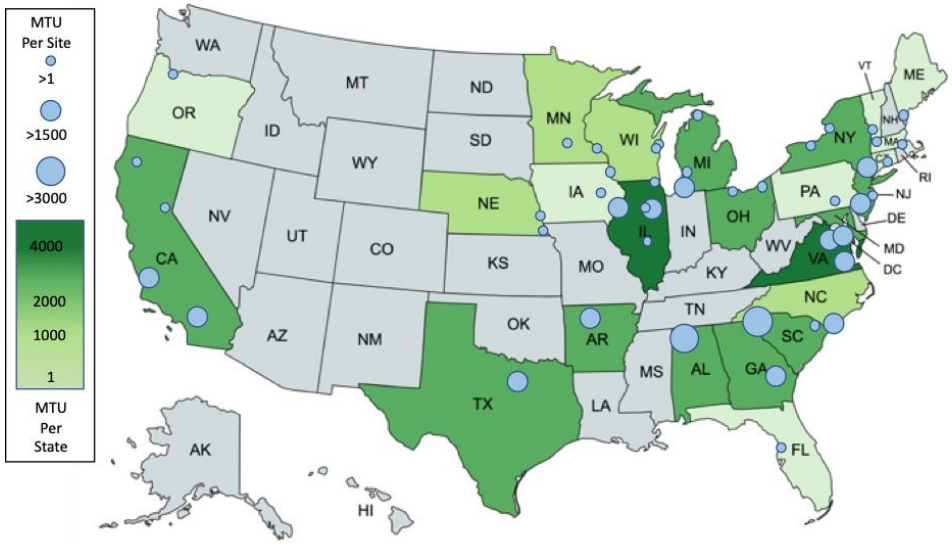

Fig. A-4. Shutdown reactor sites with SNF in storage in 2040 if waste acceptance is deferred.

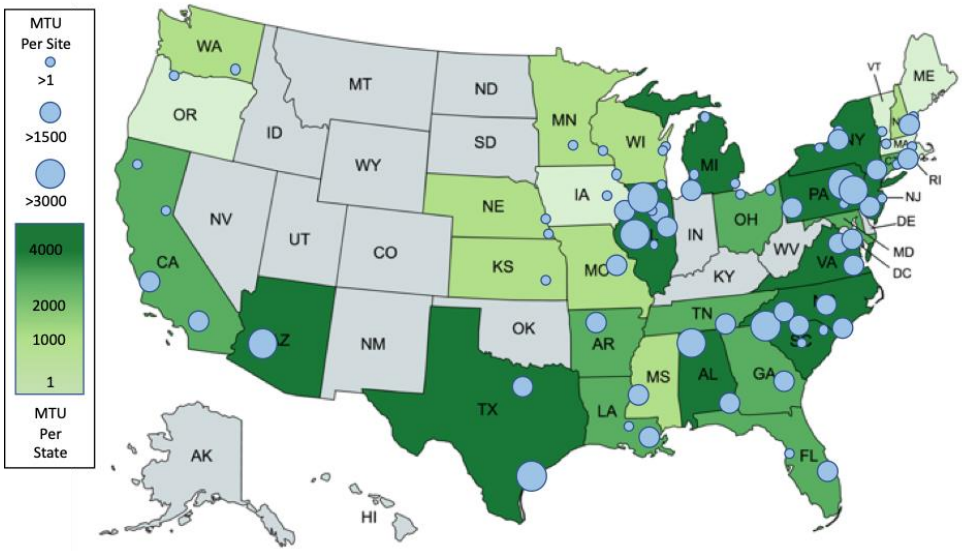

Fig. A-5. Shutdown reactor sites with SNF in storage in 2050 if waste acceptance is deferred.

A-1.2.2 Making the SNF management system increasingly consent based

The integrated waste management system could become increasingly more consent based if SNF were moved from sites where consent for long-term storage was never expressly sought or granted to a host community that has negotiated the facility's terms and conditions. As the BRC noted:

> …these communities were never asked about, and never contemplated or consented to, the conversion of these reactor sites into indefinite long-term storage facilities. As a result, they generally also did not have an opportunity to negotiate for rights of participation or incentives and benefits of the sort that would likely be available to the host community of a dedicated storage facility.[49,50]

As more sites are shutting down, at least some commenters from host communities do not accept continued storage at the site.[51,52] Consequently, if an ISF is sited using a consent-based process as endorsed by multiple sources[53,54,55,56] and directed by Congress in 2020,[57] then removing fuel from shutdown sites could result in the SNF management system becoming more consent-based as fuel is moved from sites, where consent for long-term storage was never expressly sought or granted to a willing host community that has negotiated the terms and conditions of hosting the facility.[58]

A-1.2.3 Allowing decommissioned reactor sites to be reclaimed

The decommissioned sites could be reclaimed for economically productive or otherwise desirable uses. The BRC concluded "[t]he arguments in favor of consolidated storage are strongest for 'stranded'

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[49] Blue Ribbon Commission on America's Nuclear Future 2012, 35. "Moreover, these communities were never asked about, and never contemplated or consented to, the conversion of these reactor sites into indefinite long-term storage facilities. As a result, they generally also did not have an opportunity to negotiate for rights of participation or incentives and benefits of the sort that would likely be available to the host community of a dedicated storage facility."

[50] Monitored Retrievable Storage Review Commission 1989, 79. Note that although the MRS Review Commission provided an extensive discussion of the equity aspects of moving spent fuel to a central storage facility, this included only one limited reference to the equity impacts of leaving it at shutdown reactor sites instead.

[51] U.S. Department of Energy 2016, 14. "A sense of urgency was especially pronounced among commenters from communities that are already hosting spent nuclear fuel at operating and shutdown reactor sites. As several of these commenters pointed out, consent had neither been sought nor granted in earlier decisions to site nuclear facilities in their communities in the first place. Thus many of them expressed a desire to see spent fuel removed from their communities as soon as possible (as well as a desire to be compensated for their involuntary role as de facto long-term storage sites in the interim – these comments are discussed at greater length in a later section). For some of these commenters and others, the time required to design and implement a consent-based siting process provided all the more reason to move forward without delay…"

[52] Stanford University and George Washington University 2018, 53-54. "Active public groups near some shut-down power plants have reacted strongly to the continued storage of spent fuel as these sites. At the Vermont Yankee plant, public interest groups along with state government officials have opposed leaving the spent fuel on site for the decades as planned by the owner, 3 Yankees. The local municipal governments and many members of the public near the San Onofre Nuclear Generating Station (SONGS) in southern California also oppose leaving the spent fuel on site indefinitely (Victor 2016)."

[53] Blue Ribbon Commission on America's Nuclear Future 2012, vii–ix.

[54] U.S. Department of Energy 2013, 1. "This Strategy includes a phased, adaptive, and consent-based approach to siting and implementing a comprehensive management and disposal system."

[55] Government Accountability Office 2021, 24.

[56] Stanford University and George Washington University 2018, 6. "The Steering Committee recommends the adoption of a consent-based siting process that (1) establishes strong bonds of trust between localities, tribes, and states on the one hand and the implementer and that (2) fairly reallocates power among the parties."

[57] U.S. Congress 2020, 130. "Within available funds in this account for interim storage, the Department is directed to move forward under existing authority to identify a site for a federal interim storage facility. The Department is further directed to use a consent-based approach when undertaking these activities."

[58] Blue Ribbon Commission on America's Nuclear Future 2012, 35. "Moreover, these communities were never asked about, and never contemplated or consented to, the conversion of these reactor sites into indefinite long-term storage facilities. As a result, they generally also did not have an opportunity to negotiate for rights of participation or incentives and benefits of the sort that would likely be available to the host community of a dedicated storage facility."

spent fuel from shutdown plant sites. Stranded fuel should be first in line for transfer to a consolidated facility so that these plant sites can be completely decommissioned and put to other beneficial uses." [59]

A-1.2.4 Avoiding the expensive replication of the efforts

The expensive replications of efforts and costs of guarding fuel at multiple small sites could be reduced. Once all reactors on a site cease operation, the full costs of maintaining oversight and security for the site are attributed to the continued presence of SNF in storage on the site, amounting to approximately $10 million annually per site in current dollars assuming current security requirements.[60] The BRC estimated that "the added security and monitoring expenses associated with keeping stranded spent fuel at as many as 70 different shutdown reactor sites could be in the area of $350 to $550 million per year at today's costs."[61]

The discussion of the environmental impacts of potential acts of sabotage or terrorism involving the continued storage of SNF in the NRC's 2014 extended storage Generic Environmental Impact Statement "acknowledges that as the immediate hazard posed by the high radiation levels of spent fuel diminishes over time, depending on burnup, so does the deterrent to handling by unauthorized persons."[62] For this reason, the NRC notes "additional security requirements may be necessary in the future if spent fuel remains in storage for a substantial period of time. Under those circumstances, it is reasonable to assume that, if necessary, the NRC will issue orders or enhance its regulatory requirements for ISFSI and [dry transfer system] DTS security as appropriate to ensure adequate protection of public health and safety and the common defense and security." [63] The BRC noted that consolidation of fuel from shutdown reactors to centralized facilities "would also allow any new safety or security measures that might be required in the future to be implemented more cost-effectively."[64]

A-1.2.5 Potentially enhancing safety of SNF management operations

The NRC has reaffirmed that SNF can be stored safely at reactor sites in pools or dry storage systems for as long as 60 years after the reactor ceases operations.[65] While recognizing the safety of at-reactor storage in its 1989 report; however, the MRS Review Commission went on to conclude that nonetheless "it may be prudent to provide a central interim storage facility where spent fuel would be under the full-time care of trained personnel and management whose exclusive responsibility is the fuel's safe storage and handling ."[66] The MRS Review Commission went on to include this point among the major advantages of an MRS facility: "[a]n MRS facility would provide for timely removal of spent fuel from decommissioned reactors. Although the waste could be stored at reactor sites safely for up to 100 years, the fuel could be stored more efficiently and safely at a central facility."[67] The BRC noted, "Such facilities could also offer enhanced remote handling capabilities, thereby reducing the potential for worker exposures."[68] The BRC also said:

> Finally, consolidated storage could enhance the safety and security of the overall waste management system simply because facilities for this purpose could be located where

[59] Blue Ribbon Commission on America's Nuclear Future 2012, xii.

[60] Jarrell 2015, 92. Table A-1.

[61] Blue Ribbon Commission on America's Nuclear Future 2012, 36.

[62] U.S. Nuclear Regulatory Commission 2014c. "Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel Final Report." NUREG-2157 Volume 1, U.S. Nuclear Regulatory Commission. B-22.

[63] U.S. Nuclear Regulatory Commission 2014c, 4–95.

[64] Blue Ribbon Commission on America's Nuclear Future 2012, 35.

[65] U.S. Nuclear Regulatory Commission 2014b.

[66] Monitored Retrievable Storage Review Commission 1989, 40.

[67] Monitored Retrievable Storage Review Commission 1989, 96.

[68] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

> there is a much lower probability of extreme events (unlike reactors, for example, a storage-only facility need not be located near a large source of water), where the risks of broad-based population exposures in the event of a disaster are lower, and where local conditions are conducive to effectively monitoring and managing security risks. [69]

A-1.3 Increased System Flexibility and Integration

An ISF adds flexibility, durability, and operational alternatives to an integrated waste management system that includes a repository.

A-1.3.1 Provide capabilities to deal with any other unexpected developments affecting long-term storage and transportation

The ability to effectively respond to unexpected developments that would be challenging to manage at shutdown reactor sites is another benefit. In its final rule on "Continued Storage of Spent Nuclear Fuel," the NRC found:

> …reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor in a combination of storage in its spent fuel storage basin and either onsite or offsite ISFSIs.[70]

According to reports and studies supporting NRC's Continued Storage Rule (10 CFR Part 51, §51.23), confidence in the long-term safety of dry storage is based in part on confidence that SNF could be safely retrieved from dry casks for inspection or repackaging if necessary.[71] This need might result from unplanned events, resulting from either natural phenomena or human activity, discovery of an unforeseen condition, or evolution of applicable regulations over time. While regulations do not require dry storage installations to have such a capability, NRC recognizes that the potential need for such a capability at all storage sites will increase as the duration and quantity of fuel in dry storage increases. [72] That capability might require specific-use facilities not currently available at each reactor site, particularly those that have been shut down and decommissioned, and this could be done more effectively and safely at a central storage site.[73]

The BRC observed:

> [consolidated storage] facilities could…offer enhanced remote handling capabilities, thereby reducing the potential for worker exposures. This capability could be particularly important if changes in the condition of the spent fuel over time make it necessary to open storage containers and repackage the fuel before moving it elsewhere for disposition. Dry storage facilities at shutdown reactors without pools do not have any of the fuel handling and recovery capabilities that would be provided in a consolidated

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[69] Blue Ribbon Commission on America's Nuclear Future 2012, 38.

[70] U.S. Nuclear Regulatory Commission 2014a, 56241.

[71] U.S. Nuclear Regulatory Commission 2014b, xxxi. "To guide its analysis, the NRC also relied on certain assumptions regarding the storage of spent fuel… A DTS [dry transfer system] would be built at each ISFSI location for fuel repackaging…A DTS would enable retrieval of spent fuel for inspection or repackaging without the need to return the spent fuel to a spent fuel pool."

[72] U.S. Nuclear Regulatory Commission 2014b, 2–20.

[73] Carlsen and BradyRaap 2012, 24. "A key objective is to ensure that UNF is transported to its final destination, or a destination with the necessary repackaging capabilities, before the need for repackaging arises. Although presently small, the likelihood of the need for a DTS [dry transfer system] to enable retrieval of UNF for inspection or repackaging will increase as the duration and quantity of fuel in dry storage increases. Stored fuel will eventually require remediation and/or repackaging for transport. Any large-scale repackaging operations that may eventually be necessary can be more safely and effectively conducted at a consolidated facility."

> facility—in effect, these facilities are simply well-guarded parking lots for storage casks. If fuel at these sites needed repackaging, a new fuel handling facility would have to be constructed at considerable time and expense.[74]

The BRC also observed:

> Considering current uncertainties about long-term degradation phenomena in dry storage systems, it would be prudent to initiate a planned, deliberate, and reliable process for moving spent fuel from shutdown reactor sites to a central facility before any issues arise and where problems can be dealt with much more easily and cost effectively than at multiple shutdown sites. The importance of consolidating inventories of spent fuel before there might be a need to reopen dry storage containers increases as the period of storage being contemplated increases[.] [75]

A-1.3.2 Increased system integration and standardization

The BRC recommended that the federal waste management organization:

> [work] with nuclear utilities, the nuclear industry, and other stakeholders to promote the better integration of storage into the waste management system, including standardization of dry cask storage systems, with an eye to facilitating later transport and consolidation in centralized storage and/or disposal facilities[.][76]

and observed that:

> a consolidated storage facility could. facilitate the standardization of cask systems. [77]

Even if the value and/or ability to achieve greater standardization of cask systems used at reactor sites is limited, greater standardization can be provided for storage of SNF brought to an ISF.

A-1.3.3 Improvements in the reliability and flexibility of the waste-management system

The 1987 DOE MRS proposal noted that by separating the acceptance of spent fuel from reactors from emplacement in the repository and adding significant operational storage capacity to the system, an MRS facility "would produce identifiable improvements in the manageability of the system" and "allow the DOE to better accommodate the circumstances of the future."[78]

> The addition of an MRS facility … would significantly improve the reliability and flexibility of the waste-management system; these improvements would benefit nearly all operations of the waste-management system, from the unloading of reactor storage pools to final waste emplacement in a geologic repository. The inclusion of significant storage capability at the MRS facility would provide a system buffer that would allow the unloading of reactor storage pools to be independent of the loading of the repository. This system-buffer capability is important because the optimal rates and sequences for unloading the individual reactor storage pools will differ from waste-acceptance rates conducive to an efficient loading of the repository. Monitored retrievable storage would also provide additional options for optimizing these separate operations in a coordinated

[74] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

[75] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

[76] Blue Ribbon Commission on America's Nuclear Future 2012, 42.

[77] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

[78] U.S. Department of Energy 1987a, 23.

> fashion. Furthermore, delays or disruptions in one component of the system would be less likely to affect the progress of the entire system.
>
> The improvement in system flexibility and reliability, which would be realized immediately and thereafter sustained at a notably higher level, would produce identifiable improvements in the manageability of the system. Enhanced flexibility is particularly important in a program of long duration (extending at least 50 years into the future) because it would allow the DOE to better accommodate the circumstances of the future.

The 1987 amendments to the NWPA recognized the importance of this benefit in the criteria for a DOE-sited MRS under Section 144, which include "the extent to which siting a monitored retrievable storage facility at each site surveyed would... (1) enhance the reliability and flexibility of the system for the disposal of spent nuclear fuel and high-level radioactive waste established under this Act."[79]

The BRC recognized the contribution of consolidated storage to the flexibility of the waste management system throughout the operating life of the repository:

> Even after a disposal facility is open, consolidated storage would act as a buffer and provide valuable redundancy for the system as a whole. It would, for example, allow utilities to continue to ship spent fuel away from reactor sites as scheduled even if a repository had to slow or cease operation for a period of time for any reason. Alternatively, it could accommodate a surge of shipments from reactor sites if that were necessary, while allowing emplacement at a repository to proceed at a steady, pre-determined rate.[80]

The BRC also noted that some system benefits (keeping options for disposition of spent fuel and aging to reduce thermal load):

> …apply whether storage is provided at consolidated facilities or at dispersed sites, as is currently the case. But the storage arrangements in place today were not designed to maximize operational efficiency at a system level or to respond to unforeseen events or changes in management strategy, much less for indefinite storage at reactor sites after the reactors themselves have been decommissioned.[81]

A-1.3.4 Technical opportunities for the waste management system

The BRC concluded that:

> A federal facility with spent fuel receipt, handling and storage capabilities can support other valuable activities that would benefit the waste management system. These include long-term monitoring and periodic inspection of dry storage systems and work on improved storage methods. Many current dry cask systems lack instrumentation to measure key parameters such as gas pressure, the release of volatile fission products, and moisture. Some of this work can be done in laboratories, but key aspects require the ability to handle and open loaded spent fuel storage containers and examine the fuel. A consolidated storage facility with laboratory and hot cell facilities and access to a substantial quantity and variety of spent fuel would provide an excellent platform for ongoing research and development to better understand how the storage systems currently in use at both commercial and DOE sites perform over time.[82]

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[79] Public Law 100-203, 1987.

[80] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

[81] Blue Ribbon Commission on America's Nuclear Future 2012, 35.

[82] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

The BRC also noted that:

> …the opportunity to host an R&D facility of this type might itself be among the inducements for a community interested in being considered for a consolidated storage facility. A national center for ongoing research on all aspects of the storage of spent fuel could be a significant ancillary benefit for a community willing to host a storage facility.[83]

A 1993 DOE Task Force Report proposing a phased strategy for developing a repository included a proposal for "an early offsite waste packaging R&D facility to package small amounts of waste that can be emplaced in a repository for confirmatory testing soon after a license is received. The facility would also serve as a center for developing improved waste packages during the life of the repository."[84] An ISF site would provide a possible location for such a facility.

A-1.3.5 Support for development of a repository

The BRC concluded that "siting and developing one or more consolidated storage facilities would improve prospects for a successful repository program."[85]

The ways in which development of storage facilities could benefit development of a repository are discussed in the following subsections.

A-1.3.5.1 Flexibility in the repository-development schedule

An ISF will provide flexibility in the repository-development schedule by insulating it from pressures for acceptance of spent fuel, allowing adjustments in that schedule without at-reactor impacts.

In the same vein, DOE's 1991 *Draft Mission Plan Amendment*[86] identified "a decoupling of the schedules for waste acceptance and waste disposal" as one of the key elements of the waste management strategy:

> Equally important is decoupling the schedule for permanent waste disposal, which requires the development and licensing of a geologic repository, from waste acceptance, which can be provided with a facility for monitored retrievable storage (MRS). This approach will not only allow us to provide timely and adequate waste acceptance but also help to meet the objectives of timely disposal capability, schedule confidence, and flexibility.
>
> The advantages of decoupling waste acceptance from disposal stem from fundamental differences between a repository and an MRS facility. The repository is an unprecedented undertaking. It must safely isolate the wastes for thousands of years, relying principally on the natural barriers present at the site, and this capability for safe isolation must be demonstrated during licensing. Its development therefore requires years of scientific study to characterize the site, and challenges in licensing can be expected.
>
> The MRS facility, on the other hand, will be a limited-lifetime plant whose safety is based on engineering, using simple and proven technologies and methods for handling and storing the waste. The uncertainties associated with its development and licensing should therefore be much smaller than those for the repository. Furthermore, since we plan to develop the MRS facility at a volunteered site, we expect a generally favorable

[83] Blue Ribbon Commission on America's Nuclear Future 2012, 139. ENDNOTE 81.

[84] U.S. Department of Energy 1993, 3.

[85] Blue Ribbon Commission on America's Nuclear Future 2012, 38.

[86] U.S. Department of Energy 1991, 13–14.

> institutional environment. In that case, the MRS facility would start receiving waste in 1998, or 12 years ahead of the repository.

The BRC pointed out the importance of an ISF in providing the flexibility needed for a phased, adaptive approach to repository development:

> It is very important to recognize that these requirements {for phased, adaptive repository development described by the National Academies' One Step at a Time report} in turn imply a need for substantial buffer storage capacity in the waste management system so as to decouple the program's ability to accept waste from the emplacement of that waste in a repository for disposal. This in turn would provide the flexibility needed to develop repository capacity in a more gradual and stepwise manner. The need for buffer capacity is addressed by the Commission's recommendation concerning the expeditious development of one or more consolidated storage facilities for SNF, as discussed in chapter 5 of this report.[87,88]
>
> In addition, consolidated storage would provide the flexibility needed to support an adaptive, staged approach to repository development. This kind of approach was recommended as early as 1990 by the National Academies' Board on Radioactive Waste Management and is discussed in more detail in chapter 6 of this report. The main point for purposes of this discussion is that a consolidated facility would allow federal acceptance of spent fuel to proceed at a predictable, adequate and steady rate—both before a disposal facility is available and when it is in operation.[89]

A-1.3.5.2 Flexibility for future decisions about development and operation of the repository

The DOE's 1985 MRS proposal noted that waste management functions that were at that time planned to be performed at the MRS would benefit the repository by allowing the waste-handling surface facilities at the repository and the associated operations to be simplified.[90] DOE argued more generally in 1989 that "[t]he MRS facility would provide flexibility with respect to later decisions about waste aging and the preferred location of waste-packaging functions."[91] Along the same lines, the BRC pointed out:

> Consolidated storage also offers opportunities to simplify repository operations. For example, by accumulating a substantial inventory of spent fuel in one place, the storage facility could take over some of the thermal management activities that might be required for efficient repository operation (e.g., blending hot and cool fuel assemblies to create a uniform thermal load for waste packages). A consolidated storage facility could even offer the option of packaging the waste for disposal before it is shipped to the repository, further simplifying operations at the repository site.[92]

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[87] National Academies 2003. Note: this citation refers to the "One Step at a Time" report mentioned in the quote.

[88] Blue Ribbon Commission on America's Nuclear Future 2012, 53–54.

[89] Blue Ribbon Commission on America's Nuclear Future 2012, 38-39.

[90] U.S. Department of Energy 1987a, 23. "The MRS facility would provide several advantages to the repository, both during development and operations. Because many of the major waste-preparation functions would be performed at the MRS facility, the waste handling surface facilities at the repository and the associated operations would be simplified."

[91] U.S. Department of Energy 1989a, 9.

[92] Blue Ribbon Commission on America's Nuclear Future 2012, 39.

A-1.4 Near-Term Development and Demonstration of Institutional and Technical Infrastructures for Large-Scale Management of SNF

Siting, testing, licensing, and operating an ISF would create a significant base of experience related to large-scale SNF handling, storage, and transportation that could improve the efficiency of the future repository or other backend facilities.

In addition, initiation of waste acceptance would help restore trust and confidence in the intention and ability of the federal government to meet its waste management obligations. The BRC concluded that the restoration of trust and confidence in:

> …the federal government's commitment and competence to deliver on its waste management obligations. . . must be the government's first priority and is essential for getting all aspects of the nation's nuclear waste program back on track. In this context, demonstrating that it is possible to muster the policy direction, technical expertise, and institutional competence needed to site and operate one or more consolidated storage facilities (while also vigorously pursuing final disposal capability) would by itself be enormously valuable.[93]

A-1.4.1 Institutional experience in relations with host communities

DOE's 1985 MRS Proposal noted that:

> One of the potential benefits of developing the integral MRS facility is the early opportunity to demonstrate that a major Federal waste-management facility developed under the Act can be not only safe and environmentally sound but also a responsible 'corporate citizen.' Such an early demonstration would not only benefit the State and the local community hosting the MRS facility but could also help assure potential repository host States that the DOE's actions in response to their concerns will be similarly addressed.[94]

Similarly, the BRC concluded that:

> …the technical and institutional experience gained by siting, testing, licensing, and operating a consolidated storage facility, as well as planning for and executing a concurrent transport program, would benefit repository development and operation, especially because all the activities involved (apart from those uniquely associated with underground disposal) would be the same.[95]

The 2013 *Strategy* also identified such institutional benefits:

> A pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation.[96]

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[93] Blue Ribbon Commission on America's Nuclear Future 2012, 40.

[94] U.S. Department of Energy 1987a, 29.

[95] Blue Ribbon Commission on America's Nuclear Future 2012, 38.

[96] U.S. Department of Energy 2013, 6.

A-1.4.2 Technical demonstration of large-scale system operation

Development and operation of a large-scale waste transportation, handling, and storage system can build confidence in the technical and institutional ability to manage those operations so that issues of large-scale handling, transportation, and packaging are not faced for the first time at the first repository.

Along these lines, the BRC concluded that:

> …restoring that trust and confidence must be the government's first priority and is essential for getting all aspects of the nation's nuclear waste program back on track. In this context, demonstrating that it is possible to muster the policy direction, technical expertise, and institutional competence needed to site and operate one or more consolidated storage facilities (while also vigorously pursuing final disposal capability) would by itself be enormously valuable. Near-term progress on a consolidated storage facility would not only address a major source of political, legal and financial liability that will otherwise complicate efforts to move beyond the current impasse in the repository program, it would also provide practical benefits in terms of gaining experience and providing the system-wide flexibility needed to support an adaptive, staged approach to repository development. [97]

The 2013 S*trategy* noted that "Acceptance of used nuclear fuel from shut-down reactors provides a unique opportunity to build and demonstrate the capability to safely transport and store used nuclear fuel."[98]

A-1.5 Other Policy Benefits

In addition to the benefits described above, other, more-qualitative benefits of an ISF are discussed below.

A-1.5.1 Supporting nuclear power as part of a national clean-energy portfolio

In discussing the impacts of uncertainty about waste management on the use of nuclear power, the BRC noted that "the successful management of SNF has long been viewed as necessary if nuclear power is going to remain a viable energy option."[99] Reinforcing that view, Secretary Chu's introduction to the 2013 *Strategy* in response to the recommendations of the BRC emphasized that safe long-term management of SNF and HLW is priority part of the "commitment to protect public health and safety, security, and the environment is essential to ensuring that nuclear power remains part of our diversified clean-energy portfolio."[100] The *Strategy* notes a new program that "will provide near-term and long-term solutions for managing the backend of the nuclear fuel cycle" will resolve "a longtime source of conflict in nuclear policy."[101] The International Energy Agency (IEA) has noted that public concerns about safety in managing radioactive waste are an important factor that can affect the future of nuclear power.[102]

A-1.5.2 Supporting U.S. ability to influence the development of a safety and security framework for the expected growth of nuclear energy globally

Regardless of the future of nuclear power in the U.S. energy system, the use of nuclear power continues to grow globally. The International Atomic Energy Agency's 2021 report projects that by 2050,

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[97] Blue Ribbon Commission on America's Nuclear Future 2012, 40.

[98] U.S. Department of Energy 2013, 6.

[99] Blue Ribbon Commission on America's Nuclear Future 2012, 25.

[100] U.S. Department of Energy 2013.

[101] U.S. Department of Energy 2013, 14.

[102] International Energy Agency 2014, 347. "Influenced by a combination of local, national and global factors, public attitudes to nuclear power are critical to its future development. Public concerns typically include safety, radioactive waste management, nuclear weapons proliferation, transparency in the approach to public consultation, climate change and energy security."

nuclear power capacity worldwide could increase from 393 GW (in 2020) to as much as 792 GW[103]. Data presented by the BRC indicate that 15% of global nuclear capacity in 2011 was in nations with under 10 GW, with about 15 of those nations having 5 GW or less.[104] With respect to these trends, the BRC noted:

> Many countries, especially those just embarking on commercial nuclear power development, have relatively small programs and may lack the regulatory and oversight resources available to countries with more established programs. International assistance may be required to ensure they do not create disproportionate safety, physical security, and proliferation risks.[105]

The BRC concluded "U.S. leadership is urgently needed on issues of safety, non-proliferation, and security/terrorism," pointing out that "the United States will increasingly have to lead by engagement and by example" and that because "the United States cannot exercise effective leadership on issues related to the back end of the nuclear fuel cycle so long as its own program is in disarray; effective domestic policies are needed to support America's international agenda."[106] Similarly, Secretary Chu noted in the 2013 *Strategy* response to the BRC's recommendations:

> Finally, global demand for nuclear energy continues to grow, with commensurate risks in terms of safety, weapons proliferation, and terrorism if this growth occurs outside a vigorous safety and security framework. America's ability to influence the mitigation of these risks is strengthened when we demonstrate the commitment and ability to perform here at home. [107]

A-2. DISADVANTAGES OF INCLUDING INTERIM STORAGE FACILITIES

As with most large projects, there are some disadvantages to the development of away-from-reactor storage.

A-2.1 Potential Adverse Impact on Timing of Repository Availability

The most common concern about provision of a federal storage facility is that it would weaken efforts to provide permanent disposal in geologic repositories and become a de facto repository by

[103] International Atomic Energy Agency. Energy 2021, 3. "Relative to a global nuclear generating capacity of 393 gigawatts (electrical) (GW(e)) in 2020, the low case projections indicate that world nuclear capacity will remain essentially the same at 392 GW(e). In the high case, world nuclear capacity is expected to more than double to 792 GW(e) by 2050."

[104] Blue Ribbon Commission on America's Nuclear Future 2012, 113.

[105] Blue Ribbon Commission on America's Nuclear Future 2012, xiv.

[106] Blue Ribbon Commission on America's Nuclear Future 2012, xiv.

[107] U.S. Department of Energy 2013.

default.[108,109,110] The 1972 proposal of the Atomic Energy Commission to build a retrievable surface storage facility (RSSF) as an interim measure while taking decades to site a repository was withdrawn in 1975 because of such objections from the Environmental Protection Agency (EPA) and members of the public.[111] The same concern[112] led to the decision by Congress in the NWPA to focus on an ambitious program to site and operate permanent repositories while providing for later congressional consideration of a proposal for an MRS facility as an option to complement but not supplant a repository. DOE proposed siting the MRS project at three sites: one near Oak Ridge, Tennessee, and two alternative sites also in Tennessee. Using funding provided by DOE, a joint task force formed by the City of Oak Ridge and nearby Roane County (where the preferred site was located) reviewed the proposal.[113,114] Although the task force concluded that the proposed facility could be safely built and operated, they also made their acceptance conditional on legislation that would satisfactorily address several specific concerns, including the concern that the MRS facility "could delay construction of the geologic repository and become a de facto site for permanent spent fuel storage" based on the conclusion that "despite clearly stated national policy to the contrary, there are legitimate concerns that once in operation, the MRS would relieve pressure on DOE and the Congress to follow through on plans to construct a permanent repository."[115] The task force recommended that MRS-authorizing legislation specify linkages between the MRS facility and the repository that would limit (1) receipt of SNF at the MRS before a construction authorization for the repository to 300 metric tons and (2) total receipt to 10,000 metric tons before the out-shipments of consolidated fuel rods begin to the permanent repository.[116]

In its final MRS recommendations to Congress, DOE recognized the concern that a storage facility could derail the repository program and proposed that legislation include even tighter linkages than proposed by the task force:

> Earlier efforts to provide Federal storage facilities have raised the concern that the ready availability of Federal storage would make it easy for the nation to defer the difficult

[108] U.S. House of Representatives 1982, 42. "The objection most often raised to the concept of large-scale, long-term MRS storage is that it is not compatible with, and may be destructive of, a national or societal goal to dispose permanently of high-level radioactive wastes…Once waste is loaded into an MRS facility, barring a serious accident, the cost of moving the radioactive material and decommissioning the MRS in funds and human exposure would outweigh the advantage of relocating the waste underground to a permanent repository."

[109] U.S. Department of Energy 1987a, 5. "Some potential adverse programmatic effects have also been postulated by various parties, but most are perceived and avoidable rather than inevitable. The one most often cited is concern that an MRS facility would diminish the resolve to develop a geologic repository.

[110] Blue Ribbon Commission on America's Nuclear Future 2012, 39–40. "The Commission has also heard and considered arguments against proceeding with consolidated storage. Of these, the most important objection and one that will need to be thoughtfully addressed is the concern that any consolidated storage facility could become a de facto disposal facility and—by reducing the pressure to find a long-term solution—thwart progress toward developing the deep geologic disposal capacity that will ultimately be needed. This is not a new concern; it is why the 1987 NWPA Amendments explicitly tied the construction of an MRS facility to progress on a first repository and set capacity limits for the MRS facility so that it could not accommodate all the spent fuel in need of disposal."

[111] U.S. Congress Office of Technology Assessment 1985, 85. "The environmental impact statement issued by AEC in support of the RSSF concept drew intense criticism by the public and by the Environmental Protection Agency (EPA) because of concerns that the RSSFs would become low budget permanent repository sites. As a result, AEC abandoned the RSSF concept in 1975."

[112] U.S. House of Representatives 1982, 42. "The objection most often raised to the concept of large-scale, long-term MRS storage is that it is not compatible with, and may be destructive of, a national or societal goal to dispose permanently of high-level radioactive wastes…Once waste is loaded into an MRS facility, barring a serious accident, the cost of moving the radioactive material and decommissioning the MRS in funds and human exposure would outweigh the advantage of relocating the waste underground to a permanent repository."

[113] Colglazier 1991, 146.

[114] Clinch River MRS Task Force 1985.

[115] Clinch River MRS Task Force 1985, 9.

[116] Clinch River MRS Task Force 1985, 9.

> political decisions required to site a geologic repository. Conversely, the history of the waste-management program suggests that the credibility of any interim-storage measures will be suspect unless there is confidence that a permanent repository will be available within a reasonable period of time.
>
> To dispel doubts about the resolve to develop a repository, the DOE proposes a direct linkage of MRS operations to the development of a repository. Specifically, the DOE proposes that waste acceptance at the MRS facility be precluded until a construction authorization for the first repository is received from the Nuclear Regulatory Commission. In addition, the DOE recommends that the storage capacity of the MRS facility be limited to 15,000 MTU.[117]

The Nuclear Waste Policy Amendments Act of 1987, which nullified the DOE recommendation of the Tennessee site but also authorized siting and constructing an MRS facility, adopted tighter linkages than those proposed by DOE, preventing construction (rather than operation) of an MRS facility before issuance of a construction authorization for a repository.[118]

By 1989, it was clear to DOE that the schedule for the repository would slip by more than a decade, and the statutory linkages on the MRS facility would need to be relaxed to allow an MRS to be used to meet the 1998 date for start of waste acceptance:

> Linkages to the repository: The primary objective of the program is to develop a licensed geologic repository for the permanent disposal of spent fuel and high-level waste. The DOE has an obligation to accept spent fuel from the utilities in accordance with the Standard Contract for Disposal of Spent Nuclear Fuel/and or High-Level Radioactive Waste and the Nuclear Waste Policy Act as amended. However, a detailed examination of the repository schedule, allowing the time necessary for sound scientific investigation and design, shows that the DOE cannot meet the anticipated schedule set forth in the Act for the disposal of waste in a repository by 1998; furthermore, the current linkages between the repository and the MRS program make it impossible for the DOE to accept waste at an MRS facility on a schedule that is independent from that of the repository. Therefore, the DOE plans to work with the Congress to modify the current linkages between the repository and the MRS facility and to embark on an aggressive program to develop an integrated MRS facility for spent fuel. The DOE believes that if the linkages are modified, it is likely that waste acceptance at an MRS facility could begin by 1998 or soon thereafter.[119]

Further:

> The DOE testified to the MRS Commission on May 25, 1989, that it supports the development of an MRS facility as an integral part of the waste-management system because an integrated MRS facility is critical to achieving the goal of early and timely acceptance of spent fuel and because it would allow the DOE to better meet other strategic objectives, such as timely disposal, schedule confidence, and system flexibility. Though it considered a waste-management system with an MRS facility subject to the current statutory linkages superior to a system without an MRS facility, the DOE stated that a revision of the linkages and the statutory storage-capacity limit would allow the advantages of an MRS facility to be more fully realized. The DOE also expressed

[117] U.S. Department of Energy 1987a, 27.

[118] NWPA Section 148(d)(1).

[119] U.S. Department of Energy 1989b, ix–x.

> preference for an MRS facility sited through the efforts of the Negotiator, especially if these siting negotiations lead to modified linkages.[120]

The BRC also concluded that the current linkages need to be modified:

> The first of these concerns, that any consolidated storage facility could become a de facto disposal facility and siphon resolve and resources away from repository development, is a longstanding one. It is why the NWPA explicitly prohibits the construction of an MRS facility before construction authorization has been issued for a first repository. Based on the record of progress to date, the Commission believes that the benefits of moving forward on both fronts—consolidated storage and geologic disposal— at the same time outweigh the potential downside risks. But clearly the challenge of establishing positive linkages such that progress on storage does not undermine, but rather supports progress on repository development remains an important one. The linkages that exist under current law clearly have not worked as intended.[121]

The 2013 *Strategy* agreed:

> The [2013] Administration also agrees with the BRC that a linkage between opening an interim storage facility and progress toward a repository is important so that states and communities that consent to hosting a consolidated interim storage facility do not face the prospect of a de facto permanent facility without consent. However, this linkage should not be such that it overly restricts forward movement on a pilot or larger storage facility that could make progress against the waste management mission. The NWPA currently constrains the development of a storage facility by limiting the start of construction of such a facility until after the Nuclear Regulatory Commission (NRC) has issued a license for construction of a repository. This restriction has effectively eliminated the possibility of having an interim storage facility as an integral component of a waste management system.[122]

Further, the 2013 *Strategy* stated:

> As noted by the BRC, the linkage between storage and disposal is critical to maintaining confidence in the overall system. Therefore, efforts on implementing storage capabilities within the next 10 years will be accompanied by actions to engage in a consent-based siting process and begin to conduct preliminary site investigations for a geologic repository. The [2013] Administration's goal is to have a repository sited by 2026; the site characterized, and the repository designed and licensed by 2042; and the repository constructed and its operations started by 2048.[123]

A-2.2 Additional Transportation of SNF

The BRC report pointed out that one of the three main arguments raised against proceeding with consolidated storage was that consolidated storage would necessitate further handling of SNF and HLW potentially increasing safety and security risks.[124] The MRS Review Commission was directed to consider impacts on transportation in its comparison of systems with and without an MRS, and reached the following conclusion:

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[120] U.S. Department of Energy 1989b, 17.

[121] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

[122] U.S. Department of Energy 2013, 5–6.

[123] U.S. Department of Energy 2013, 7.

[124] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

> The Commission finds that transportation risks— both radiological and non-radiological—associated with all of the spent fuel management alternatives are small and are not discriminating in the determination of the need for an MRS. Further, because the risks are small, apparent differences in results arising from the use of different assumptions, whether they pertain to transportation mode split or the role of special casks, are equally non-discriminating in the decision-making. This finding is in accord with the results of other studies, although the numbers may differ. Before undertaking these analyses, the Commission conducted a review and critique of transportation and siting-related studies by the Department of Energy and the State of Tennessee, directly addressing the need for an MRS. These studies also found that transportation risks are small. Indeed, the Commission agrees with both the current position of DOE [Cited in the MRS Commission Report] and the conclusion of the University of Tennessee [Cited in the MRS Commission Report] that these small risks should not be a discriminating factor in determining the need for an MRS.[125]

The NWTRB's 1996 report on storage agreed with the MRS Commission's conclusion about the very low levels of risk with transportation, but noted that the public's perception of transportation risk is of much higher concern and will need to be addressed sooner if ISFs are built:

> Numerous analyses have been performed in recent years concerning transportation risks associated with shipping spent fuel. Although any analysis of transportation radiological risks is extremely sensitive to the assumptions made (e.g., routing, the amount of material shipped by rail versus by truck, the number of people at stops along the route), the results of these analyses (MRS 1989, Battelle 1989, NRC 1987) all show very low levels of risk under both normal and accident conditions. The safety record has been very good and corroborates the low risks estimated analytically. In fact, during the decades that spent fuel has been shipped, no accident has caused a radioactive release. The Board is mindful that the public's perception of transportation risk is of a much higher concern and, therefore, becomes a factor in public policy decisions. If a centralized storage facility were developed in the near future, transportation operations would begin much sooner than previously anticipated by repository operation schedules. The level of spent fuel transportation activity and the complexity of the total set of operations would be distributed more widely than in the past.[126]

The NWTRB subsequently underscored the public concern about the potential for increased transportation risks associated with inclusion of a storage facility in its letter to DOE following the October 16–17, 2012 meeting on transportation issues:

> As indicated by several comments from the public at the meeting, transportation of HLW and SNF remains a major concern. It is by no means clear to those individuals that transporting this material, especially to a consolidated storage facility, will actually reduce risks. The Board notes below that DOE needs to remain sensitive to this concern and address it in a candid and transparent fashion.[127]

The BRC recognized the concerns about handling and moving waste twice but concluded the benefits more than offset the risks:

> The concern about increased handling risks as a result of potentially moving SNF and HLW twice, first from decentralized storage to consolidated storage and then from consolidated storage to a geologic disposal facility, is a legitimate but in our view

[125] Monitored Retrievable Storage Review Commission 1989, 57.

[126] Nuclear Waste Technical Review Board 1996, 19-20.

[127] Nuclear Waste Technical Review Board 2012, 1–2.

manageable one. Clearly, there are trade-offs: some risks might increase but benefits to the system as a whole (such as the ability to learn early lessons by moving spent fuel from shutdown reactors to consolidated storage, and the creation of increased capability to respond to emergency situations, for example) could more than offset these impacts so that overall risk for the waste management system as a whole could decline. A 2007 study by the American Physical Society specifically looked at transport risks related to moving spent fuel twice and concluded these risks would be small[128]. Ultimately, we believe the many safety and security benefits that would come with having one or more well-equipped, consolidated storage facilities outweigh objections centered on extra handling risks.[129]

In addition, based on system analyses,[130,131] there is only a slight increase in the transportation costs due to potentially moving the fuel twice. For example, as shown in Fig. A-6, assuming constant dollar values, the transportation costs increase from 7% to 9% of the total system cost by adding an ISF. However, the total system costs are decreased by 9% due to the reduction in at-reactor costs. The fundamental conclusion is that the costs of transporting fuel twice are small when compared to the overall cost of managing SNF from generation to storage, through transportation, and to eventual disposition.

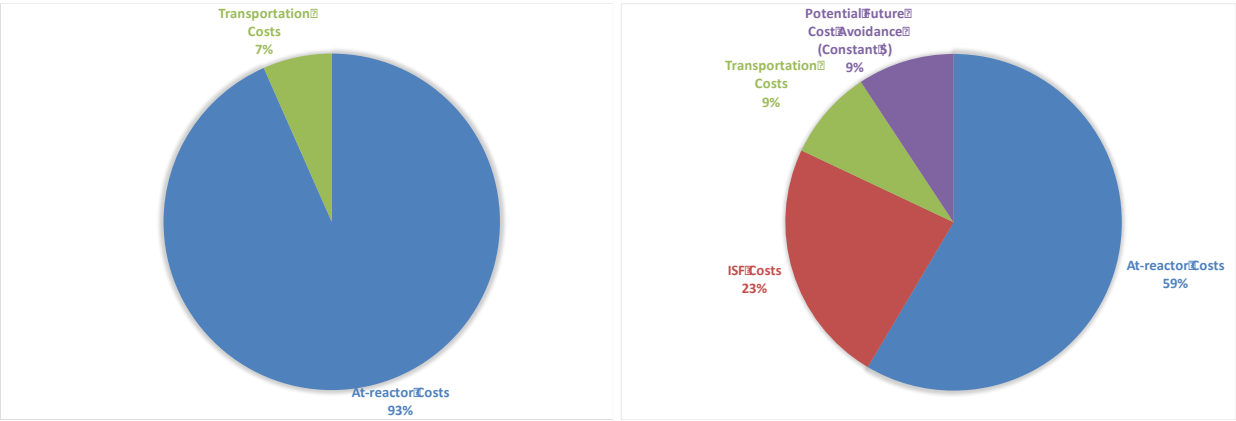

Fig. A-6. Percentage of total system costs broken down by activity when an ISF is not included (left) and when an ISF is included in the system (right). Note that the disposal and potential packaging of waste packages' costs are not included in this figure.

[128] American Physical Society 2007.

[129] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

[130] Cumberland et al. 2016.

[131] Jarrell et al. 2016.

A-3. Large Upfront Economic Investment

Economic trade-offs associated with building a new facility as part of an integrated waste management system must be analyzed.

A-3.1 Previous Studies

DOE's 1985 MRS Proposal concluded that:

> The cost of the total improved-performance system is estimated to be about 5 percent higher than that of the system without an MRS facility; the cost is thus within the range of uncertainty associated with cost estimates for a total system without an MRS facility and is considered small in comparison with the benefits.[132]

DOE expanded on that conclusion in its 1989 *DOE Position on the MRS Facility*:

> The results of the DOE's evaluations indicate that the inclusion of such an MRS facility would provide significant advantages to the Federal waste-management system, but the addition of the MRS facility would increase the cost of the system. The DOE recognizes that storage at reactor sites can be safely continued and that additional at-reactor storage will, continue to be necessary until such time, and for some time, thereafter, as the Federal Government is able to begin receiving spent fuel, with or, without an MRS facility. However, an MRS facility can provide direct and substantial benefits in demonstrating early Federal capability to successfully solve the waste-management problem through early and adequate waste acceptance, enhancing confidence in the development of the waste-management system, and providing needed flexibility both in operations and timing.[133]

BRC concluded:

> The Transportation and Storage Subcommittee looked in some detail at the third issue, concerning cost. As discussed elsewhere in this section, it found potentially substantial cost savings associated with removing SNF from shutdown reactor sites and with accelerating the federal government's ability to begin accepting waste in fulfillment of its existing contractual commitments (and thereby avoiding further damage payments to utilities). The Subcommittee also looked at estimates of the cost of providing consolidated storage based on eight studies of this subject published since 1985. The conclusion was that it would be impossible to arrive at a single point estimate of centralized storage costs given the large uncertainties involved. The more important conclusion, however, was that the extra cost to site, design and obtain a license for a consolidated storage facility was likely to be in the range of $50 to $100 million. While appreciable, these are small levels of commitment from the perspective of the overall spent fuel management program. At the same time, a wide variety of circumstances can be anticipated in which centralized storage facilities could prove invaluable. In these circumstances, savings on the order of billions of dollars are possible. With these findings in mind, the Commission concludes that it would be prudent to pursue the development of consolidated storage capability without further delay, recognizing that there will be an opportunity to make course corrections later as needed.[134]

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[132] U.S. Department of Energy 1987a, 4-5.

[133] U.S. Department of Energy 1989a. 2.

[134] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

Recognizing the growing liability costs for continued failure to accept SNF, the 2013 *Strategy* concludes that "the projected long-term cost of insufficient action surpasses the cost of implementing the program in the short run."[135]

A-3.2 Recent Assessments

The total system costs must be considered when evaluating a large investment like an ISF, in addition to the yearly expenditure profiles.

Construction and operation of ISFs that can eventually stop and then reverse the continued build-up of inventories of SNF in dry storage at reactor sites will increase near-term federal expenditures on waste management. DOE's budget request for FY 2015 indicated that the 10-year projected cost of construction and operation of a pilot interim waste storage facility within the next 10 years, as well as notable progress on both full-scale interim storage and long-term permanent geologic disposal, would be approximately $5.7 billion. To the extent that acceptance of SNF from reactors reduces the amount that utilities pay to place SNF in dry storage at the reactor sites, the basis for damage claims will be reduced, offsetting to some extent the costs of moving the SNF to an ISF and storing the SNF there instead.[136] In the long term, however, the picture changes as more and more reactors are expected to shut down and decommission. Once all the reactors on a site stop operation, the full costs of maintaining oversight and security for the site are attributed to the continued presence of spent fuel in storage on the site, amounting to approximately $10 million annually per site in today's dollars. [137] The BRC recognized the importance of post-shutdown storage costs: "[d]irect cost considerations alone provide a compelling reason to move stranded spent fuel as quickly as possible to a consolidated storage facility. This is because the cost attributable to storing spent fuel at plant sites increases dramatically once the reactor is shut down."[138]

Fig. A-7 shows the potential order of magnitude of at-reactor, ISF, and transportation costs over time with a single ISF becoming operational in 2025 and without an ISF.[139]. As noted by the BRC, a single point estimate is impossible, and this is simply one example of the many possible deployment scenarios.

[135] U.S. Department of Energy 2013, 12.

[136] Government Accountability Office 2009, 30. "Finally, if DOE uses centralized facilities to store commercial spent nuclear fuel, this alternative could allow DOE to fulfill its obligation to take custody of the commercial spent nuclear fuel until a long-term strategy is implemented. As a result, DOE could curtail its liabilities to the electric power companies, potentially saving the government up to $500 million per year after 2020, as estimated by DOE. The actual impact of centralized storage on the amount of the liabilities would depend on several factors, including when centralized storage is available, whether reactor sites had already built on-site dry storage facilities for which the government may be liable for a portion of the costs, how soon waste could be transported to a centralized site, and the outcome of pending litigation that may affect the government's total liability."

[137] Jarrell 2015, A-1, Table A-1.

[138] Blue Ribbon Commission on America's Nuclear Future 2012, 35.

[139] Jarrell et al. 2016, Fig. 7, 14.

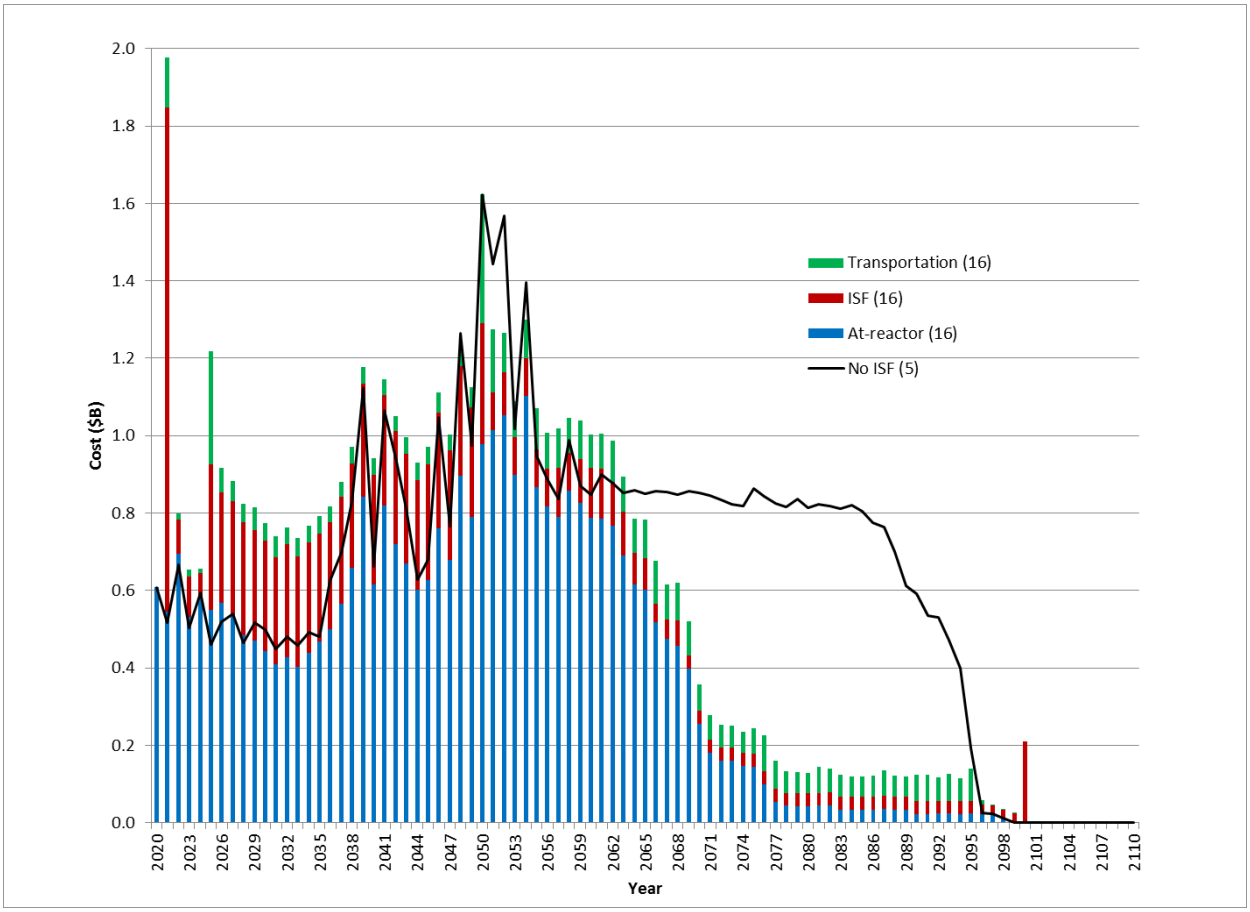

Fig. A-7. Potential year-of-expenditure costs for integrated waste management system, neglecting repackaging and repository costs (data sets superimposed).

Additionally, the report from which this figure is drawn analyzed scenarios with ISF start dates of 2025, 2030, and 2035 with MGR opening dates of 2040, 2050, and 2060 and found that an ISF reduces total system costs in all scenarios in which an MGR opens at least 10 years after an ISF.[140] The report also notes that the estimated savings in at-reactor costs could be greater if higher acceptance rates and/or site-specific allocation/acceptance strategies that have been evaluated in other studies were used [141]

[140] Jarrell et al. 2016, 16. As can be seen in Figure 9 (which shows breakeven years when the no ISF and ISF scenarios accumulate the same total system cost with ISF start dates of 2025, 2030, and 2035 and repository open dates of 2040, 2050, and 2060), eight of the nine scenario comparisons reach a point at which the no-ISF costs exceed the ISF costs. The actual date is determined by the relative startup dates for the ISF and the repository. The scenario without a breakeven point assumes that a flow-through ISF opens in 2035 and repository opens in 2040.

[141] Jarrell et al. 2016, 3. "This study assumes a constant 3,000 MTHM/yr acceptance rate and, following shipment of SNF from an initial set of nine shutdown reactor sites, applies an allocation strategy in accordance with the oldest-fuel-first (OFF) acceptance priority ranking defined in the Standard Contract. However, previous NFST research determined that higher acceptance rates and/or site-specific allocation/acceptance strategies could lead to significant benefits for at-reactor management logistics and costs. Therefore, this study's assumptions of acceptance rates and strategies are deemed to be conservative from an at-reactor cost perspective since implementation of an ISF combined with site-specific allocations and/or higher acceptance rates should result in an even greater reduction of at-reactor costs beyond those described in this study."

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APPENDIX B

Historical Recommendations Regarding Implementation of an ISF and the SNF Management System

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Appendix B
Historical Recommendations Regarding Implementation of an ISF and the SNF Management System

NOTE: In this summary of findings and recommendations, direct quotes from the cited reports are identified by quotation marks or italics. In addition, Sections B-1.1, B-1.3, and B-1.4 are direct quotes from the MRS Review Commission.

B-1. MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION (MRS COMMISSION) 1989[1]

The MRS commission provided a detailed overview of MRS benefits and detriments (B-1.1) as well as provided conclusions (B-1.2) and recommendations (B-1.3)

B-1.1 Letter of Transmittal Summary of Report[2]

The Monitored Retrievable Storage Review Commission herewith submits its final report as required by the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, as amended by Public Law 100-507.

The Congress created the Commission to provide a report on the need for a Federal monitored retrievable storage facility (MRS) as part of the Nation's nuclear waste management system. In essence, Congress asked the Commission to review the U.S. Secretary of Energy's proposal to create an MRS, evaluate the technical need for an MRS, obtain data and comments from affected parties, and recommend whether such a facility should be included in the nuclear waste management system.

The Commission concludes that the MRS as presently described in the law, which links the capacity and schedule of operation of the MRS to a permanent geologic repository, cannot be justified. The Commission finds, however, that while no single factor would favor an MRS over the No-MRS option, cumulatively the advantages of an MRS would justify the building of an MRS if: (1) there were no linkages between the MRS and the repository; (2) the MRS could be constructed at an early date; and (3) the opening of the repository were delayed considerably beyond its presently scheduled date of operation.

The Commission notes that the Congress, for many years, has expressed concern that an unlinked MRS might be regarded as a de facto repository and could reduce the impetus for proceeding with permanent geologic disposal. The Commission recognizes this expression of Congressional will, as well as similar sentiments voiced during the course of its hearings. Although the Commission does not believe that there is a technical basis for the linkages, the Commission concludes that some linkages are justified.

Based on our studies, and the conclusions noted above, the Commission has decided that some limited interim storage facilities would be in the national interest to provide for emergencies and other contingencies. The Commission feels that such facilities would be especially desirable in light of delays which have already been experienced as well as additional delays that might be encountered in building a permanent geologic repository. The Commission therefore recommends that the Congress take the following actions:

1. Authorize construction of a Federal Emergency Storage (FES) facility with a capacity limit of 2,000 metric tons of uranium.

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[1] Monitored Retrievable Storage Review Commission 1989.

[2] Monitored Retrievable Storage Review Commission 1989. Section B-1.1 is a direct copy of the text in the transmittal letter.

2. Authorize construction of a User-Funded Interim Storage (UFIS) facility with a capacity limit of 5,000 metric tons of uranium. Such a facility would provide only storage, and would be in addition to the FES.

3. Reconsider the subject of interim storage by the year 2000 to: (a) take into account uncertainties that exist today and that might be resolved or clarified within ten years; (b) consider developments that cannot be anticipated today; and (c) evaluate the experience with the two facilities recommended above.

The Commission believes that these recommendations, together with the analyses contained in the report, carry out the mandate given the Commission by the Congress.

B-1.2 MRS Risks and Advantages

- ***Cumulatively the advantages of an MRS would justify the building of an MRS if:***

  - ***There were no linkages between the MRS and the repository*.** The MRS Review Commission concluded that although some linkages are justified to address the concern that a storage facility would impede development of a repository, the statutory linkages established in 1987 were too tight:

    The Commission agrees a balance must be struck between providing enough flexibility for a sound repository development schedule and maintaining sufficient pressure to move forward with the repository program. The existing linkages, particularly those that tie the MRS schedule to that of the repository, keep pressure on the repository program but severely limit the flexibility of the waste management system.[3]

- ***[T]he Commission finds that an MRS whose schedule of operation and capacity is not linked to the repository would serve the following purposes:***

  - ***Supplying storage for emergencies*.** While the MRS Commission did not conclude that an MRS facility with the tight statutory linkages to the repository established in law in 1987 would be justified, its first recommendation was that Congress should authorize construction of a limited Federal Emergency Storage facility:

    In light of the continuing delay in the building of a repository, the Commission believes it would be in the national interest to have available a safety net of storage capacity for emergency purposes, such as an accident at a nuclear power plant, which would make it advantageous to have the plant's spent fuel pool available for decontamination of affected parts of reactors and for storage of debris.[4]

  - ***Allowing greater redundancy in the system in the event of unforeseen circumstances*.**

  - ***Offering more surge capacity to facilitate the flow of spent fuel to the repository*.**

[3] Monitored Retrievable Storage Review Commission 1989, 95.

[4] Monitored Retrievable Storage Review Commission 1989, 101.

- ***Providing storage for utilities that have insufficient space in their spent fuel pool or on-site or that cannot obtain licenses for additional at-reactor storage, thus preventing the shutdown of otherwise satisfactorily operating nuclear power plants.***

- ***Furnishing storage for spent fuel from shutdown reactors, especially at sites where utilities no longer operate nuclear power plants.***

- ***Creating economies in the waste management system if an MRS could be completed substantially in advance of the repository.***

- ***Providing more flexibility in storage options and future waste preparation functions.***

- ***Assistance in standardization*** **[of storage/transportation methods].** The MRS Review Commission predicted that "unless a standardized storage form or package is required by DOE or NRC, utilities will respond to their interim storage needs on an individual, cost-effective basis."[5] It went on to find one of the major potential benefits of an MRS would be that:

  if standardization [of storage systems] is not mandated by the Federal government, an MRS facility that accepts waste early could promote standardization by reducing the variety of spent fuel forms and packages to be handled and could limit the number of reactors providing storage for other than intact, unpackaged spent fuel.[6]

- ***Initiating Federal responsibility for taking possession of spent fuel.*** The MRS Review Commission stated that "Institutional experience in siting and licensing an MRS could be beneficial to the repository program." It further states:

  The repository program may benefit from siting an MRS facility to some degree, especially if another repository site must be found. The technical issues associated with siting an MRS are different than the technical issues involved in siting the repository. However, DOE experience in negotiating with a potential host State over permissible site investigation activities for an MRS and negotiating a benefits agreement with a potential MRS host State could prove useful should similar efforts be required in the repository program. This experience could be useful whether the MRS is sited by DOE or by the Negotiator… Any institutional experience from siting and licensing a repository would be significantly reduced if the schedules for siting and licensing of the repository and the MRS overlap, as would be the case under the current statutory schedule linkages.[7]

- **The MRS Review Commission concluded that the cost differences between an MRS and no-MRS system decreased the longer a repository was delayed.** Section 143(a)(4) of the NWPA

[5] Monitored Retrievable Storage Review Commission 1989, 90.

[6] Monitored Retrievable Storage Review Commission 1989, 92. Note that with the passage of time, (almost) every reactor eventually had to provide for dry storage, but provision of an ISF still can limit the amount of spent fuel in dry storage at reactor sites, particularly after the reactors are decommissioned. As discussed earlier, the current trend in at-reactor storage is towards a multiplicity of large cask systems that are optimized for the needs of operating reactors but that could delay and complicate the ability to clear the fuel off the sites once the reactors are shut down.

[7] Monitored Retrievable Storage Review Commission 1989, 87.

as amended in 1987 directed the MRS Review Commission to compare systems with and without an MRS facility in terms of impacts on a range of factors including costs as well as other factors such as "the reliability of the national system for the disposal of radioactive waste" and "the ability of the Secretary to fulfill contractual commitments of the Department under this Act to accept spent nuclear fuel for disposal." On the specific issue of cost, the final report of the MRS Review Commission stated:

The Commission finds that the costs of building and operating an MRS are greater than the savings in reactor storage costs if the repository starts according to current DOE schedules or is subject to a modest delay. If the MRS [sic. Should be "repository"] is delayed beyond 2013, when the cost of delaying the removal of spent fuel from shutdown reactors begins to accumulate, then the cost differences between a No-MRS and unlinked MRS system become negligible. Since the criteria that the Commission used to evaluate the desirability of including a monitored retrievable storage facility in the national spent fuel management and disposal system are not limited to lowest cost, these data do not demonstrate conclusively that a No-MRS strategy is to be preferred, even if one is optimistic about the repository schedule. Moreover, the uncertainty apparent in the cost data suggests it would not be prudent to base decisions primarily on what is currently perceived to be the lowest cost strategy.[8]

- **Risks due to increased transportation of SNF are small.** The MRS Review Commission was directed to consider impacts on transportation in its comparison of systems with and without an MRS, and reached the following conclusion:

  The Commission finds that transportation risks— both radiological and non-radiological— associated with all of the spent fuel management alternatives are small and are not discriminating in the determination of the need for an MRS. Further, because the risks are small, apparent differences in results arising from the use of different assumptions, whether they pertain to transportation mode split or the role of special casks, are equally non-discriminating in the decision-making. This finding is in accord with the results of other studies, although the numbers may differ. Before undertaking these analyses, the Commission conducted a review and critique of transportation and siting-related studies by the Department of Energy and the State of Tennessee, directly addressing the need for an MRS. These studies also found that transportation risks are small. Indeed, the Commission agrees with both the current position of DOE[9] *and the conclusion of the University of Tennessee*[10] *that these small risks should not be a discriminating factor in determining the need for an MRS.*[11]

B-1.3 Overall MRS Conclusions[12]

In light of the Commission's studies and the considerations noted above, the Commission has reached five conclusions:

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[8] Monitored Retrievable Storage Review Commission 1989,74.

[9] The report cites: Isaacs, Thomas H., Associate Director, External Relations and Policy, Office of Civilian Radioactive Waste Management, Department of Energy, "DOE Position on the Monitored Retrievable Storage (MRS) Facility," Prepared Remarks Before the Monitored Retrievable Storage Review Commission, May 25,1989, pp. 19–21.

[10] The report cites: University of Tennessee, Transportation Center, "Monitored Retrievable Storage of Spent Nuclear Fuel: Transportation Studies," December 16, 1985, revised October 20, 1986, p. 48.

[11] Monitored Retrievable Storage Review Commission 1989, 57.

[12] Monitored Retrievable Storage Review Commission 1989. Section B-1.3 is a direct copy of the text in the Report 99–101.

Conclusion No. 1. From a technical perspective, both the No-MRS and MRS options are safe.

Although neither option is completely without risk, the risks are expected to be small and within regulatory limits, and the degree of difference in risks between the No-MRS and MRS options is so small that the magnitude of difference should not affect the decision whether there should be an MRS.

Conclusion No. 2. The net cost of a waste management system that includes an MRS would be lower than previously estimated because of delays that have already occurred in the expected date of repository operation and the likelihood of further slippages of that date.

As Chapter Six noted, the economics of an MRS would become more favorable if the repository were delayed and the MRS were to accept fuel as early as possible. These economic effects would be especially significant if the repository operation were to be delayed beyond 2013, when there will be a sharp increase in the number of nuclear power plants whose current licenses will expire. If a repository were not accepting spent fuel by that time, utilities would incur major additional costs because they would be unable to remove spent fuel from plants being decommissioned. The possibility of further delay in the repository opening therefore places the economic benefits of an MRS in a different and more favorable light than previously reported.

If the repository were to be delayed to the year 2013, the undiscounted costs of a system without an MRS facility nevertheless would be slightly lower than those of a system that included an MRS available in the year 2000. If the costs were discounted and expressed as present values, assuming a 4 percent rate of discount, the No-MRS case would remain less expensive than the MRS case even if the repository were delayed to 2023. (See Chapter Six and Table 6.8.)

Conclusion No. 3. There are no single discriminating factors that would cause the MRS alternative to be chosen in preference to the No-MRS alternative.

However, the Commission finds that an MRS whose schedule of operation and capacity is not linked to the repository would serve the following purposes:

a. Supplying storage for emergencies, such as after a nuclear power plant accident, when it would be advantageous to have the plant's spent fuel pool available for decontamination of affected reactor parts and storage of debris.

b. Providing storage for utilities that have insufficient space in their spent fuel pool or on-site or that cannot obtain licenses for additional at-reactor storage, thus preventing the shutdown of otherwise satisfactorily operating nuclear power plants.

c. Furnishing storage for spent fuel from shutdown reactors, especially at sites where utilities no longer operate nuclear power plants.

d. Creating economies in the waste management system if an MRS could be completed substantially in advance of the repository, especially if the repository were delayed beyond 2013 and an MRS were in operation by 2000.

e. Allowing greater redundancy in the system in the event of unforeseen circumstances.

f. Offering more surge capacity to facilitate the flow of spent fuel to the repository.

g. Providing more flexibility in storage options and future waste preparation functions.

h. Assisting in standardization.

i. Initiating Federal responsibility for taking possession of spent fuel.

None of these factors alone would warrant an MRS, but cumulatively they justify a facility not limited in capacity or linked to the repository schedule and operation.

Conclusion No. 4. An MRS linked as provided in current law would not be justified, especially in light of uncertainties in the completion time for the repository. Consequently, the Commission does not recommend a linked MRS as required by current law and as proposed by DOE.

For many years, Members of Congress have expressed concern that an unlinked MRS might be regarded as a de facto repository, thereby reducing the impetus for proceeding with permanent geologic disposal. The MRS Review Commission acknowledges this expression of congressional will. During the Commission's public hearings, Members of Congress, congressional staff, environmental groups, and members of the public expressed concern that an MRS would become a de facto repository. Although the Commission does not believe there is a technical basis for the linkages, it agrees that, in light of congressional and other concerns about a de facto repository, some linkages are justified.

However, as Chapter Eight indicated, the schedule linkage presently in the law (MRS construction may not begin until the Nuclear Regulatory Commission (NRC) issues a license for the repository's construction) would make it impossible for an MRS to become operational more than three years before the repository. Because of delays already experienced in the scheduled repository opening and continued uncertainty surrounding the repository's location and date of operation, the value of the MRS would be greatly diminished if its construction were tied to the schedule of the repository. Most of the need for an MRS would have disappeared because utilities would have had to make other arrangements for storage.

As noted in Chapter Eight, the capacity and schedule linkages currently contained in the NWPA, as amended, would significantly reduce the benefits of providing backup to on-site storage or for operational emergencies, surge capacity, early waste acceptance, institutional experience in siting and licensing, and standardization. The benefits of removing spent fuel from shutdown reactors would also be reduced, especially if the repository opening were delayed beyond about 2013.

Conclusion No. 5. Some interim storage facilities, substantially more limited in capacity and built under different conditions than the DOE-proposed MRS, are in the national interest to provide for emergencies and other contingencies.

The Commission recognizes the need to provide certain services that would be in the national interest, but that could not be provided by an MRS restricted by the schedule linkages currently in the law. The Commission concludes that spent fuel storage for emergency and other purposes and storage necessary to prevent utilities from shutting down otherwise satisfactorily operating nuclear power plants would be in the national interest. Facilities to fulfill this national interest could be more limited in scope and could be built under different conditions than the DOE-proposed MRS.

B-1.4 MRS Commission Recommendations[13]

In view of the above conclusions, and in consideration of Section 143(a)(1)(C)(iv) of the NWPA, as amended, the Commission submits three recommendations for "improving the flexibility of the repository-development schedule, and providing temporary storage of spent nuclear fuel accepted for disposal":

Recommendation No. 1. Congress should authorize construction of a Federal Emergency Storage (FES) facility with a capacity limit of 2,000 metric tons of uranium (MTU).

In light of the continuing delay in building a repository, the Commission believes it would be in the national interest to have available a safety net of storage capacity for emergency purposes, such as an accident at a nuclear power plant, which would make it advantageous to have the plant's spent fuel pool available for decontamination of affected reactor parts and for storage of debris.

Recommendation No. 2. Congress should authorize construction of a User-Funded Interim Storage (UFIS) facility with a capacity limit of 5,000 MTU. Such a facility would provide storage only, and

[13] Monitored Retrievable Storage Review Commission 1989, 101–104. Section B-1.4 is a direct copy of the text in the MRS Review Commission Report.

would be used in addition to the Federal Emergency Storage facility proposed in Recommendation No. 1.

Although spent fuel can be stored safely at reactor sites for as long as 100 years, some utilities may not have space at their reactor sites for life-of-plant storage or may not be able to obtain a license for additional storage.

In view of the uncertainties regarding the date of availability of a repository, it would not be in the national interest to force utilities to shut down otherwise satisfactorily operating nuclear power plants because they lack storage for spent fuel. Congress recognized this problem by authorizing, in Section 135 of the NWPA, a Federal Interim Storage facility. It is the Commission's intention that the 5,000 MTU storage facility recommended herein should also be available in such contingencies.

The UFIS facility also should provide storage for: (a) shutdown reactors at sites where a utility no longer operates nuclear power plants, and (b) utilities that would prefer to ship spent fuel to this facility rather than retain it on-site.

Recommendation No. 3. Congress should reconsider the subject of interim storage by the year 2000 to:

(a) take into account uncertainties that exist today and that might be resolved or clarified within ten years, (b) consider developments that cannot be anticipated today, and (c) evaluate the experience with the two facilities recommended above.

As has been indicated throughout this report, there are many uncertainties which make it extremely difficult to plan for long-term interim storage of spent fuel. Although the date of opening a permanent repository is the most notable uncertainty, many other questions, such as those noted below, also remain unresolved.

The Commission believes that the actions recommended above should adequately take care of the needs of interim storage at least until 2006. The Commission arrived at this conclusion after considering the schedule of cumulative need for spent fuel storage, the option of at-reactor storage, and the fact that the need for storage will become acute only after a significant number of reactors shut down and if neither an MRS nor a repository is available.

However, by the year 2000, Congress should reconsider the question of interim storage of spent fuel, taking into account, among other things, the following factors:

- *a. Status of the repository;*
- *b. Status of nuclear power plants, i.e., number that shut down early, license extensions, utilization of extended burnup, etc.;*
- *c. Availability of at-reactor storage;*
- *d. Utilization and adequacy of the 2,000 MTU Federal Emergency Storage facility;*
- *e. Utilization and adequacy of the 5,000 MTU User-Funded Interim Storage facility;*
- *f. Status of rod consolidation, dual-purpose casks, and other technological developments in spent fuel storage;*
- *g. System optimization; and*
- *h. The fee schedule established for the user-funded facility.*

The Monitored Retrievable Storage Review Commission believes that these recommendations, together with analyses contained in other sections of this report, carry out the Commission's mandate from Congress. If implemented, the recommendations would provide safe interim storage of spent nuclear fuel, would be consistent with the goals of the national nuclear waste management system, and would provide for flexibility and unforeseen contingencies. The Commission urges Congress, whatever its

decision, to act as promptly as possible with regard to interim spent fuel storage, so that DOE, utilities, and other affected parties can plan accordingly.

B-2. Other Historical Recommendations

In addition to the MRS Review Commission, a number of other recommendations have been developed over the previous two decades. As above, italicized text or those in quotes are direct quotes from References.

B-2.1 Nuclear Waste Technical Review Board (1996)[14]

Recently, as a result of concerns primarily on the part of nuclear utilities and public utility commissions, several legislative proposals have been introduced in Congress that would require the DOE to develop a federal centralized storage facility at or near Yucca Mountain, Nevada, that could begin accepting commercial spent nuclear fuel in 1998 or soon thereafter. In addition, a large group of state agencies and utilities have sued the DOE in the U.S. Court of Appeals for the District of Columbia to obtain a judgment that makes the DOE legally responsible to begin accepting utility spent fuel in 1998. These initiatives have placed storage at the forefront of the debate about the ultimate fate of spent fuel. They also portend a possible change in the nation's goal of timely disposal and a redirection in program focus — from permanent disposal to temporary storage.[15]

Summary of Board recommendations:[16]

After evaluating various technical and policy-related considerations regarding federal centralized storage, the Board believes that it is possible to find the right balance between permanent disposal and temporary storage of commercial spent nuclear fuel.

1. Developing a permanent disposal capability should remain the primary national goal and, for the next several years, determining the suitability of the Yucca Mountain site should remain the primary objective of the DOE's waste management program. Assigning the Office of Civilian Radioactive Waste Management any significant new activities at this time could compete for funding and other resources with site-characterization and repository development efforts at the Yucca Mountain site.

2. The Board recommends that during the next several years generic planning for a centralized storage facility and for a supporting transportation infrastructure begin at a funding level modest enough to avoid competition with the repository program. From a technical, operational, and fiscal perspective, 2010 is the key milestone for storage. Therefore, plans should be made to have this storage facility operating at full capacity (able to accept 3,000 metric tons/year for 30 years) by about 2010. This will allow the federal government to remove the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur.

Successful development of a [waste management] system for the nation … will require sound program management and sufficient and consistent funding the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur.

3. The construction of a federal centralized storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site for repository development. If Yucca Mountain proves suitable, the centralized storage facility should be located there.

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[14] Nuclear Waste Technical Review Board 1996.

[15] Nuclear Waste Technical Review Board 1996, vii.

[16] Nuclear Waste Technical Review Board 1996, xii–xiii.

4. The Board recommends developing storage incrementally by limiting the amount that can be transported to Yucca Mountain until repository construction has been authorized by the NRC. This will address the potential risks associated with linking storage to the earlier milestone of site suitability.

5. The Board also recommends reauthorizing limited-capacity backup storage, similar to the one previously authorized by the Nuclear Waste Policy Act, at an existing federal nuclear facility. Actual development of the backup facility should begin only if a clear need for the facility is established. Its operation should be phased out once the operation of a large centralized storage facility commences.

6. Because siting a centralized storage facility may be extremely difficult without a viable disposal program, if the site at Yucca Mountain proves unacceptable for repository development, the Board recommends that other potential sites for both disposal and centralized storage be considered.

B-2.2 MIT The Future of Nuclear Power (2003)[17]

A period of many decades of interim spent fuel storage should be incorporated into the design of the waste management system as an integral part of the system architecture. A network of centralized facilities for storing spent fuel for several decades should be established in the U.S. and internationally.[18]

Replacing the current ad hoc approach to spent fuel storage with an explicit strategy to store spent fuel for a period of several decades, prior to reprocessing and/or geologic disposal, will create additional flexibility and robustness in the waste management system and, if organized internationally, can also provide significant non-proliferation benefits.[19]

B-2.3 National Commission on Energy Policy (2004)

The [2004] Administration and the Congress should move expeditiously to establish a project for centralized, interim, engineered storage of spent fuel at no fewer than two US locations, as a complement and interim back-up to the geologic repository program.[20]

B-2.4 National Resources Defense Council (2005) [21]

NRDC's Preferred Solution:

- *Terminate proliferation risky R&D on fast reactors and pyroprocessing.*
- *Initiate a search for a second geological repository in the United States.*
- *Improve interim dry cask storage of spent fuel at operating reactor sites.*
- *Allow away-from-reactor spent fuel storage for decommissioned reactors.*

[17] Massachusetts Institute of Technology 2003.

[18] Massachusetts Institute of Technology 2003, 87.

[19] Massachusetts Institute of Technology 2003, 86.

[20] The National Commission on Energy Policy 2004, 61.

[21] Cochran 2005, 12.

B-2.5 American Physical Society (2007)[22]

We focus on the issues associated with proposals to establish one or more sites for the consolidated storage of spent nuclear power reactor fuel as an interim measure before final disposition. In reviewing numerous reports and research articles, we find that:

- *There are no substantive safety or security reasons for establishing consolidated interim storage.*
- *There are no compelling cost savings to the Federal government associated with consolidated interim storage, so long as Yucca Mountain is not delayed well beyond its currently planned opening.*
- *There is sufficient space at all operating nuclear reactors to store all spent nuclear fuel in pools and in existing or additional dry casks that will be discharged even with plant license extensions. Although, some states may limit the amount of dry storage at a reactor site.*
- *Nevertheless, we also find that:*
- *Consolidated storage could facilitate the decommissioning of sites with reactors that have been shut down.*
- *Consolidated interim storage would establish a process for taking Federal title to commercial spent fuel and decouple private sector nuclear power plant operators from the long-term spent-fuel management problem, thereby removing a potential obstacle to siting new nuclear power plants and to continued operation of existing plants.*

  Such a decoupling could arguably also be accomplished if the Federal government took title to the spent fuel at the reactor sites.

  A permanent repository is the cornerstone of the nation's waste management strategy. Consequently, if the Federal government were to proceed with interim storage, it should be done in a manner consistent with Federal strategies for long-term management. Further, any development of consolidated interim storage must be sensitive to the significant hurdles to siting which would make it difficult to open a consolidated storage site in less than a decade. If Congress chooses to direct the development of consolidated storage facilities, the exploration of strategies to improve their economic and social attractiveness to potential host communities should receive careful consideration.

B-2.6 National Commission on Energy Policy (2007)[23]

Take action to address the current impasse on nuclear waste disposal, while reaffirming the ultimate objective of siting and developing one or more secure geologic disposal facilities, by amending the Nuclear Waste Policy Act (NWPA) to:

- *Align its requirements with human engineering and scientific capabilities, while adequately protecting public health and safety and the environment.*
- *Require DOE to site and operate consolidated national or regional interim storage options.*
- *Undertake R&D to explore technological alternatives to the direct geologic disposal of waste from a once-through cycle that meet commercial requirements and nonproliferation objectives,*

[22] American Physical Society 2007.

[23] National Commission on Energy Policy 2007.

reduce the challenge of waste disposal, ensure adequate protection of public health and safety, and extend fuel supply.

- *Codify that interim storage and federal responsibility for disposal of nuclear waste is sufficient to satisfy the Nuclear Regulatory Commission's waste confidence requirement.*
- *Require the Secretary of Energy to take possession of and/or remove fuel from reactor sites that have been, or are in the process of being fully decommissioned.*

B-2.7 Natural Resources Defense Council (NRDC) Response to the Recommendations of the National Commission on Energy Policy (NCEP) (2007)24

NRDC's Nuclear Program Response to the Recommendations of the National Commission on Energy Policy:

NCEP Recommendation:

- *Require the Secretary of Energy to take possession of and/or remove fuel from reactor sites that have been, or are in the process of being fully decommissioned.*

NRDC Comment:

- *In contrast to the other recommendations, we have no objection to this proposal.*

B-2.8 Keystone Center Nuclear Power Joint Fact-Finding (2007)25

With regard to older spent fuel that must be stored on an interim basis until an operating repository is available, the NJFF participants believe that this spent fuel can be stored safely and securely in either spent fuel pools or dry casks, onsite. The NJFF group also agrees that centralized interim storage is a reasonable alternative for managing waste from decommissioned plant sites and could become cost-effective for operating reactors in the future.

Three options exist for spent fuel storage: on-site fuel pools, on-site dry cask storage systems, and centralized storage in dry casks. Although pool storage capacity is constrained at some sites, the dry storage option generally is not; however, dry cask storage incurs additional costs. Centralized dry cask storage for spent fuel currently at decommissioned plant sites may make sense, because it would allow more efficient management and oversight of the spent fuel and allow reuse of land at decommissioned plants.

MIT The Future of the Nuclear Fuel Cycle (2011)[26] ***Recommendations:***

Planning for long term managed storage of spent nuclear fuel—for about a century—should be an integral part of nuclear fuel cycle design. While managed storage is believed to be safe for these periods, an R&D program should be devoted to confirm and extend the safe storage and transport period.

The possibility of storage for a century, which is longer than the anticipated operating lifetimes of nuclear reactors, suggests that the U.S. should move toward centralized SNF storage sites—

[24] National Resources Defense Council 2007, 5.

[25] Keystone Center 2007,16.

[26] Massachusetts Institute of Technology 2011, xi.

starting with SNF from decommissioned reactor sites and in support of a long-term SNF management strategy.

This will have the additional benefits of resolving federal liability for its failure to start moving SNF from reactor sites starting in 1998.

B-3. PERSPECTIVES ON LINKAGE

There have been a number of different perspectives on the linkage between away-from-reactor storage and a repository.

DOE 1987 MRS Proposal:[27]

The perceived and potential programmatic impacts of adding an MRS facility are the weakening of resolve to develop a repository, the potential for diverting the resources needed to develop a repository, and the enlargement of the system to be implemented. Earlier efforts to provide Federal storage facilities have raised the concern that the ready availability of Federal storage would make it easy for the nation to defer the difficult political decisions required to site a geologic repository. Conversely, the history of the waste-management program suggests that the credibility of any interim-storage measures will be suspect unless there is confidence that a permanent repository will be available within a reasonable period of time.

To dispel doubts about the resolve to develop a repository, the DOE proposes a direct linkage of MRS operations to the development of a repository. Specifically, the DOE proposes that waste acceptance at the MRS facility be precluded until a construction authorization for the first repository is received from the Nuclear Regulatory Commission. In addition, the DOE recommends that the storage capacity of the MRS facility be limited to 15,000 MTU. This capacity is sufficient to offset potential storage shortfalls at reactors for approximately 5 years, but it is less than one-third of the spent-fuel inventory expected by the year 2000. Finally, the DOE has a statutory obligation to develop a geologic repository, and progress in achieving this mandate is monitored very closely by a wide range of interested and potentially affected parties (e.g., States, Indian Tribes, and utilities) in addition to the Congress as well as Government audit and accounting groups. This close scrutiny and commitment provide additional assurance that progress will be sustained or else corrective measures taken.

The financial and manpower resources projected for an MRS facility are modest considering the scope of the existing program. Competition for these resources can be minimized, if not prevented, through proper management and planning, as shown in the program plan (Volume 3). By these means the DOE can ensure that a priority on resources is maintained for the repository and that the MRS program does not take away or limit any resources needed by the repository program. Furthermore, the maturity of the technologies for spent-fuel handling and storage and the extensive consideration the DOE has given to the technical, economic, schedule, and institutional feasibility of an MRS facility should minimize the demands placed on the upper management of the DOE and further contribute to confidence that an MRS facility can be constructed and operated without compromising the repository schedule.

In the final analysis, the Congressional mandate that assures that permanent disposal in a geologic repository is the national choice also assures that the MRS facility will serve the intended—and only the intended—purpose for the MRS.

[27] U.S. Department of Energy 1987, 27.

The Nuclear Waste Policy Amendments Act of 1987

The amendments adopted tighter linkages than those proposed by DOE, preventing construction (rather than operation) of an MRS facility before issuance of a construction authorization for a repository.

Sec. 148 (d) Licensing conditions. Any license issued by the Commission for a monitored retrievable storage facility under this section shall provide that –

(1) construction of such facility may not begin until the Commission has issued a license for the construction of a repository under section 115(d);

(2) construction of such facility or acceptance of spent nuclear fuel or high-level radioactive waste shall be prohibited during such time as the repository license is revoked by the Commission or construction of the repository ceases;

(3) the quantity of spent nuclear fuel or high-level radioactive waste at the site of such facility at any one time may not exceed 10,000 metric tons of heavy metal until a repository under this Act first accepts spent nuclear fuel or solidified high-level radioactive waste; and

(4) the quantity of spent nuclear fuel or high-level radioactive waste at the site of such facility at any one time may not exceed 15,000 metric tons of heavy metal.

Monitored Retrievable Storage Review Commission Report, 1989:[28]

The Commission disagrees that interim storage at an MRS would be an indication that DOE is not effectively dealing with the disposal problem. One of Tennessee's own studies recognizes "a considerable period of time will be necessary to evaluate a repository site, and that a more experimental, evolutionary, flexible, and cheaper approach to investigation, with less pressure from a rigid schedule, would be beneficial and, perhaps, avoid a perceived failure of the program in the mid-1990s. Dr. E. William Colglazier, the author of the study, supports the I-No-MRS option, but he also states,

" Even though it is technically feasible and cost effective to store on-site at reactors for the foreseeable future, as assumed in the Integrated No-MRS case, the pressure for government acceptance of utility spent fuel may increase in the 1990's, especially if the repository program begins to falter. This pressure for early federal acceptance of spent fuel is one of the reasons for the rigid repository development schedule in the NWPA. How to deal with this pressure is, for me, one of the major problems with the Integrated No-MRS option."

The Commission agrees a balance must be struck between providing enough flexibility for a sound repository development schedule and maintaining sufficient pressure to move forward with the repository program. The existing linkages, particularly those that tie the MRS schedule to that of the repository, keep pressure on the repository program but severely limit the flexibility of the waste management system.

The State of Tennessee asserted that progress on the MRS should remain linked to the repository schedule as mandated in the NWPAA. As the foregoing analysis of DOE's postulated benefits shows, the existing statutory linkages significantly reduce the benefits associated with an MRS. However, the Commission observes that Congress, for many years, has also expressed concern that an unlinked MRS might be regarded as a de facto repository and could reduce the impetus for proceeding with permanent geologic disposal. The Commission recognizes this expression of congressional will, Tennessee's sentiments, and the concerns others voiced during the Commission's hearings.

[28] Monitored Retrievable Storage Review Commission 1987, 95.

Although the Commission does not believe there is a technical basis for the linkages, the Commission finds that, in light of congressional and other concerns, some linkages are justified.

DOE, Reassessment of the Civilian Radioactive Waste Management Program: Report to the Congress by the Secretary of Energy, 1989:

Linkages to the repository: The primary objective of the program is to develop a licensed geologic repository for the permanent disposal of spent fuel and high-level waste. The DOE has an obligation to accept spent fuel from the utilities in accordance with the Standard Contract for Disposal of Spent Nuclear Fuel/and or High-Level Radioactive Waste and the Nuclear Waste Policy Act as amended. However, a detailed examination of the repository schedule, allowing the time necessary for sound scientific investigation and design, shows that the DOE cannot meet the anticipated schedule set forth in the Act for the disposal of waste in a repository by 1998; furthermore, the current linkages between the repository and the MRS program make it impossible for the DOE to accept waste at an MRS facility on a schedule that is independent from that of the repository. Therefore, the DOE plans to work with the Congress to modify the current linkages between the repository and the MRS facility and to embark on an aggressive program to develop an integrated MRS facility for spent fuel. The DOE believes that if the linkages are modified, it is likely that waste acceptance at an MRS facility could begin by 1998 or soon thereafter.[29]

The DOE testified to the MRS Commission on May 25, 1989, that it supports the development of an MRS facility as an integral part of the waste-management system because an integrated MRS facility is critical to achieving the goal of early and timely acceptance of spent fuel and because it would allow the DOE to better meet other strategic objectives, such as timely disposal, schedule confidence, and system flexibility. Though it considered a waste-management system with an MRS facility subject to the current statutory linkages superior to a system without an MRS facility, the DOE stated that a revision of the linkages and the statutory storage-capacity limit would allow the advantages of an MRS facility to be more fully realized. The DOE also expressed preference for an MRS facility sited through the efforts of the Negotiator, especially if these siting negotiations lead to modified linkages[30]

Nuclear Waste Technical Review Board, 1996:[31]

The Nuclear Waste Technical Review Board's 1996 report on storage pointed out that the existing statutory linkages "created a situation in which storage is permitted only when the need for it is reduced through successful repository development"[32] and stated the Board's belief "that one of the best ways to allay these concerns [that a storage site could become a de facto disposal site] is through continued pursuit of a technically credible site-characterization and repository development program for waste disposal."[33]

As described above in Section B-2.1, the Board recommended a looser linkage to the proposed repository at Yucca Mountain (the only repository site under consideration at the time), allowing construction of a federal centralized storage facility after a decision was made about the suitability of the site for a repository. If the site proved suitable, the storage facility should be located there. The Board added that "[b]ecause siting a centralized storage facility may be extremely difficult without a viable disposal program, if the site at Yucca Mountain proves

[29] U.S. Department of Energy 1989, ix–x.

[30] U.S. Department of Energy 1989, 17.

[31] Nuclear Waste Technical Review Board 1996.

[32] Nuclear Waste Technical Review Board 1996, 6.

[33] Nuclear Waste Technical Review Board 1996, 36.

unacceptable for repository development, the Board recommends that other potential sites for both disposal and centralized storage be considered."

Blue Ribbon Commission on America's Nuclear Future, 2012:[34]

> *The first of these concerns, that any consolidated storage facility could become a de facto disposal facility and siphon resolve and resources away from repository development, is a longstanding one. It is why the NWPA explicitly prohibits the construction of an MRS facility before construction authorization has been issued for a first repository. Based on the record of progress to date, the Commission believes that the benefits of moving forward on both fronts—consolidated storage and geologic disposal— at the same time outweigh the potential downside risks. But clearly the challenge of establishing positive linkages such that progress on storage does not undermine, but rather supports progress on repository development remains an important one. The linkages that exist under current law clearly have not worked as intended.*[35]

***DOE** Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste**, 2013**:*

> *The [2013] Administration also agrees with the BRC that a linkage between opening an interim storage facility and progress toward a repository is important so that states and communities that consent to hosting a consolidated interim storage facility do not face the prospect of a de facto permanent facility without consent. However, this linkage should not be such that it overly restricts forward movement on a pilot or larger storage facility that could make progress against the waste management mission. The NWPA currently constrains the development of a storage facility by limiting the start of construction of such a facility until after the Nuclear Regulatory Commission (NRC) has issued a license for construction of a repository. This restriction has effectively eliminated the possibility of having an interim storage facility as an integral component of a waste management system.*[36]
>
> *As noted by the BRC, the linkage between storage and disposal is critical to maintaining confidence in the overall system. Therefore, efforts on implementing storage capabilities within the next 10 years will be accompanied by actions to engage in a consent-based siting process and begin to conduct preliminary site investigations for a geologic repository. The [2013] Administration's goal is to have a repository sited by 2026; the site characterized, and the repository designed and licensed by 2042; and the repository constructed and its operations started by 2048."*[37]

Testimony of Secretary of Energy Moniz, 2013:[38]

> *The rationale for deploying interim storage in no way minimizes the need for a permanent disposal capability, and the [2013] Administration is committed to advancing development of both interim storage and geologic disposal facilities in parallel, even though they may become operational at different times. The development of geologic disposal capacity is currently the most cost-effective way of permanently disposing of used nuclear fuel and high-level radioactive waste while minimizing the burden on future generations. The [2013] Administration agrees with the BRC that linkage between storage and disposal is critical to maintaining confidence in the overall system. Therefore, efforts to implement storage capabilities within the next 10 years will*

[34] Blue Ribbon Commission on America's Nuclear Future 2012.

[35] Blue Ribbon Commission on America's Nuclear Future 2012, 41.

[36] U.S. Department of Energy 2013, 5–6.

[37] U.S. Department of Energy 2013, 7.

[38] Moniz 2013.

be accompanied by actions to engage in a consent-based siting process and initiate preliminary site investigations for a geologic repository.

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