Disposal and Storage of Spent Nuclear Fuel — Finding the Right Balance

A Report to Congress
and
the Secretary of Energy

Nuclear Waste Technical Review Board
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Nuclear Waste Technical Review Board

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Executive Summary

The Nuclear Waste Policy Act of 1982, as amended, established a statutory basis for managing the nation's civilian (or commercially produced) spent nuclear fuel. The law established a process for siting, developing, licensing, and constructing an underground repository for the *permanent disposal* of that waste. Utilities were given the primary responsibility for storing spent fuel until it is accepted by the Department of Energy (DOE) for disposal at a repository — originally expected to begin operating in 1998. Since then, however, the repository operation schedule has been delayed several times, and according to testimony submitted to the U.S. Senate by the Secretary of Energy in December 1995, repository operations may be delayed again, perhaps until 2015. These delays, along with the absence of a federal centralized storage facility, similarly delay the prospect of federal acceptance and removal of the spent fuel from utility sites. As a result, much more commercial spent nuclear fuel will require *temporary storage* for much longer time periods than originally were anticipated.

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.

The Board is encouraged by recent progress…at Yucca Mountain, Nevada

As a result of its technical review, the Board found the connection between storage and disposal to be key to any discussion about where to store commercial spent fuel. Although the DOE's disposal program has been subjected to much past criticism, the Board is encouraged by recent progress in site-characterization and repository development efforts at Yucca Mountain, the only site being characterized for potential repository development. The tunnel-boring machine excavated to the level of the proposed repository in November 1995. Key repository-level exploration and testing activities are being initiated. In addition, the DOE is making progress developing a clear and coherent waste isolation strategy, which should permit an improved delineation of priorities and a more efficient allocation of funds among the activities being conducted at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years if Yucca Mountain is suit-

able for repository development. Ironically, the changes being proposed in Congress to refocus program efforts on storage are coming at a time when previous investments in site characterization and repository development finally are beginning to pay off.

Debates during the past two decades about the storage of commercial spent fuel reflect the complexity of the issues, the diversity of perspectives, and the strongly held views of different stakeholders. Up to now, a broad consensus on this issue has eluded the nation. Ultimately, because of the controversy involved, any attempt to reach a decision about how to store commercial spent fuel over the long term will require making a series of value judgments.

Board conclusions and recommendations

After reviewing about two-dozen technical and nontechnical issues, the Board believes that *it is possible to find the right balance* between disposal and storage. Long-term spent fuel storage needs can be addressed in a way that keeps the goal of repository development on track.

Is there an urgent technical need for centralized storage of commercial spent fuel?

The Board sees no compelling *technical* or safety reason to move spent fuel to a centralized storage facility *for the next few years*. The methods now used to store spent fuel at reactor sites are safe and are likely to remain safe for decades to come. Despite some recent public opposition to utility efforts to develop additional storage, so far, utilities have been able to add new storage capacity at their sites when needed.

Will federal storage be needed in the future?

The Board believes that federal storage capacity *will* be needed *in the future* for two reasons. First, when a repository begins operating, a centralized storage capability will be needed to provide added flexibility to handle the waste. For example, storage would provide a buffer between the repository and the rest of the waste management system if waste emplacement rates in the repository are less than spent fuel acceptance rates. Storage capacity also offers technical advantages, such as allowing spent fuel to be mixed and matched to optimize the thermal loading of the repository to improve repository performance.

Second, 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.

Although currently prohibited by law, there is no *technical* reason why a centralized storage facility (and supporting transportation infrastructure) cannot be constructed prior to repository construction. In fact, because of the lead time needed for planning and development, the Board believes it would be practical to begin *planning* now for a federal storage facility(s) that can achieve full-scale operation (i.e., accept 3,000 metric tons/year) by 2010 when reactors begin shutting down in large numbers.

Can the right balance be found between meeting future spent fuel storage needs and continuing to pursue permanent disposal?

The nation needs both a repository development program and a plan to address future spent fuel storage needs

In the past whenever there has been a choice between storage and disposal, disposal has always been made the primary focus of the federal high-level waste management program. This is because the storage of commercial spent fuel is not an acceptable substitute for disposal. Ultimately, spent fuel (commercial and defense) as well as sizable amounts of high-level radioactive defense waste will have to be disposed of. The Board believes that the nation needs *both* a repository development program and a plan to address future spent fuel storage needs. However, efforts now to refocus the program from disposal to storage, especially at a time when budgets are tight, could jeopardize site-characterization and repository development efforts in three ways: (1) by competing with the disposal program for resources, (2) by causing a real or perceived prejudicing of a future decision about the suitability of the Yucca Mountain site, and (3) by eroding the impetus and political support for repository development.

Given the stage of the current site-characterization program and the fact that substantial new storage capacity will not be needed until 2010, the Board has concluded that it makes technical, management, and fiscal sense to await the decision on the suitability of the Yucca Mountain site for repository development before beginning development of a federal centralized storage facility. The

Board believes that the following approach *strikes the right balance* between maintaining the national goal of permanent disposal while meeting future storage needs.

- Disposal: The nation has a program for developing a repository for the permanent disposal of spent fuel. So far, no technical reasons have been found for abandoning the site being characterized at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years if the Yucca Mountain site is suitable. By *suitable* the Board means that there is a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation. Therefore, *the Board recommends that for the next several years the DOE continue to focus its efforts on evaluating the suitability of the Yucca Mountain site for repository development*.

- Storage: *The Board recommends that generic planning for a federal storage facility and for a supporting transportation infrastructure begin now at a funding level modest enough to avoid competition with the repository program. Development of the storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site* for hosting a repository. Because of the increased advantages of having a storage facility located at an operating repository site, *if Yucca Mountain proves suitable for repository development, the centralized storage facility should be located there*. Activities could begin around 2000 to construct a storage facility that would be operating at full scale by 2010 — at the repository site. Operation by this date would largely eliminate the need to store significant amounts of spent fuel at reactors after they are shut down.

  Development of the storage facility should be deferred until after a decision has been made about the suitability of Yucca Mountain for hosting a repository

  The Board also recommends developing storage incrementally by limiting the amount that can be transported to Yucca Mountain until the repository has been licensed for construction. This will address the potential risks associated with linking storage to the earlier milestone of site suitability, rather than waiting until the NRC licenses the construction of the repository as required by existing law.

  The Board suggests planning now for a limited-capacity backup facility, similar to the one previously authorized by the Nuclear Waste Policy Act, for emergency storage to be located at an existing federal nuclear facility. Development of the backup facility should begin only if a clear need for the facility is established. Its operation should be phased out once operation of a large storage facility at the repository site commences.

The process of licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it will take time; estimates range from five to seven years. Even if passed into law now, none of the proposals before Congress would enable operation of a centralized storage facility to begin much before 2002 — and then not at full scale. With the spent fuel stockpile currently at 32,000 metric tons and growing at 2,000 metric tons per year, it will take as long as 30 years to empty the inventory at all the individual reactor sites. So, developing a centralized storage facility at Yucca Mountain now would only *reduce*, but not eliminate, the need to continue adding spent fuel storage capacity at reactor sites. The Board's suggested approach differs from currently proposed strategies only by the time it will take to determine site suitability — at most five years.

To avoid having substantial amounts of spent fuel sitting at shutdown reactors…2010 is the key milestone

With respect to storage, 2010 is the key milestone. Being able to accept small amounts of spent fuel in 1998 or 2002 will address the storage concerns of only a few utilities. Being able to accept 3,000 metric tons per year for 30 years beginning in 2010 will be necessary to avoid having substantial amounts of spent fuel sitting at shutdown reactors.

How should the costs of federal storage be paid?

Given current funding projections, it appears that the Nuclear Waste Fund will be only marginally capable, at best, of supporting the long-term development and operation of a repository for the permanent disposal of spent fuel. Therefore, the costs of a limited federal storage facility could be recovered through a new fee assessed on the users of that facility. The costs of a large storage facility located at a repository site (which would be used for all spent fuel) could be recovered by increasing the current 1 mill-per-kwh fee going into the Nuclear Waste Fund. This would avoid having the taxpayer bear the costs of final closure of the repository.

What would it take to implement these recommendations?

These Board recommendations represent a departure from existing policies. The Nuclear Waste Policy Act currently links development of a storage facility to the construction of a repository. *The Board recommends that development of a storage facility at Yucca Mountain be linked to the earlier decision about the suitability of the Yucca Mountain site as defined above.*

This new approach is not free of risk. Given the inherent difficulties associated with proving safe repository performance over many thousands of years, a site-suitability decision would not be an iron-clad guarantee that the site could be developed as a repository. However, the Board believes that the risks of linking storage to a site-suitability decision, rather than to the NRC licensing decision, can be minimized if the DOE clearly delineates its site-characterization program and focuses on the timely completion of the needed scientific activities *and* if it continues to work closely with the oversight groups (e.g., the NRC) that have been involved thus far with the program. Working closely with these groups can help ensure that the decision about the suitability of Yucca Mountain for repository development is technically sound.

Successful development of a [waste management] system for the nation… will require sound program management and sufficient and consistent funding

Finally, successful development of a system for managing the nation's spent fuel and high-level waste will require sound program management and sufficient and consistent funding. Without adequate funding for disposal *and* storage, a significant amount of spent fuel will remain in storage at reactor sites well after large numbers of reactors begin shutting down in 2010.

Summary of Board recommendations

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.

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.

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.

Preface

The Nuclear Waste Technical Review Board was established by Congress in the 1987 Nuclear Waste Policy Amendments Act to provide independent evaluation of the scientific and technical aspects of the Department of Energy's program to manage civilian spent nuclear fuel and high-level radioactive defense wastes. To date, the Board has issued nine reports detailing its views and recommendations regarding the Office of Civilian Radioactive Waste Management's (OCRWM) activities. Those reports focused primarily on the OCRWM's site-characterization program at Yucca Mountain, Nevada, and on issues related to geologic disposal and repository design. In addition, the Board has issued several letters and two special reports addressing broad policy issues the Board believed were affecting the scientific and technical program. In this, our third, special report, the Board analyzes numerous issues related to the temporary storage of commercial spent nuclear fuel.

Introduction

The Nuclear Waste Policy Act of 1982, as amended, established a statutory basis for managing the nation's civilian (or commercially produced) spent nuclear fuel. The law established a process for siting, developing, licensing, and constructing an underground repository for the *permanent disposal* of that waste. Utilities were given the primary responsibility for storing spent fuel until it is accepted by the federal government for disposal at a repository, which originally was expected to begin operating in 1998. In December 1995, however, in testimony submitted to the Senate, the Secretary of Energy projected that a repository may not begin operating until around 2015 (DOE 1995c). Delays in repository operation mean that much more commercial spent nuclear fuel will require storage for much longer time periods than originally were anticipated.

Recently, as a result of efforts 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 that could begin accepting commercial spent nuclear fuel in 1998 or soon thereafter. In addition, because they believe that they have unconditional contracts that require the DOE to begin accepting their spent fuel in 1998, a large group of state agencies and utilities have sued the federal government to obtain a judgment on the nature of the DOE's contractual obligation. In response to utility concerns, Congress's fiscal year 1996 appropriation included an $85 million set-aside for possible development of a federal spent fuel storage facility. The activities in Congress foreshadow a possible change in focus for the DOE's civilian radioactive waste management program — from permanent disposal to temporary storage. The prospect of a change in program focus has heightened the debate about how to address utility concerns about continuing at-reactor storage of spent fuel while keeping the program focused on the long-term national goal of permanent disposal.

In this report, the Board looks at issues related to storing commercial spent nuclear fuel. The Board identified about two-dozen issues that reflect the concerns of wide-ranging, strongly held, often conflicting perspectives. Some of these issues, which are listed in Note 1, are of a technical nature; some are institutional; many are policy-related. Because of the diversity of opinions about these issues, any attempt to reach a decision about how best to store commercial spent fuel until a repository begins operating ultimately will involve making value judgments. The Board found that, from its technical perspective, the *connection* between storage and disposal is of particular relevance to a debate about where to store commercial spent fuel. Timing of storage initiatives also has significant implications for repository development.

To facilitate their discussion in this report, we have tried to group the issues: (1) Concerns of the nuclear utilities and public service commissions that have motivated them to place the interim storage and acceptance issue on the legislative and judicial agendas; (2) Issues that are primarily technical in nature; (3) Other institutional issues including concerns of public interest and community groups. The report is organized into chapters that address most of the issues specifically. At the end of most chapters, the Board's key thoughts from that chapter are summarized.

The reader will find that the lines separating the groupings are blurry at times. For example, some technical issues have cost and planning implications for nuclear utilities or reflect concerns of other stakeholders. Some stakeholder concerns, such as the concern that a storage facility could become a de facto disposal site, have potential technical implications for repository development. After reviewing all of these issues, however, the Board concluded that it is possible to find the right balance between disposal and storage and that long-term spent fuel storage needs can be addressed in such a way that the goal of repository development stays on track.

Note 1:
Considerations associated with storage

Concerns of Utilities and Public Utility Commissions

- Delays in federal acceptance of spent fuel
- Delays in repository operation
- Costs of planning and managing on-site storage
- Community opposition to additional at-reactor storage
- Management of the Nuclear Waste Fund
- Potential issues relating to nuclear plant decommissioning

Technical/Waste Management System Issues

- Health and safety risks
- Environmental effects
- Transportation risks
- Sabotage and security
- Total system costs
- Repository operation and long-term performance
- Waste management system efficiencies
- Future uncertainties
- Potential effects of storage on repository development
- Determining the suitability of Yucca Mountain for repository development
- Prejudging suitability

Public/Institutional Considerations

- Perceived transportation risks
- Community acceptance of storage
- General public acceptance
- Risk of creating de facto repositories
- Geographic equity
- Concerns about the risks of storing spent fuel at shutdown reactors
- Concern about reprocessing spent fuel
- Concern for intergenerational equity
- Interutility and ratepayer equity

Chapter 1: Past Initiatives — Framework for Today's Debate

Over the past three decades, policy makers have wrestled a number of times with the question whether to leave commercial spent fuel at reactor sites or to develop a federal centralized storage facility for the fuel until a repository begins operating. In the course of those debates, choices were made that created the framework within which today's spent fuel storage debate is taking place. That framework provides a useful point of departure for this report.

Efforts in spent fuel management prior to 1987

Since 1970, the federal government has had the responsibility of developing a repository for permanently *disposing* of high-level waste and spent fuel (10 CFR 50). The Atomic Energy Commission (AEC) first investigated a potential repository site in a salt formation near Lyons, Kansas. In 1971, however, newly discovered technical problems appeared to render the site unsuitable, and, a year later, the agency formally rejected the site.

The AEC then proposed constructing at one or more of its existing nuclear sites a retrievable surface *storage* facility for the high-level radioactive reprocessing waste while continuing to pursue disposal on a developmental basis (AEC 1974). The Environmental Protection Agency, however, strongly criticized the AEC proposal, arguing that its emphasis on storage would divert attention from the search for a permanent disposal solution (EPA 1974). As a result, the AEC proposal was withdrawn, and efforts were renewed to find a disposal site. (See Note 2 for a discussion of the difference between disposal and storage.)

In 1977, the Department of Energy (DOE), one of the AEC's successor agencies, again proposed developing one or more away-from-reactor storage facilities. The DOE proposal would have provided for federal acceptance of commercial spent nuclear fuel for storage until a repository could begin operating (DOE 1978). Improved storage technologies just coming on-line, however, enabled utilities to rerack their pools and expand their pool storage capacity, making federal storage unnecessary.

The Nuclear Waste Policy Act of 1982 (NWPA) was the first *law* that specifically addressed the question of spent fuel storage. It placed primary responsibility for storing spent fuel on producers — in the case of commercial spent fuel, on the utilities. To "prevent disruptions in the orderly operation" of nuclear power plants, the act authorized the DOE to accept and store for a fee a limited amount (up to 1,900 metric tons) of spent fuel. No utility ever requested these storage services, and in 1990 the DOE's authority to do this expired.

Note 2:
Storage and disposal — what's the difference?

The *disposal* of nuclear waste, often called *permanent disposal or geologic disposal*, refers to the permanent isolation of nuclear waste from the accessible environment. Isolation would be provided underground in an excavated geologic repository by a combination of natural and engineered barriers. To ensure that the repository, including the engineered barrier system, can isolate the waste for thousands of years, extensive scientific investigations (of the site and of potential engineered barriers) must be undertaken. The current disposal concept calls for a period of postemplacement monitoring for about 100 years. The repository would then be permanently closed and sealed.

Storage, on the other hand, refers to the *temporary* placement of the waste in safe containment with the intent that ultimately it will be disposed of. Spent fuel storage currently is taking place in cooling pools and in dry storage facilities at nuclear reactor sites.

Finally, the NWPA charged the DOE with making a proposal for the development of a long-term storage facility, called a monitored retrievable storage (MRS) facility. This facility would be subject to a *location linkage*: the DOE could not site a storage facility in any state where characterization for a repository was taking place. This linkage had two effects: (1) it reduced the risk that investments in a *storage* site might lead to choosing that site for a *repository* and (2) it ensured that the elements of the waste management system — along with their benefits and burdens — would be shared.

In its draft mission plan, the DOE's Office of Civilian Radioactive Waste Management (OCRWM) proposed a centralized storage facility to provide backup storage to utilities who needed it (DOE 1984). A year later, the DOE foresaw a much expanded role for the MRS facility. It would function as a pass-through facility located in the East near the majority of the reactors, where eastern spent fuel could be collected and prepared for disposal at a yet-to-be-determined repository site. The DOE identified one preferred site (at Oak Ridge on the Clinch River) and two alternative sites for the MRS facility — all in the state of Tennessee (DOE 1985). The plan proposed that the facility begin operating in 1998 and provided for the storage of 15,000 metric tons of spent fuel. This capacity limit was intended to allay concerns that the storage facility would become a de facto disposal site. In 1987 the DOE finally submitted its MRS proposal to Congress. But by then, Tennessee state opposition to a centralized storage facility was so great that Congress annulled and revoked the Clinch River MRS facility proposal in the 1987 amendments to the NWPA.

The 1987 amendments to the NWPA

In 1987, Congress made a number of additions and changes to the NWPA. For example, the DOE was given the authority to site, construct, and operate one MRS facility, subject to two more constraints: (1) A *timing linkage* provided that a particular location for a centralized storage facility could not be selected until the Secretary of Energy recommended a repository site to the President, and construction of the storage facility could not begin until the DOE received a license to construct a repository. (2) A *capacity linkage* limited facility storage to no more than 10,000 metric tons of spent fuel until a repository began accepting waste. Once that happened, up to 15,000 metric tons could be stored at the facility. Those two linkages reduced the risk that an MRS facility could become a de facto disposal site and reinforced the goal of timely disposal in the national radioactive waste management policy. However, these linkages created a situation in which storage is permitted only when the need for it is reduced through successful repository development.

The 1987 amendments made other changes. A Monitored Retrievable Storage Review Commission was established to evaluate the need for a monitored retrievable storage facility as part of the nation's nuclear waste management system.[1] The 1987 amendments also set up the Office of the Nuclear Waste Negotiator to try to broker an agreement under which a state or Native American tribe would volunteer to host an MRS facility. Two negotiators engaged over the years in a large number of exchanges with interested parties, but neither was able to conclude a proposed agreement with a willing community by January 1995 when the office's authority expired. Finally and perhaps most important, the 1987 amendments limited the focus of the DOE's site-characterization work to the site at Yucca Mountain, Nevada.[2]

1 The commission's report, submitted to Congress in November 1989, recommended the development of two small storage facilities (2,000 metric tons to accommodate emergencies and a 5,000-metric-ton, user-funded facility). The report recommended that Congress revisit the issue in the year 2000. The MRS Commission did not consider the potential effects of developing an MRS on the site-characterization and repository development program (MRS Review Commission 1989).

2 The 1982 NWPA originally established a schedule for siting, constructing, and operating *two* repositories for the permanent disposal of spent nuclear fuel. Sites for the first repository were located primarily in the West, sites for the second, primarily in the East. Under the act, the DOE was to nominate at least five sites and characterize three of those to determine their suitability for repository development. In February 1983, the DOE identified a number of sites for potential repository development in the West, including sites at Yucca Mountain, Nevada; in Deaf Smith County, Texas; and at Hanford, Washington.

Recent program progress

Since 1987, the DOE's civilian radioactive waste management program has progressed more slowly than expected. However, the Board is quite encouraged by recent progress and believes that the DOE program has reached a pivotal phase. Significant progress in excavating the underground exploratory facility is being made. The tunnel-boring machine reached the level of the proposed repository in November 1995, and important underground data about the suitability of the site are now being acquired. Progress also is being made on repository design and on the engineered barrier system. The DOE finally is developing a waste isolation strategy, which, in combination with recent advances in performance assessment, should permit a better delineation of priorities and a more efficient allocation of funds among program activities. However, fiscal year 1996 funding for the program was cut severely — from $520 million to $400 million, $85 million of which was set aside for future development of a federal spent fuel storage facility. In addition, legislation has been introduced in Congress that could change the focus of the program from disposal to storage at the Yucca Mountain site. (See Note 3.)

Note 3:
Current legislative efforts

Activities in the 104th Congress foreshadow a possible major change of focus in the DOE's civilian radioactive waste management program that could include siting and constructing a federal storage facility at the Nevada Test Site near Yucca Mountain *well before* the NRC has granted a license to construct a permanent repository. (The NWPA, as written, prohibits construction of a federal storage facility until repository construction has been authorized.)

House and Senate bills, for instance, direct the DOE to build a storage facility for spent fuel; authorize the development of a transportation system, including truck and rail transport; identify transportation routes in Nevada; and support continued site-characterization studies at the Yucca Mountain site. (The NWPA, as written, prohibits siting a storage facility in a state with a potential repository site.)

In addition, in anticipation of authorizing legislation, the fiscal year 1996 Energy and Water Appropriations Act (which funds the OCRWM) set aside $85 million of the program's $400 million budget for future development of a federal interim storage facility. The conference report does emphasize the importance of continuing the existing scientific work to determine the ultimate feasibility and licensability of a permanent repository at the Yucca Mountain site. The report also directs the DOE to structure its program to focus on completion of the core scientific and technical site-characterization activities at Yucca Mountain.

It remains unclear at this time, however, what the final results of these legislative initiatives will be.

Key thoughts on past initiatives to develop centralized storage facilities

(1) *The few attempts to site a federal centralized spent fuel storage facility during the past two decades all have failed.*

(2) *Whenever there was a choice between storage and disposal, timely disposal has been retained as the primary focus of the federal high-level waste management program*.

(3) *Proposals to develop centralized storage usually raise the concern that a storage facility could become a de facto disposal site. A viable disposal program may be a key ingredient in any successful storage initiative.*

(4) *To help allay those concerns, legislative linkages between storage and repository development were devised. Some of these linkages address concerns that remain today*.

Chapter 2: Current Storage Policy and Utility Concerns

Commercial spent fuel is stored primarily at the reactor sites where it is produced. Once a repository begins operating, plans are for the fuel to be shipped to the repository site for disposal. However, the utilities and public service commissions are becoming increasingly concerned about delays in the repository program. Their recent legislative and legal efforts to focus the program on storage have raised questions about the goal of the civilian radioactive waste management program. As in the past, these legislative efforts are not without controversy. The following sections explore some of the reasoning behind utility concerns and lay out the controversy.

The nation's spent fuel inventory

By the end of 1995, approximately 32,000 metric tons of spent fuel had been generated by commercial nuclear reactors located at 70 sites nationwide. (See Figure 1.) Unless a significant number of reactors shut down early, spent fuel will continue to be produced at a rate of roughly 2,000 metric tons per year through the year 2010. If there are not a significant number of reactor license

Figure 1: Location of 119 commercial reactors (includes 110 operating reactors, 9 shutdown reactors)

Source: NRC. Information Digest: *1993, 1994, and 1995, plus personal communications with NRC staff. In December 1995, the newest reactor, at Watts Bar, Tennessee, went on-line.*

extensions, the rate of spent fuel production will slowly decline thereafter until the last of the presently operating reactors reaches the end of its scheduled 40-year lifetime sometime in the 2030s. By that time, the amount of commercial spent nuclear fuel will total approximately 85,000 metric tons (DOE 1994). The practice at all commercial reactors is to store the newly discharged spent fuel in pools on site for at least five years to allow for initial cooling. However, the total pool storage capacity nationwide is only about 60,000 metric tons. This means that, if a repository does not become available, storage capacity of approximately 25,000 metric tons *in addition to pool storage* will have to be provided somewhere over the next 35 years to accommodate commercial spent fuel.

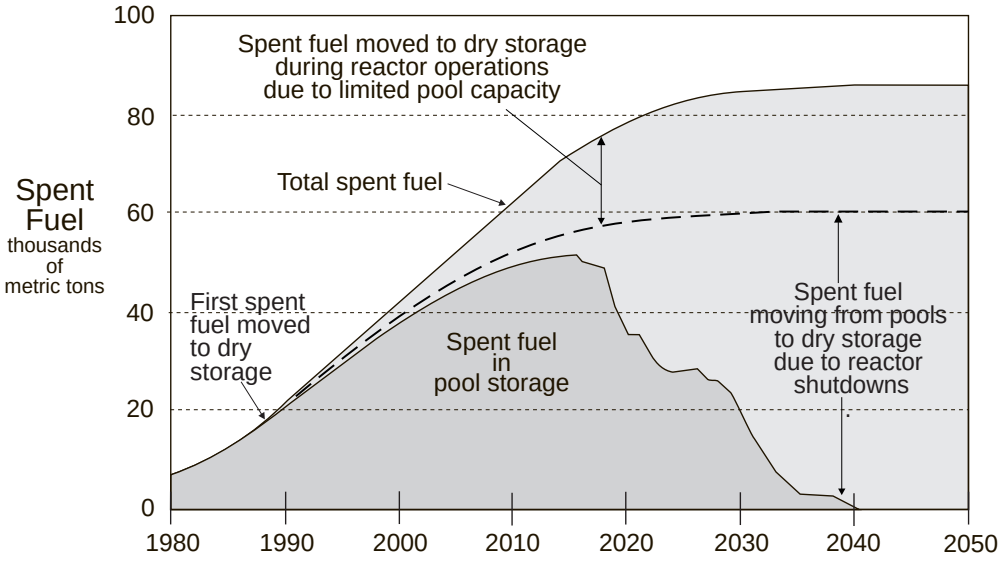
But aggregate numbers do not tell the whole story. Because spent fuel pool sizes vary considerably, different utilities have different storage needs. At some reactors, the pools are relatively small. Many of the older reactors were built assuming that spent fuel would require only short-term storage before movement to a reprocessing facility. In many of the newer reactors, pools are large enough to store all of the spent fuel that will be produced during the typical 40-year licensed operating period. Once a reactor's pool begins to fill up, additional storage capacity — in the form of dry storage — is typically developed on site. This has happened at seven reactor sites so far.

After a reactor shuts down for whatever reason, managers have two options. They can keep the pools operating, or, if they anticipate at-reactor storage for more than a few years, they can more economically move all of the spent fuel into dry storage. So far, utilities owning three shutdown reactors have opted for dry storage: Rancho Seco, California; Trojan, Oregon; and Fort St. Vrain, Colorado.

If current trends continue, increasing amounts of spent fuel will move from pool to dry storage.[3] The amount of spent fuel that actually ends up in dry storage *at reactors* will depend on when a repository begins to operate and if and when a centralized storage facility is built. Should the opening of a repository be delayed significantly and a centralized facility not be constructed, all the spent fuel generated eventually would move from pool to dry storage at reactor sites probably along the path shown by the light shading in Figure 2. If a repository does not begin operating until 2015, a significant number of utilities will have to procure some dry-storage capacity for their nuclear power plants.

3 Dry-storage systems can be purchased from commercial vendors. The Nuclear Regulatory Commission (NRC) has promulgated a generic rule to facilitate the licensing of at-reactor dry-storage facilities (10 CFR 72).

Figure 2:
Movement of spent fuel from pools to dry storage under a no-repository scenario



Note: The figure showing spent fuel in pool storage assumes the movement of all spent fuel from pools to dry storage approximately five years after plant shutdown. Assumptions include: 40-year operating licenses with no renewals and no new plant orders; all spent fuel remains at reactors.

Source: Adapted from DOE, Spent Fuel Storage Requirements: 1992–2036*, Dec. 1993 and DOE,* Spent Fuel Storage Requirements: 1993–2040*, Sept. 1994.*

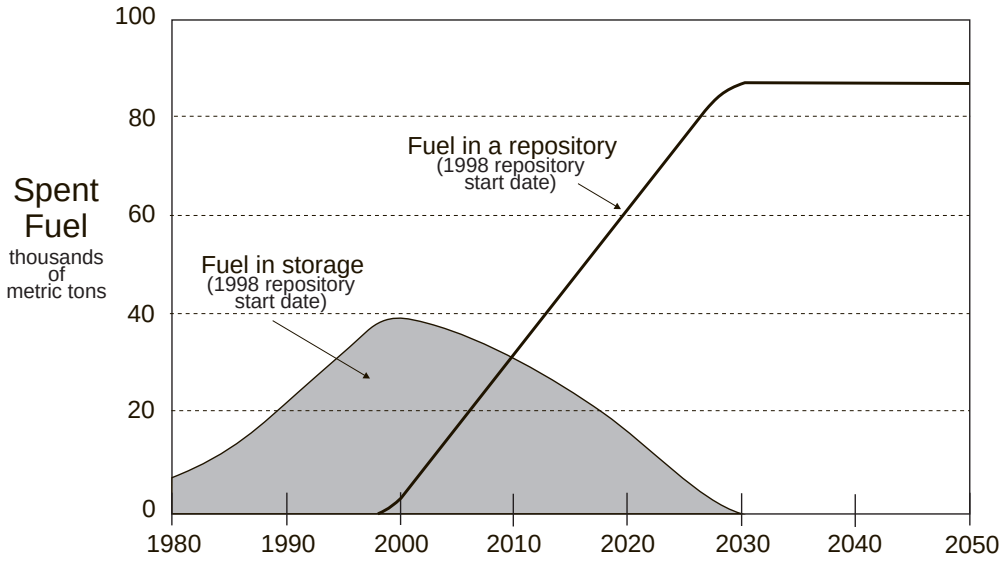
By the year 2000 alone, 25 plants are estimated to require additional spent fuel storage capacity (DOE 1993). Beginning in 2015, much of the fuel moving into dry storage probably will be at shutdown reactors. (See Figure 2.)

Planning for storage

As Figure 3 shows, in the early 1980s when repository operation was expected to begin in 1998, a maximum of about 40,000 metric tons of spent fuel were projected to require storage. Moreover, assuming the DOE's planning number of 3,000 metric tons shipped per year, all of the backlog could have been disposed of by the mid-2020s. On the other hand, if repository operations do not begin until sometime between 2015 and 2020,[4] nearly 80,000 metric tons of spent fuel will require storage. The spent fuel would not be disposed of completely until approximately 2050. As Figure 4 illustrates, each decade of delay

4 The Secretary of Energy projected in testimony submitted to the U.S. Senate that repository operations probably would not begin before 2015 (DOE 1995c).

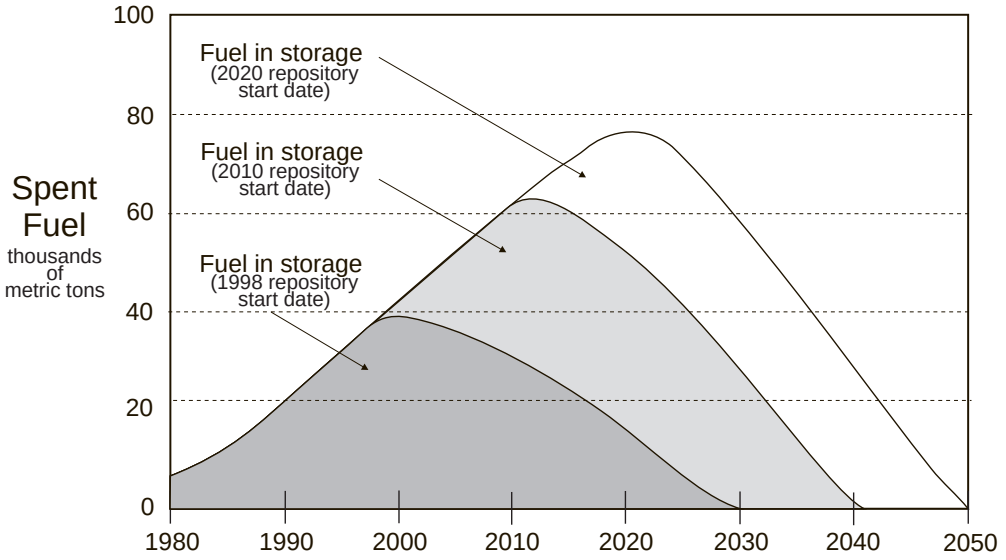
Figure 3:
Storage expectations in early 1980s when the repository start date was 1998



Note: Disposal curve based on 3,000 metric tons/year acceptance rate in a repository after a five-year ramp up. Curves assume 40-year operating licenses with no renewals and no new plant orders.

Source: Storage curves adapted from DOE, Spent Fuel Storage Requirements*:* 1993–2040, *Sept. 1994.*

Figure 4:
Repository delays increase storage needs by about 20,000 metric tons each decade



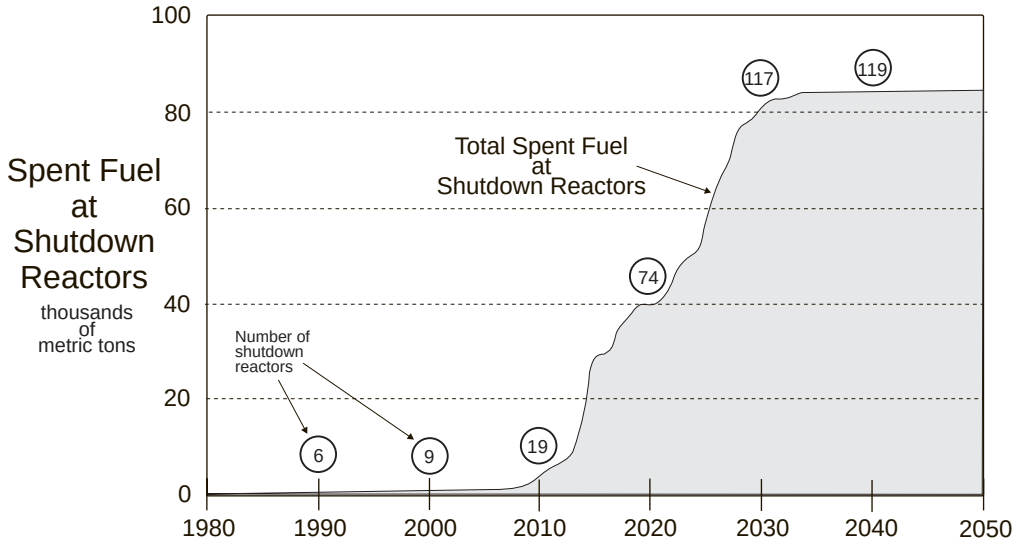
Note: Assumes 3,000 metric tons/year acceptance rate in a repository after a five-year ramp up. Curves assume 40-year operating licenses with no renewals and no new plant orders. Recent DOE estimates put repository start date at around 2015.

Source: Storage curves adapted from DOE, Spent Fuel Storage Requirements: 1993–2040, *Sept. 1994.*

in repository operation adds roughly 20,000 metric tons to the spent nuclear fuel storage inventory.

Matters are complicated further by the fact that an increasing number of reactors operating today will begin shutting down around 2010. Assuming no license extensions, all reactors are scheduled to shut down by the mid-2030s. Unless spent fuel starts moving from shutdown reactors at the rate of about 3,000 metric tons per year for 30 years beginning around 2010, it will be very difficult to avoid a significant accumulation of spent fuel at shutdown nuclear power plants. (See Figure 5.) Because the nation has had little experience storing spent nuclear fuel at shutdown reactors, the prospect raises some uncertainties. (See the section on future uncertainties beginning on page 24.)

Figure 5:
Projected amounts of spent fuel at shutdown reactors under an *indefinitely delayed repository scenario*



Note: Unless spent fuel is moved from shutdown reactors at the rate of 3,000 metric tons/year beginning in 2010, it will be very difficult to avoid significant accumulations of spent fuel at shutdown reactors. Shutdown projections are based on several assumptions, including expiration of 40-year operating licenses with no license renewals and no new plant orders.

Source: Adapted from DOE, Spent Fuel Storage Requirements: 1992–2036*. Dec. 1993.*

Utility concerns about spent fuel

There are a number of reasons why the nuclear utilities and public utility commissions are working to change the policy of at-reactor storage. The major reasons discussed in the following sections center on the implications of continuing delays in repository development and resulting delays in federal acceptance. Once expecting to begin turning their spent fuel over to the federal government beginning in 1998, utilities and public utility commissions are now concerned and upset that they may have to provide *and pay for* the storage of much more spent fuel for much longer time periods than originally anticipated. Recent projections put the capital cost of developing additional at-reactor interim storage at $20 to $30 million per plant (OTA 1993). In addition, according to preliminary utility calculations, the costs of maintaining dry storage could be somewhere in the neighborhood of $2 million per year per site (NES 1994). But utilities have other concerns as well.

Increasing public opposition to at-reactor storage

Although developing dry storage at reactors generally has proceeded smoothly, installing dry-storage systems has produced public opposition at several locations recently. At least some of this opposition has been caused by concern that development of a repository for permanent disposal is not proceeding fast enough. Consequently, people fear that a temporary storage site could become a de facto disposal site. For example, in Michigan in 1993, the attorney general and an environmental group challenged the validity of the Nuclear Regulatory Commission's (NRC) generic licensing rule when Consumers Power Co., sought to use dry-storage casks at its Palisades reactor. Although litigated for several years, the suit was unsuccessful.[5] In Minnesota in 1994, the Minnesota state legislature imposed several conditions for dry-storage development on Northern States Power, Co., including that some storage capacity had to be secured elsewhere.[6] Although, every attempt to develop at-reactor dry storage has succeeded so far, utilities are concerned about opponents' political, economic, regulatory, or legal challenges to on-site storage.

5 In January 1994, a U.S. Court of Appeals unanimously upheld the NRC generic rule. The Supreme Court subsequently refused to hear the case (*Kelley v. Selin* 1995).

6 See Newman 1994.

Prospects for decommissioning reactor sites

In addition to concerns about the costs of developing and maintaining large amounts of storage at their reactor sites, nuclear utilities and public utility commissions are beginning to think about other long-term planning and cost uncertainties, for instance, those associated with decommissioning shutdown reactors (OTA 1993). When a reactor shuts down, its owners theoretically have three options: prompt and complete dismantlement; delayed dismantlement (sometimes called SAFSTOR); and entombment, probably in concrete. In reality, however, dismantlement of the entire facility is not really possible because there is no place to ship spent nuclear fuel. To realistically broaden utility decommissioning choices, a repository (or centralized storage facility) and accompanying transportation infrastructure would have to begin full-scale operation sometime around 2010.[7]

Management of the Nuclear Waste Fund

The utilities also are concerned about how the Nuclear Waste Fund is being managed. The 1982 NWPA stipulates that the generators of spent fuel pay for its storage and disposal.[8] In addition, the NWPA authorized the DOE to enter into contracts with the owners of nuclear reactors. Based on the amount of nuclear electricity they generate, nuclear utilities pay a fee (1 mill per kilowatt hour) into the Nuclear Waste Fund to cover the costs of disposal. With the permission of their state public utility commissions, the utilities pass the fee on to their ratepayers. The DOE is to use the fund to develop a repository and transport the spent fuel to the disposal site.[9]

Through 1995, the nuclear utilities contributed approximately $9 billion (plus interest) into the Nuclear Waste Fund, but only half of this sum has been appropriated by Congress for development of the waste management system. This fact has led to the perception that utility fees are being used, at least in part, to

7 By 2010, 19 reactors already will have shut down. By 2020, 74 reactors will have shut down. Spent fuel remains in cooling pools for at least five years after removal from the reactor core.

8 On-site storage of commercial spent fuel and any privately negotiated off-site storage are to be paid for directly by utilities.

9 Except for the 1,900-metric-ton backup facility, past proposals to develop federal centralized storage have assumed that the Nuclear Waste Fund was adequate to cover the costs for disposal and storage. The adequacy of the fee is supposed to be evaluated periodically and, if necessary, adjusted (with the consent of Congress). (The federal government must pay for disposing of the high-level waste created by national defense activities.)

finance the federal deficit. There even have been calls among utilities to withhold payments into the fund and cease participation in the program.[10]

Fulfillment of agreements with the DOE

At the moment, utility efforts to address their concerns about at-reactor storage are focused primarily on congressional action on the proposed legislation outlined in Note 3 and on achieving the *fulfillment of the federal government's agreement* to begin accepting spent fuel from reactor sites by 1998. The nuclear utilities are taking the position that they have unconditional contracts that require the DOE to begin accepting their spent fuel in 1998. Agencies from 29 states, 8 municipal utilities, and 25 investor-owned utilities have sued the federal government to obtain a judgment on the nature of the DOE's contractual obligation. Oral arguments were heard in January 1996, and a decision is expected soon.

Why is there a spent fuel storage controversy?

During discussions about what to do with commercial spent fuel, an array of perspectives are brought to the discussion table. For the utilities and public utility commissions, the policy of long-term at-reactor storage of commercial spent fuel is not acceptable. These stakeholders wish to change the status quo by having the federal government develop a centralized storage facility and begin accepting spent fuel as soon as possible. Long-term cost and planning issues compounded by recent public opposition to developing additional storage and further slippages in the repository schedule have moved the nuclear energy industry and public utility commissions to take their complaints to Congress, and the federal government to court.

Some stakeholders, however, do not believe that developing a centralized storage facility now is the right approach. For many reasons (e.g., the desire to keep DOE's program focus on disposal, fear of creating a de facto disposal site), these stakeholders believe that the nation should continue to emphasize determining the suitability of the site at Yucca Mountain, Nevada, and on developing a permanent repository for spent fuel and high-level waste. If a decision were made to develop a centralized storage facility now, other issues

10 The National Association of Regulatory Utility Commissioners (NARUC) is "encouraging states to investigate alternatives to paying into the...Nuclear Waste Fund." This was proposed in a November 17, 1995, resolution "in response to Congress's continued use of NWF monies to offset the deficit" (*Nuclear Waste News* 1995).

could take on increased importance, for example, community opposition at proposed storage sites, perceived transportation risks, concern about geographic equity, and concern that storage could make reprocessing spent fuel more possible. Some of these concerns, because they are strongly felt, may make such a decision difficult to implement. Finally, the question of who should pay the costs of storage is part of the debate. Much of the remainder of this report addresses the concerns of these stakeholders, illustrating the breadth of the controversy and the complexity of the issues.

Finally, it must be noted that there are those who do not support the continued use of nuclear power. Some may use continuing delays in repository development to enhance their arguments against the continued operation of existing power plants, not to mention the construction of new ones.

Key thoughts about current storage policy

(1) *The controversy over storage has intensified during recent years due to slippages in the repository development schedule, the consequent accumulation of spent fuel at reactor sites, and the disagreement among key stakeholders about the advantages of centralized versus at-reactor storage.*

(2) *It is no longer realistic to consider the storage of commercial spent nuclear fuel to be short term; significant amounts of spent fuel will remain in storage somewhere for several decades.*

(3) *Nine shutdown reactors are storing spent fuel, but without a centralized storage facility, the number of shutdown reactors with spent fuel in storage would increase markedly beginning around 2010.*

(4) *Recently there has been substantial public opposition at some reactor sites where utilities have added on-site storage capacity.*

(5) *Because of the costs and planning required to store large amounts of spent fuel at reactor sites for long time periods, the utilities and public utility commissions have taken their case to Congress and to court. They are asking that the federal government fulfill its agreement with the utilities and begin accepting spent fuel from the utilities in 1998. Some of the legislation before Congress would require the DOE to develop a centralized storage facility by 1998.*

Chapter 3: Technical Considerations Regarding Storage

As indicated in previous sections of this report, debates about the storage of commercial spent fuel reflect the complexity of the issues, the diversity of perspectives, and the strongly held views of different stakeholders. In the following sections, the report focuses primarily on technical considerations relating to a choice between at-reactor or centralized storage. Of major importance here are health, safety, and environmental risks, overall system costs, and the potential effects of centralized storage on the overall waste management system. Some of the institutional or policy implications associated with these considerations also are discussed.

Health and safety risks and environmental effects

Human health and safety risks include those risks associated with the operation of storage facilities, whether they are at reactor sites or at a centralized facility. They also include risks associated with transportation operations. Potential environmental effects primarily include those on air and water quality as well as on land use. The following discussion reviews whether the potential effects in these areas influence a choice of at-reactor or centralized storage of spent nuclear fuel.

Health and safety risks associated with spent fuel storage

During the last ten years, several studies have concluded that storing spent nuclear fuel in pools or in dry storage presents low risks to workers and even lower risks to the general public.[11] Pool storage (required for at least five years after removal of spent fuel from the reactor) involves more monitoring and management than dry storage.[12] Projected radiation exposures to workers and the public resulting from pool or dry-storage activities would equal only a small fraction of exposures due to background radiation. Essentially the same dry-storage technologies would be used to store spent fuel whether at reactor sites or at a centralized facility. And the NRC found in its 1990 *Waste Confidence Decision Review* that spent nuclear fuel could be stored safely for as much as 100 years (NRC 1990). The same basic NRC requirements would have to be met regardless of storage facility location.

11 See, for example, *Nuclear Waste: Is There A Need For Federal Interim Storage?* (MRS Review Commission 1989). Also, *System Architecture Study* (TRW 1994).

12 Former NRC Chairman Ivan Selin stated that both pool and dry storage are “abundantly safe” methods. Recently, however, some concern has arisen about the long-term safety of spent fuel stored in pools (Bizjak 1995, Kerber 1995).

Environmental effects

Most of the potential environmental effects of a spent fuel storage facility would be on air and water quality, on the local environment, and on land use. Based on NRC and DOE analyses, the impact of any storage approach — no matter what the location — on air and water quality appears to be small (NRC 1979, DOE 1987). Even if a storage facility were built at a previously untouched location, effects on the local natural vegetation and animal habitats appear to be minor. (Construction of a full-scale centralized facility would require less than 500 acres of land.) Finally, any centralized facility that might be developed would most likely be sited in a relatively sparsely populated area or at an existing DOE nuclear site. At neither type of location would there arise significant competition for land use by other development activities.

Transportation risks

If centralized storage were developed, spent fuel would have to be shipped from reactor sites to the facility and eventually to a repository. The DOE projects that approximately 3,000 metric tons of spent fuel per year for about 30 years would be shipped, mostly by train, but partly by truck. Between 50 and 100 train shipments and dozens of truck shipments would be required annually. Although the amount in metric tons that would have to be carried is very large compared to historical volumes, the nation has more than three decades of experience transporting both civilian and DOE-owned spent fuel. In 1977, 471 shipments were made, 444 of which were by truck (OTA 1986). In the 1980s, 100 to 200 such shipments were typically made each year.[13]

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 deci-

13 Between 1983 and 1987, more than 200 highway shipments of fuel originated from West Valley, New York, alone, to return fuel to several originating plants (Battelle 1988).

sions. 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. Issues related to public perception of transportation risk are discussed on page 34 of this report.

Sabotage and security

One consideration related to safety is that of security. Requirements for minimizing the likelihood of theft or sabotage of nuclear materials, referred to as "safeguards," are set by the NRC (10 CFR 73). Based on its experience and analysis, the NRC has concluded that the physical security of either on-site or off-site spent fuel storage is not a significant problem.[14] The NRC reached a similar conclusion about transportation safeguards risks (NRC 1979).

However, several recent events have raised some concerns about the safeguards question. In February 1992, an unarmed driver intruded into the Three Mile Island (TMI) nuclear plant;[15] shortly thereafter terrorists bombed the World Trade Center. Since then, a federal building in Oklahoma City was bombed and a passenger train derailed in Arizona. Intuitively, it would seem easier and more economical to install an effective protective system at one centralized facility than installing multiple systems at reactor sites.[16] But it also could be argued that a single facility with a large stockpile of spent fuel might be a more tempting and visible target. Until more analyses have been performed, it is premature to assert that either an at-reactor or centralized storage facility would be more exposed to theft or sabotage.

In summary, the various kinds of health, safety, and environmental risks associated with at-reactor and centralized storage of spent fuel are all very low. Thus, differences in risk between at-reactor and centralized storage are not great enough to provide a decided advantage to either storage option.

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14 These general conclusions were repeated in briefings by Robert Bernero, former director of the Office of Nuclear Material Safety and Safeguards, before the Board on January 5, 1993, and November 1, 1993 (NWTRB 1993a, 1993b).

15 In 1994 in response to the incident at TMI, the NRC issued new rules for power plant security to guard against vehicle-carried bombs (NRC 1994).

16 The potential advantage of having all of the spent fuel at one location would only apply once the spent fuel actually is at one location. Because approximately 2,000 metric tons of spent fuel are accumulating each year, at the transportation rate of 3,000 metric tons per year, it could take more than 30 years to move current accumulations and newly generated spent fuel to a centralized site.

Total system costs — waste fund adequacy

Several studies have been undertaken to estimate the total system costs (federal and utility) for managing commercial spent fuel. Costs projected include the total amounts expended on spent fuel storage (at-reactor versus centralized storage), spent fuel transportation, site characterization and licensing of a repository design, and repository construction, operation, and closure. Recent studies (DOE 1995a, Peterson 1995) indicate that storage costs are typically about 15 to 20 percent of overall waste management system costs of $30 to $35 billion (1994 dollars). Some studies conclude that at-reactor storage is less expensive than centralized storage (e.g., MRS 1989); other studies indicate the reverse is true (e.g., TRW 1994). The explanation for these different conclusions no doubt lies in the choice of methodology, the modeling, and the empirical assumptions used.

When a reactor shuts down, managers have two options. They can keep the pools operating, or, if they anticipate at-reactor storage for more than a few years, they can more economically move all of the spent fuel into dry storage. Indications are that there may be some cost advantages associated with long-term centralized storage once reactors begin shutting down in large numbers, in large part, because of the high cost of operating pools.[17] However, as long as reactors are operating, the costs of centralized and at-reactor storage appear to be comparable.

In a discussion of costs, however, the Board believes a more important question is whether the Nuclear Waste Fund is adequate to pay the costs of disposal as well as previously unanticipated long-term storage. In the past, the DOE concluded that the fund was adequate to pay the costs of both. In 1990, however, the DOE reported that the amount of money that might be collected in the fund and the interest earned on money not yet spent would be roughly equal to the total projected waste management costs (DOE 1990a, 1990b). In its recently published 1995 total life cycle cost study, the OCRWM's management and operating contractor is now estimating total system costs to total $33.1 billion (1994 dollars), not including centralized storage (DOE 1995a). Although the DOE has not yet made a formal determination of the fund's adequacy, in a presentation before this Board, analysts who conducted an independent financial and management review of the Yucca Mountain project suggested that the Nuclear Waste Fund as currently projected would be *deficient* by $3 to $5 billion (Peterson 1995).

17 For more, see presentation by Eileen Supko at the Nuclear Waste Issues Forum, sponsored by the National Association of Regulatory Utility Commissioners on May 25, 1995, Washington, D.C., and NES 1994.

Uncertainties about the fund's adequacy could increase as a result of at least two additional circumstances. (1) If some nuclear power plants shut down earlier than now anticipated, the fund would collect less money. (2) If Congress decided to develop and operate a large centralized storage facility now and pay for it out of the Nuclear Waste Fund, the fund will be used up sooner. Should the fund prove inadequate to pay for both storage and disposal, either the utilities and their ratepayers would have to contribute more into the fund,[18] or federal taxpayers would have to absorb the costs of final disposal of commercial spent fuel. As illustrated in Note 4, views on how storage should be paid for differ. Adequacy of a different kind relates to the potential competition for resources between developing centralized storage and the goal of disposal. This issue is discussed later on page 26.

Waste management system operations

Considerations of a different sort pertain to how developing and operating a centralized storage facility could affect the efficiency of the waste management system, including storage, handling, transportation, and disposal.

Repository operation and long-term repository performance

The Board believes that having a centralized storage facility available could enhance opportunities to tailor spent fuel going into a repository, thus increasing the options for improving repository performance. For example, if it is shown that maintaining a specific thermal output of the spent fuel is desirable to achieve a particular repository system performance, a centralized storage facility could function as a holding site for spent fuel for the significant periods of time (several decades or more) required for the fuel to age and cool. Precisely how long the fuel might need to be aged depends on the final repository design, which is still emerging. Ageing, in and of itself, would not tilt the choice toward centralized storage since ageing can be done at the reactor sites just as easily. However, few data exist as yet about the possible effects of very long term storage on the integrity of the fuel or its canisters, so if long-term ageing — on the order of 50 years or more — is contemplated, a centralized facility may provide for a safer and more efficient way to monitor storage containers and transfer fuel.

18 If storage costs were paid from the fund, as financed, an increase in the 1-mill-per-kwh fee would probably be required to handle both storage and disposal. If no adjustments were made, those utilities who continue to operate nuclear power plants would have to pay the increased fee while those utilities with shutdown plants would not.

Note 4:
Who should pay?

One issue related to storing commercial spent nuclear fuel that always brings debate is who should pay for storage. There are several views on this issue.

National policy

The Nuclear Waste Policy Act, as amended, makes it clear that generators of nuclear electricity should pay for the storage *and* disposal of the spent fuel they produce. Nuclear utilities now pay 1 mill per kilowatt-hour into the Nuclear Waste Fund and pass this fee on to their ratepayers.

One view

The nuclear utilities often argue that disposal was to begin in 1998 and they are responsible for storing their spent fuel only until that time. They believe their contracts with the DOE obligate the federal government to begin accepting spent fuel in 1998 even without an available federal facility. They argue that since they already have paid $9 billion into the Nuclear Waste Fund for the management of their spent fuel, it is the federal government's responsibility to begin managing it in 1998 whether or not there is a facility available for disposal. They further maintain that the federal government should pay any additional costs to accomplish this.

Some alternative views

During the 1980s, DOE analyses indicated that the fund was sufficient to pay for both centralized storage and disposal. Recently, however, questions have arisen about the adequacy of the fund to pay for disposal, not to mention disposal *and* unanticipated long-term centralized storage. If this is indeed the case, some have suggested that fees going into the Nuclear Waste Fund be increased; others suggest that the fund be reserved for disposal and that any storage costs be paid for by *separate* fees charged to the storage facility users.

A centralized storage facility also could facilitate the possible need to prepare the spent fuel assemblies for disposal (e.g., the addition of filler material to the waste packages) or to "mix and match" the spent fuel and defense wastes for emplacement in the repository. Exactly what this matching requirement might be and what it implies in terms of managing the spent fuel inventory depends on yet-to-be-decided repository design requirements. Although such a potential requirement in and of itself would not tilt the choice toward a centralized facility, a centralized facility at an operating repository would provide a more efficient approach to tailoring spent fuel prior to emplacement.

A centralized storage facility located at the repository also could provide added flexibility to system operations. Storage capacity could accommodate slowdowns in waste emplacement in a repository, for example, or other unanticipated disposal problems. If the fuel is retrieved from the repository at some

time, a storage facility would be necessary.[19] A storage facility located at a repository site would maximize system flexibility and minimize transportation costs and perceived risks.

Transportation and handling

Logistics can influence the efficiency of any system involving the movement of material. In a radioactive waste management system, one should strive to minimize the number of times spent fuel is handled. Ideally, leaving it at its source until shipment for disposal would be the most efficient approach to spent fuel management. An approach that is less efficient (but perhaps more realistic, in light of existing uncertainties about repository design and operation) would involve transporting the fuel from its source to a storage location, unloading the fuel for storage, and later repackaging and reloading it and shipping it to a repository for disposal. Under this scenario, the most efficient location for a potential centralized storage facility would be at a repository site so the fuel would only have to be shipped long distances once.

Coping with future uncertainties

In the course of the Board's evaluation, several questions emerged that cannot be answered today. However, depending on their outcome, these issues have the potential of significantly affecting the waste management system in the future. These issues are discussed briefly below.

The repository development schedule

Although geologic disposal of spent fuel and high-level waste enjoys broad support from the scientific community in this country and abroad, a site has not yet been judged suitable for a repository nor has a repository design received final regulatory approval in any nation developing a radioactive waste management program. So, as with all similar programs, the DOE's activities at Yucca Mountain are, in a sense, "first of a kind." Experience from attempts to site other critical facilities suggests that any long-term strategy and schedule should take the likelihood of surprises into account (NWTRB 1995a). Unanticipated technical questions could crop up during licensing, and it could take some time to resolve them in a scientifically and technically credible fashion. Further-

19 Current repository designs call for retrievability to be possible for as much as 100 years.

more, delays could arise due to institutional and regulatory processes that must be completed before a repository begins operation. Therefore, the repository start date cannot be set with precision, and the exact amount and duration of spent fuel storage that will be needed remains uncertain. A centralized storage facility would provide a way to accommodate such delays.

Other future uncertainties

Other potential uncertainties also should be considered during a discussion of spent fuel storage. One uncertainty pertains to the long-term storage of spent nuclear fuel. Few data on the very long term effects of storing spent fuel in dry casks have been gathered so far. During the next decade, more information will be gained about what it takes and what it costs to store and monitor spent nuclear fuel in dry storage. Over time, as-yet-unanticipated technical issues could provide more insight into the dry storage of spent fuel.

Current trends toward open markets and increased competition in the electric power industry also raise questions about at-reactor storage of spent fuel. One of the major uncertainties involves the fate of so called stranded costs that have yet to be paid for by the ratepayers. These costs could make nuclear electricity more expensive and less competitive. About $70 billion of stranded costs are tied up in nuclear plants.[20] Although nuclear plants likely will not be shut down prematurely because of high stranded costs, questions do arise about the quality of care that might be given to spent fuel stored at plants with high stranded costs or being operated by financially troubled utilities.

Two recent reports highlight the kind of dilemmas that some utilities may be facing. Because of the costs involved, officials at shutdown Rancho Seco Nuclear Power Plant are weighing whether to fix a leak in their cooling pool or to begin moving spent fuel into dry storage as soon as possible (Bizjak 1995). In New England, two utilities were accused of cutting corners on safety as a result of cost control efforts (Kerber 1996). Having a centralized storage facility available to utilities with operational problems would reduce potential concerns about the maintenance and care of spent fuel at those facilities.

Finally, although there seem to be few incentives today for utilities to seek license extensions for their reactors, being able to move spent fuel to a centralized facility (either storage or disposal) could make license extensions easier to pursue.

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20 For more, see Moodys 1995 and Byrd 1995.

To summarize, having a centralized storage facility available offers some technical advantages for repository performance and for waste system operations in general. Benefits increase if a centralized storage facility is located at an operating repository. The major benefits, however, will not be realized until later. Some advantages, such as the need for fuel ageing, cannot be assessed until more becomes known about the design of the repository. Others, such as providing a buffer for repository operations, do not accrue until a repository is operating. Finally, the Board believes that future uncertainties and the likelihood that many reactors will be shutting down beginning in 2010 argue for having a fully operational centralized storage facility available — and capable of accepting around 3,000 metric tons of spent fuel per year — by at least 2010, ideally at a repository site.

Potential effects of storage on repository development

During its analysis of the technical implications of storage, the Board evaluated potential near-term effects of developing centralized storage on the DOE's current site-characterization and repository development efforts. The timing of storage initiatives emerges as a key factor.

Competition for funding and other resources

The costs for disposing of commercial spent fuel are paid from the Nuclear Waste Fund. But, because the disposal program must compete for funding against other energy programs both inside the DOE and before Congress, competition for funding has been and will continue to be intense. This already constrained financial situation could be squeezed even more severely by the possible diversion of funds from the disposal program to develop and operate a centralized storage facility. (This problem would be exacerbated if the facility is located at Yucca Mountain, which has no rail access.) The DOE has estimated that it will cost about $600 million to construct a centralized storage facility and approximately $250 million a year to operate it at full capacity, including transporting 2,000 metric tons of spent fuel to the facility annually.[21]

In keeping with long-standing policy, the OCRWM's principal focus over the last decade has been characterizing a site for potential repository development.

21 Testimony of Dr. Daniel Dreyfus, director, OCRWM, before the Congress (U.S. Congress 1995). Based on DOE projections, the Congressional Budget Office has estimated that the initial five-year cost of developing and operating a centralized storage facility would be approximately $1.2 billion (CBO 1995).

Headway has been made, especially during the last couple of years, in assembling a more focused and disciplined management team. Asking the OCRWM to develop and operate a centralized storage facility and the related transportation system would create major additional responsibilities. At the very least, management structures — both within the agency and within its contractor family — would have to be modified. Diverting limited funds and other resources now would slow the process of characterizing Yucca Mountain and could even jeopardize support for the disposal program. Deferring disposal ultimately increases the risk, and creates the perception, that any storage facility could become a de facto disposal site. Deferring disposal has additional implications for the fate of the nation's government-owned spent fuel and defense high-level waste. (See Note 5.)

Note 5:
Government-owned spent fuel and defense high-level waste also require disposal

The lack of a viable program for disposing of spent nuclear fuel would raise important questions not only about the ultimate fate of commercial spent nuclear fuel, but also about the fate of government-owned spent fuel as well as high-level defense wastes. The following are a few examples of materials eventually requiring permanent disposal in a deep geologic repository.

- At Savannah River, Hanford, and INEL, more than 8,000 metric tons (DOE 1991) of high-level waste from reprocessing materials irradiated for atomic energy defense purposes reside in tanks and bins in liquid or granular form. Before disposal, this material must be converted to appropriate solid forms (e.g., glass) and placed in suitable containers.

- At Hanford, there are more than 2,000 metric tons of spent fuel resulting from atomic energy defense activities. The fuel is currently in pool storage, but efforts are under way to move it to on-site dry storage (DOE 1995b).

- At INEL, there are approximately 10 metric tons of spent naval fuel in storage, and another 50 tons are scheduled to be shipped there over the next several decades.* This is highly enriched spent fuel that was used to power nuclear U.S. Navy warships. In October 1995, the state of Idaho and the DOE executed a formal agreement requiring the DOE to remove all spent fuel from Idaho by January 1, 2035, and providing for a penalty of $60,000 for each day the requirement is not met.

- At Savannah River, the DOE has begun accepting highly enriched spent fuel from foreign research reactors. Eventually approximately 20 metric tons will be accepted (DOE 1996). Prior to disposal, this material must be processed into appropriate solid forms and placed in suitable containers.

** Presentation by Don Conners at June 6, 1995 Board meeting* (NWTRB 1995b).

Prejudging the suitability of a potential repository site

Congress is now considering proposals to locate a centralized storage facility in the vicinity of Yucca Mountain. In the NWPA, Congress established a process to ensure that sound technical judgment plays the primary role in determining whether a particular site could be used to host a permanent repository. Furthermore, the act specifically prohibits the development of a federal centralized storage site in the same state where a site is being characterized for potential repository development. Deciding now to develop a storage facility at or near Yucca Mountain, *prior* to a decision about the suitability of that site for repository development, could undermine seriously the credibility of the process established by Congress. Institutional momentum to develop a repository there could increase by creating the perception that the suitability of the site has already been determined.

The decision to characterize only Yucca Mountain for potential repository development already is viewed by some as a political, rather than scientific, choice. A decision made now to develop storage at or near Yucca Mountain would only reinforce that perception. The Board believes that a premature decision to develop centralized storage at Yucca Mountain could raise additional questions about the credibility of the entire DOE waste management program. In the Board's view, this would be particularly unfortunate given the fact that the DOE is close to being able to determine the suitability of the site at Yucca Mountain based on sound technical and scientific analyses.

Determining the suitability of a potential repository site

Progress is being made by the DOE's site-characterization program at Yucca Mountain. The Board believes that the DOE is now obtaining some of the information needed to decide whether the site at Yucca Mountain is technically suitable for repository development. Simply put, the DOE must understand and be able to explain how a potential repository at Yucca Mountain would perform. To do this a number of activities will have to be completed. In December 1994, the Board outlined in a letter to the director of the OCRWM the activities it believed needed to be completed before a decision about the suitability of the site for repository development could be made. Those activities are summarized briefly in Note 6.

In the Board's judgment, if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years whether the Yucca Mountain site is suitable

Note 6:
Determining site suitability

In a December 6, 1994, letter to the director of the OCRWM, the Board outlined in some detail those activities it felt needed to be completed to be able to determine site suitability (NWTRB 1994). By suitable we mean that there is *a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation.* Setting detailed program priorities will remain an iterative process but key activities that need completing include the following.

- Continue development of a coherent waste isolation strategy
- Continue underground exploration north-south and east-west across the proposed repository area to access major geologic structures and rock types and to investigate hydrogeologic characteristics of the site vital to repository performance
- Predict the amount of water that could reach the repository, corrode the waste packages, and transport radionuclides to the environment
- Collect initial results from underground drift-scale heater experiments to better predict the movement of water in the rock surrounding the hot waste packages

Increasing the level of confidence in predictions of repository performance will require additional testing, analysis, and exploration after the site-suitability determination. Given the inherent difficulties associated with proving safe performance over many thousands of years, a site-suitability decision would not be an iron-clad guarantee that the site could be developed as a repository.

for repository development, that is, whether there is *a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation*.[22] Of course the program must continue to operate under strong management and with sufficient and consistent funding to be able to achieve this goal.

In addition to completing the technical activities outlined in Note 6, the DOE must be certain that any decision about the suitability of the Yucca Mountain site is technically sound and that the supporting data and technical judgments are fully open to scrutiny. To achieve these goals, the process for judging suit-

22 In the past the DOE has used various terms to define a provisional decision about Yucca Mountain, including *early site suitability*, and *technical site suitability*, which were based on 10 CFR 960 (General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories). These guidelines are tied to the EPA's 40 CFR 191, which is presently not applicable to Yucca Mountain, and the Nuclear Regulatory Commission's 10 CFR 60, which will be revised once the EPA issues a Yucca Mountain specific standard. More recently the DOE has phrased its provisional decision in the context of a *viability assessment.*

ability must (1) provide access to sufficient technical information about the site, (2) encourage input from interested and affected parties, and (3) provide a logical and understandable explanation for technical conclusions, including those based on expert judgment. In addition, the bases for judging site suitability should be established and available for review in advance of the decision.

Key thoughts about the technical aspects associated with storage

(1) *There are no compelling technical reasons for moving commercial spent fuel to a centralized storage facility at this time. Health, environmental, and safety risks, including those associated with transportation, are very low for both at-reactor and centralized storage and are not distinctive measures for choosing between at-reactor and centralized storage.*

(2) *A large centralized storage facility (with accompanying transportation infrastructure) offers some logistical and operational advantages for the waste management system. The advantages increase markedly if the facility is located at or near an operating repository.*

(3) *It makes sense to have a large centralized storage facility available by around 2010 when reactors begin to shut down in large numbers for two reasons: (a) There are uncertainties regarding the management of significant amounts of spent fuel stored at shutdown reactors for long time periods. (b) There may be some cost advantages associated with long-term centralized storage once reactors begin shutting down in large numbers*.

(4) *The long-term adequacy of the Nuclear Waste Fund to pay for spent fuel management has been questioned, especially in light of recent increased cost estimates for repository development and the possibility that storage could be paid for out of the Nuclear Waste Fund.*

(5) *Requiring the DOE to develop and operate a centralized storage facility now could adversely affect the progress and credibility of the nation's disposal efforts (a) because of the potential drain on limited funding and other resources from current site-characterization efforts at Yucca Mountain and (b) because developing a storage site at or near Yucca Mountain now risks prejudging the suitability of the site for repository development.*

(6) *The DOE has made considerable progress recently in characterizing the site at Yucca Mountain for repository development, developing a repository design, and improving assessments of repository system performance. If recent*

program progress continues at Yucca Mountain, the Board believes that a technically defensible decision about the site's suitability can be reached within five years, assuming continued strong program management and sufficient and consistent funding.

Chapter 4: Institutional Issues

In previous sections, the report addressed utility concerns about maintaining the current approach of at-reactor storage of commercial spent nuclear fuel until a repository begins operating. Then the report discussed technical considerations associated with at-reactor versus centralized storage. The Board concluded that there are no compelling technical reasons to move spent fuel from reactor sites at this time. However, the Board understands that other considerations — some of which are discussed in this chapter — may play a role in decisions about the storage of commercial spent nuclear fuel. Congress may decide, for example, that the federal government has an obligation to accept spent fuel from the utilities as soon as practical; the courts may decide that the federal government has a legal obligation to begin accepting spent fuel from the utilities in 1998.

Although utilities and public utility commissions strongly support the development of a federal centralized storage facility now, other stakeholders are not so enthusiastic. For example, some think that keeping spent fuel at reactors will keep the utilities and, thus, the federal government actively pursuing the repository development program. Some believe in intergenerational equity — the generation that produces the waste is responsible for its disposal. To the extent that storage might substitute for disposal, waste management burdens could be passed on to future generations. The following sections examine those issues that currently are of concern to stakeholders and those issues that could come to the forefront if the decision is made to develop some kind of centralized storage facility now. This section concludes with a table that lays out in simplified fashion the generic advantages of at-reactor and centralized storage (See Table 1, page 37).

Community acceptance

Opposition to spent fuel storage often reflects underlying concerns about a variety of issues and can be expected to some degree around any radioactive waste management facility. Opposition to storing spent nuclear fuel has occurred primarily at the local level in some communities where spent fuel is stored or where utilities are adding additional storage capacity. Concerns seem to reflect the belief that the sites might become de facto disposal sites or, in a few cases, they reflect unease about storing spent fuel at shutdown reactors.

Opposition at reactor sites

Recently there has been opposition at some operating reactor sites where utilities tried to add on-site dry-storage capacity. This happened at sites in Minnesota, Michigan, and Wisconsin. Many of the opponents to dry storage seem worried about the risks associated with the continued accumulation of spent fuel and about the lack of assurance that the fuel will ever leave the plant, especially in light of delays in the repository schedule. In general, plans to develop a centralized storage facility could reduce public opposition at reactor sites. The larger the capacity of such a centralized facility, the smaller the amount of spent fuel that would have to stay at reactors, thus lessening the basis for public opposition at affected reactor sites.

Concern about storing spent fuel at shutdown reactors

Although the risk of storing spent fuel at shutdown reactors is low, there is some uneasiness in that regard. So far, community response to spent fuel storage at shutdown reactors has been mixed. For example, in a survey of residents living near the shutdown Humboldt reactor in northern California, respondents *believed* that the risk of on-site dry storage of spent fuel is higher than the risk of continuing operation of the power plant itself (Pasqualetti 1993). On the other hand, the owners of Rancho Seco in central California encountered little if any opposition to storing spent fuel on site after the plant was shut down.[23] However, the level of concern about having spent fuel at shutdown reactors could change in response to increasing uncertainties in the changing electric power industry, or as more reactors begin shutting down in a decade or so.

General public acceptance

Deciding to develop centralized storage most likely will create public opposition at the proposed storage site or even on a broader level. Some important general public acceptance issues include geographic equity, perceived transportation risks, the fear of creating de facto disposal sites, and the possibility of reprocessing spent fuel. General public acceptance of a centralized storage facility is probably unlikely. However, some choices about storage could influence the *intensity* of public opposition while others could shift opposition to different population groups, as discussed below.

23 See Ken Miller in NWTRB 1993b.

Geographic equity

Decisions about spent fuel storage will affect geographic equity in some way. For example, the greater the number of storage sites, the more equitable the distribution of real and perceived risks associated with storage. The most geographically equitable approach to storage is to leave the spent fuel at reactors near the communities that have benefitted from the power generated. Developing several small regional storage facilities would achieve some moderate degree of geographic equity. A single, large centralized facility offers the least geographic equity.

Perceived transportation risks

Often of a much higher concern than calculated transportation risks, *perceived transportation risks* will play an important role during any discussion of moving spent fuel. Large segments of the public fear radiation and carry those fears over to any activity involving radioactive materials (Weart 1988, Slovic 1987). Those concerns will understandably grow once people realize that current levels of spent fuel transportation would increase several-fold once a full-scale storage facility (or repository for that matter) begins operating. A decision to build a centralized facility now would raise the public's perception of transportation risks sooner rather than later.

Concern about the possibility of reprocessing spent fuel

Prior to 1977, it was assumed generally that spent fuel would be reprocessed to recover uranium and plutonium for recycling. The Carter administration implemented a policy of indefinitely deferring reprocessing to discourage nuclear weapons proliferation. The Reagan administration reversed that policy in 1981.

The economics of reprocessing are unfavorable today and are likely to remain so for some time. Nonetheless, the debate about the future viability of reprocessing continues. Some assert that centralized storage encourages nuclear weapons proliferation by making reprocessing more convenient than it would be if spent fuel were disposed of in a repository (DOE 1995c). The Board does not believe that consolidating spent fuel at a centralized storage facility would alter the economics or the likelihood that spent fuel will be reprocessed. Reprocessing could *delay* by a decade or two the need to permanently dispose of reprocessing wastes, but it does not *eliminate* that need. In the end, the cost of

reprocessing would be in addition to, rather than in place of, expenditures for deep geologic disposal.

The siting process

Finally, most spent fuel is still stored at reactor sites, despite past initiatives to develop centralized storage. In part this is because of community opposition created during these past attempts to site a storage facility. As in the past, much opposition will result from concern that a proposed storage site could become a de facto disposal site.

The possibility of creating a de facto disposal site has been an important focus of community opposition during past attempts to site a storage facility. When in 1974 the AEC proposed building a retrievable surface storage facility while pursuing disposal on a developmental basis, the concern was raised that moving spent fuel to one central site would erode support for finding a permanent disposal solution (EPA 1974). The implication was that without a disposal option, storage could become de factor disposal. Indeed, the quantity and timing linkages contained in the 1987 NWPA amendments addressed those concerns.

The nation has yet to reach a consensus on the need for centralized storage of spent nuclear fuel. Without this consensus, it could prove easier for Congress to designate a storage site than it will be for the DOE to carry out the process of developing a facility there. The recent disappointing experience of two nuclear waste negotiators who tried to identify a willing host community, coupled with the slower than anticipated progress in the DOE's disposal program over the last decade, have only intensified the debate over the storage of commercial spent nuclear fuel. The Board believes that one of the best ways to allay concerns about the creation of a de facto disposal site is by maintaining a viable, technically credible, site-characterization and repository development program for disposal that is open to public review and comment.

Key thoughts on public acceptance of storage

(1) *Public opposition to spent fuel storage currently is focused primarily at the local level in communities where additional on-site storage is being developed.*

(2) *A decision to build any centralized facility now would probably make obvious sooner the general public's perception of transportation and associated health and safety risks.*

(3) *The most geographically equitable approach to storage is to leave the spent fuel at reactors near the communities that have benefitted from the generated power.*

(4) *The quantity and timing linkages contained in the 1987 NWPA amendments sought to address concerns that a storage site could become a de facto disposal site. The Board believes that one of the best ways to allay these concerns is through continued pursuit of a technically credible site-characterization and repository development program for waste disposal.*

(5) *Due to the lack of a national consensus on the need for centralized storage, it has not been possible so far to site a centralized storage facility.*

Table 1: Advantages of At-Reactor and Centralized Storage

This table tries to capture the major generic advantages of at-reactor and centralized spent fuel storage. Only those issues that offer clear advantages have been included. Many of the advantages to centralized storage increase if a centralized storage facility is developed at an operating repository site. Those advantages are indicated by squares.

■ = advantage increases if a centralized storage facility is developed at an operating repository site.

Issues	Advantages of At-Reactor Storage	Advantages of Centralized Storage
Waste Management Considerations		
Progress in repository development	• Avoids prejudicing a Yucca Mountain site-suitability decision • Reduces competition between storage and the repository development program for funds and other resources • Helps maintain political pressure for repository development	
Waste management system operations	• Minimizes handling and number of shipments since fuel would be transported directy to the repository site	■ Provides greater flexibility in system operations ■ Facilitates thermal management and blending of fuel for emplacement ■ Facilitates retrieval ■ Provides buffer storage for unanticipated repository operational problems.
Future uncertainties		• Facilitates monitoring of spent fuel and possible remediation during prolonged storage • Enables acceptance of sufficient spent fuel by 2010 when reactors begin shutting down • Provides backup storage if the repository is delayed due to technical problems
Institutional Considerations		
Utility/PUC* concerns		• Allows federal acceptance of spent fuel, but not before about 2002** • Reduces planning uncertainties for utilities • Facilitates decommissioning of shutdown plants; lowers post-shutdown costs • Reduces opposition at reactor sites
Public acceptance/ opposition	• Preserves geographical equity; spent fuel is stored near the consumers of the nuclear power that produced the fuel • Defers until later concerns about perceived risks related to transportation	

** PUC: Public Utility Commission*

*** The process of licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it would take time. As a result, the federal government could not begin accepting limited amounts of spent fuel at any centralized facility much before 2002.*

Chapter 5:
Evaluation of Three Alternatives to At-Reactor Storage

Because Congress may decide to authorize a centralized storage facility in the near future this chapter offers insight into such a decision. Three of the most obvious generic alternatives to the current approach of at-reactor storage are discussed: (1) the federal government takes title to spent fuel and arranges for continued storage at reactor sites until a repository becomes available; (2) the federal government accepts spent fuel and transports it to one or more existing federal nuclear sites; (3) the federal government develops storage capacity for commercial spent fuel at one or more sites away from reactors and away from existing federal nuclear sites. Except for the first, these options could be developed in a number of ways, including in various sizes and numbers. The Board assumes during this discussion that the DOE would continue to provide storage for government-owned spent fuel and high-level wastes — separate from commercial spent fuel.

The process of licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it would take time. Developing a transportation system will require the acquisition of sufficient numbers of trucks or rail cars and casks, the establishment of transportation routes, and the development of emergency preparedness plans at the affected state and local levels. As a result, the federal government could not begin accepting spent fuel at a facility much before 2002, and then not in significant amounts. Congressional action to begin developing centralized storage now would only *reduce*, but not eliminate, the need to continue storing spent nuclear fuel at reactor sites.

Before beginning a discussion of how the alternatives differ, it is useful to emphasize that they are similar in many ways. For example, there appear to be no substantial differences among alternatives in the health, safety, and environmental risks they might pose. The technical and regulatory feasibility of dry-cask storage likely to be used in all cases has already been proven. All alternatives would compete to some degree with the repository program for funding and other resources, especially if storage is paid for from the Nuclear Waste Fund. And, for all alternatives, there is the concern that a storage site could become a de facto disposal site. With the exception of the take-title-and-store-at-reactors alternative, perceived transportation risks become apparent sooner.

Although similar in many ways, these alternatives also have important differences. The following discussion emphasizes those differences. When noteworthy, some of the considerations discussed in previous sections of the report are reiterated.

Alternative 1. Federal government takes title and continues to store spent fuel at reactors

Transferring title to the federal government would unequivocally place the legal and financial responsibility for the spent fuel in the hands of the government. However, this option would not include physically removing spent fuel from reactor sites until a repository site were found suitable or a repository began operating. This alternative would not prejudice the decision about the suitability of a repository site. If repository development were significantly delayed, some uncertainty would remain about the long-term use of reactor sites since sites cannot be fully decommissioned as long as spent fuel is stored there. Depending on funding, there could be some competition for resources with the disposal program; however, it would be less than if the large costs of developing and operating a system for transporting the fuel to a centralized location had to be paid now.

Maintaining spent fuel storage at a large number of reactor sites, rather than at one large or several small centralized storage sites, could help to maintain political support for continuing repository development, although once the federal government has accepted spent fuel, utility support for repository development could diminish. Any community opposition to spent fuel storage would remain focused on the existing reactor sites. Opposition to spent fuel transportation would be delayed for several years while repository site characterization continues. This is the most geographically equitable alternative because spent fuel remains stored near the locations where electrical power is generated.

Alternative 2. Store spent fuel at an existing federal nuclear site(s)

Spent fuel could be accepted by the DOE, then transported to and stored at one or more existing federal nuclear facilities (federal sites currently storing defense/research spent fuel and high-level radioactive wastes include Savannah River, Hanford, and INEL[24]). This option is attractive for several reasons. Some of the infrastructure for transporting, handling, and monitoring spent nuclear fuel already is available at these sites. If multiple sites were selected, this option could offer geographic flexibility (e.g., reactors in the East could ship to an eastern site). Some community opposition to spent fuel storage would be eased near reactor sites that are relieved of their spent fuel; storing additional spent fuel at federal sites already holding similar types of wastes could raise

24 A recent agreement between the DOE and the state of Idaho prohibits the DOE from shipping spent fuel from commercial reactors to INEL (PSC of Colo. v. Batt 1995).

less opposition than might occur at a newly proposed site. Opposition along transportation routes would arise much sooner than if spent fuel remained at reactors until a repository began operating.

Variant 1: One variant of this option is to make a few thousand metric tons of *federal emergency backup storage space* available. The 1982 NWPA authorized the DOE to accept up to 1,900 metric tons of spent fuel from utilities that faced possible reactor shutdown because of insufficient at-reactor storage capacity. This plan, which expired in 1990 without any utility making use of it, provides ratepayer equity in that only the utility(s) in need would pay a new user fee to the DOE for services provided. This authority could be renewed, providing stop-gap storage as needed while characterization of the Yucca Mountain site continues.

Establishing this kind of a limited backup storage capability could satisfy concerns about insufficient storage capacity at reactors without foreclosing future storage options. In theory, a restrictive inventory limit could ease community opposition near the backup storage facility, although recent experience with naval and research reactor fuels suggests that small size does not always ease opposition. Because the capacity of the facility would be limited, less transportation infrastructure would be required and that which is needed could be developed relatively rapidly. However, the limited capacity of such a facility would not satisfy overall utility concerns about long-term spent fuel storage and would do little to prevent continued storage of spent fuel at reactors that shut down in the years ahead.

Variant 2: Another variant of this alternative is that which currently is being considered by Congress: *develop storage now at the Nevada Test Site* (NTS). Because Yucca Mountain borders the NTS, developing a storage facility there has technical, operational, and logistical advantages if the site is found suitable and a repository eventually is developed there. The storage facility would be able to provide logistical support to the repository once it begins operating, and the real and perceived risks of spent fuel handling and the number of shipments would be minimized.

If a storage facility is developed at the NTS now and the Yucca Mountain site proves unsuitable for a repository, either the spent fuel in storage at the NTS would eventually have to be moved to a repository site elsewhere, or the site risks becoming a de facto disposal site. It must be noted that if the site at Yucca Mountain is not suitable for repository development, it could become very difficult to site a storage facility at any location because of concerns that such a facility could become a de facto disposal site.

Other disadvantages associated with developing centralized storage now at the NTS were discussed previously in this report in the section on potential effects of developing storage on repository development (see page 26). The NTS is the one existing federal site that lacks rail access, so a rail line would have to be constructed to move significant amounts of spent fuel. This would exacerbate the problem of limited resources for site characterization and repository development. Furthermore, developing a storage facility at the NTS now could prejudice the later decision about the suitability of Yucca Mountain for repository development. Other advantages and disadvantages of storage at the NTS are essentially the same as for storage at any other federal nuclear site.

Alternative 3. Store spent fuel away from reactors, but not at an existing federal nuclear site(s)

Under this alternative, the DOE, which is still authorized to work with communities on the development of a volunteer storage site, would be charged with identifying, licensing, and constructing one or more storage site(s) at new location(s). Developing one large (or several small) storage facility(s) would largely eliminate the need to develop additional on-site storage. Community opposition to spent fuel storage would be eased near reactor sites, but would increase near the interim storage site(s). Even if a volunteer site were to emerge, opposition in surrounding regions can be expected. Opposition along transportation routes would arise sooner than if spent fuel were stored at reactors until a permanent repository began operating. The degree of geographic equity associated with this option would depend on the number and location of storage facilities developed.

Variant: One possible variation of this alternative would be to take a "wait-and-see approach" to allow ongoing private-sector efforts to develop centralized storage to take their natural course. During the last couple of years a group of utilities and the Mescalero Apaches of New Mexico have been negotiating the development of a centralized storage facility for commercial spent fuel on tribal lands. If these efforts are successful, a centralized storage facility could become operational around 2002. A private-sector initiative would not compete for the DOE funding or management resources needed to pursue site-characterization efforts at Yucca Mountain. However, federal efforts now on storage could undermine private-sector efforts.

Key thoughts on the alternatives to at-reactor storage

(1) *Because it would take time to license and develop a federal centralized storage facility and the transportation infrastructure that goes with it, even if development began today, the federal government would need at least five years before it could begin moving meaningful amounts of spent fuel away from reactor sites.*

(2) *The DOE could be reauthorized to provide a limited amount of emergency backup storage at an existing federal site to accommodate those utilities that, for one reason or another, cannot continue to store their own spent fuel.*

(3) *Storing spent fuel at or near Yucca Mountain offers a number of advantages, but only if a repository is eventually developed there. However, storing spent fuel at or near Yucca Mountain now, before the site has been determined suitable for repository development, risks prejudicing the decision about site suitability and threatening the credibility of the waste management program; it also would exacerbate the problem of limited resources for the site-characterization program.*

(4) *Since a viable repository development program seems to be important for the development of additional storage capacity, if Yucca Mountain proves unsuitable, it may be difficult to develop storage anywhere.*

Chapter 6:
Board Conclusions and Recommendations

Earlier, this report summarized the current and projected inventories of commercial spent nuclear fuel; it described current practices for storing spent fuel; and it discussed the technical considerations related to at-reactor versus centralized storage. The report also addressed a variety of important institutional and policy-related considerations associated with at-reactor versus centralized storage. Finally, three generic alternatives to at-reactor storage were evaluated. To summarize, those issues the Board believes are key to a decision about storing commercial spent nuclear fuel are presented using the following five key questions.

Key questions

- Is there an urgent technical need *at this time* for centralized storage of commercial spent fuel?
- Will federal storage be needed in the future?
- Can the right balance be found between meeting future spent fuel storage needs and continuing to pursue permanent disposal?
- How should the costs of federal storage be paid?
- What would it take to implement these recommendations?

Is there an urgent technical need for centralized storage of commercial spent fuel?

The Board sees no compelling *technical* or safety reason to move spent fuel to a centralized storage facility *for the next few years*. The methods now used to store spent fuel at reactor sites are safe and are likely to remain safe for decades to come. Despite some recent public opposition to utility efforts to develop additional storage, so far, utilities have been able to add new storage capacity at their sites when needed.

Will federal storage be needed in the future?

The Board believes that federal storage capacity *will* be needed *in the future* for two reasons. First, when a repository begins operating, a centralized storage capability will be needed to provide added flexibility to handle the waste. For example, storage would provide a buffer between the repository and the rest of

the waste management system if waste emplacement rates in the repository are less than spent fuel acceptance rates. Storage capacity also offers technical advantages, such as allowing spent fuel to be mixed and matched to optimize the thermal loading of the repository to improve repository performance.

Second, 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.

Although currently prohibited by law, there is no *technical* reason why a centralized storage facility (and supporting transportation infrastructure) cannot be constructed prior to repository construction. In fact, because of the lead time needed for planning and development, the Board believes it would be practical to begin *planning* now for a federal storage facility(s) that can achieve full-scale operation (i.e., accept 3,000 metric tons/year) by 2010 when reactors begin shutting down in large numbers.

Can the right balance be found between meeting future spent fuel storage needs and continuing to pursue permanent disposal?

In the past whenever there has been a choice between storage and disposal, disposal has always been made the primary focus of the federal high-level waste management program. This is because the storage of commercial spent fuel is not an acceptable substitute for disposal. Ultimately, spent fuel (commercial and defense) as well as sizable amounts of high-level radioactive defense waste will have to be disposed of. The Board believes that the nation needs *both* a repository development program and a plan to address future spent fuel storage needs. However, efforts now to refocus the program from disposal to storage, especially at a time when budgets are tight, could jeopardize site-characterization and repository development efforts in three ways: (1) by competing with the disposal program for resources, (2) by causing a real or perceived prejudicing of a future decision about the suitability of the Yucca Mountain site, and (3) by eroding the impetus and political support for repository development.

Given the stage of the current site-characterization program and the fact that substantial new storage capacity will not be needed until 2010, the Board has concluded that it makes technical, management, and fiscal sense to await the decision on the suitability of the Yucca Mountain site for repository development before beginning development of a federal centralized storage facility. The Board believes that the following approach *strikes the right balance* between maintaining the national goal of permanent disposal while meeting future storage needs.

- Disposal: The nation has a program for developing a repository for the permanent disposal of spent fuel. So far, no technical reasons have been found for abandoning the site being characterized at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years if the Yucca Mountain site is suitable. By *suitable* the Board means that there is a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation. Therefore, *the Board recommends that for the next several years the DOE continue to focus its efforts on evaluating the suitability of the Yucca Mountain site for repository development*.

- Storage: *The Board recommends that generic planning for a federal storage facility and for a supporting transportation infrastructure begin now at a funding level modest enough to avoid competition with the repository program. Development of the storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site* for hosting a repository. Because of the increased advantages of having a storage facility located at an operating repository site, *if Yucca Mountain proves suitable for repository development, the centralized storage facility should be located there*. Activities could begin around 2000 to construct a storage facility that would be operating at full scale by 2010 — at the repository site. Operation by this date would largely eliminate the need to store significant amounts of spent fuel at reactors after they are shut down.

  The Board also recommends developing storage incrementally by limiting the amount that can be transported to Yucca Mountain until the repository has been licensed for construction. This will address the potential risks associated with linking storage to the earlier milestone of site suitability, rather than waiting until the NRC licenses the construction of the repository as required by existing law.

> *The Board suggests planning now for a limited-capacity backup facility, similar to the one previously authorized by the Nuclear Waste Policy Act, for emergency storage to be located at an existing federal nuclear facility. Development of the backup facility should begin only if a clear need for the facility is established.* Its operation should be phased out once operation of a large storage facility at the repository site commences.

The process of licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it will take time; estimates range from five to seven years. Even if passed into law now, none of the proposals before Congress would enable operation of a centralized storage facility to begin much before 2002 — and then not at full scale. With the spent fuel stockpile currently at 32,000 metric tons and growing at 2,000 metric tons per year, it will take as long as 30 years to empty the inventory at all the individual reactor sites. So, developing a centralized storage facility at Yucca Mountain now would only *reduce*, but not eliminate, the need to continue adding spent fuel storage capacity at reactor sites. The Board's suggested approach differs from currently proposed strategies only by the time it will take to determine site suitability — at most five years.

With respect to storage, 2010 is the key milestone. Being able to accept small amounts of spent fuel in 1998 or 2002 will address the storage concerns of only a few utilities. Being able to accept 3,000 metric tons per year for 30 years beginning in 2010 will be necessary to avoid having substantial amounts of spent fuel sitting at shutdown reactors.

How should the costs of federal storage be paid?

Given current funding projections, it appears that the Nuclear Waste Fund will be only marginally capable, at best, of supporting the long-term development and operation of a repository for the permanent disposal of spent fuel. Therefore, the costs of a limited federal storage facility could be recovered through a new fee assessed on the users of that facility. The costs of a large storage facility located at a repository site (which would be used for all spent fuel) could be recovered by increasing the current 1 mill-per-kwh fee going into the Nuclear Waste Fund. This would avoid having the taxpayer bear the costs of final closure of the repository.

What would it take to implement these recommendations?

These Board recommendations represent a departure from existing policies. The Nuclear Waste Policy Act currently links development of a storage facility to the construction of a repository. *The Board recommends that development of a storage facility at Yucca Mountain be linked to the earlier decision about the suitability of the Yucca Mountain site as defined above.*

This new approach is not free of risk. Given the inherent difficulties associated with proving safe repository performance over many thousands of years, a site-suitability decision would not be an iron-clad guarantee that the site could be developed as a repository. However, the Board believes that the risks of linking storage to a site-suitability decision, rather than to the NRC licensing decision, can be minimized if the DOE clearly delineates its site-characterization program and focuses on the timely completion of the needed scientific activities *and* if it continues to work closely with the oversight groups (e.g., the NRC) that have been involved thus far with the program. Working closely with these groups can help ensure that the decision about the suitability of Yucca Mountain for repository development is technically sound.

Finally, successful development of a system for managing the nation's spent fuel and high-level waste will require sound program management and sufficient and consistent funding. Without adequate funding for disposal *and* storage, a significant amount of spent fuel will remain in storage at reactor sites well after large numbers of reactors begin shutting down in 2010.

Summary of Board recommendations

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.

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.

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.

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