Appendix G

Repository or MRS Loading Capacity Required To Remove Spent Fuel From Reactor Sites Within 10 and 15 Years After Reactor Decommissioning

Practically all of the spent fuel discharged by the end of this century is likely to still be in storage at that time, most likely storage basins at the sites of the reactors that produced it. The possibility of further delays in the availability of reprocessing or disposal facilities has led to concern that existing reactor sites might become de facto long-term repositories. This appendix is an effort to estimate how long spent fuel might have to remain at reactor sites if geologic repositories (or alternative Federal waste management facilities) do not become available until the high-confidence dates discussed in chapter 6—2008 and 2012 for the two geologic repositories, or as late as 2012 for both of two monitored retrievable storage (MRS) facilities. For purposes of comparison, the Nuclear Regulatory Commission (NRC) has determined that spent fuel can be stored at reactor sites "safely and without significant environmental impacts" for at least 30 years after the reactor ceases operational

There are two key determinants of the time spent fuel would have to remain at reactor sites: 1) the maximum rate at which spent fuel can be unloaded from storage at reactor sites; and 2) the maximum rate at which it can be loaded at Federal waste management facilties. This analysis assumes that a loading rate of 3,000 tonnes per year (tonnes/yr) can be achieved for either a geologic repository or an MRS facility. Consequently, the feasible loading schedule is primarily determined by the dates on which such facilities become available. The curves bounding area "C" in table G-1 show the total cumulative loading capacity that will be available if two 3,000-tonnes/yr repositories or MRS facilities begin operating in 2008 and 2012, or if both begin operating (upper bound) in 2012 (lower bound).

The other crucial assumption in these calculations is the rate at which spent fuel can be removed from reactor sites. A precise analysis of achievable reactor unloading scenarios would require a detailed evaluation of the conditions at each reactor, an analysis that was beyond the scope of this study. To estimate a reasonable upper bound of the time it would take to unload reactor sites, OTA made the following assumptions:

1. ***Only legaf weight truck casks are used.*** This is a conservative assumption, since many reactors have a railroad spur that would allow the use of rail casks with a much larger capacity than truck casks.
2. No ***rod consolidation is done** at **the reactor site prior to shipment.*** This also adds conservatism, because consolidation (which may prove to be an economically attractive means of providing additional storage capacity) could increase the amount of spent fuel in each cask and thus reduce the number of shipments needed to remove a given amount of fuel from the reactor site.
3. ***The truck casks are designed for fuel that is at least 10 years old.*** Existing casks are designed for very hot spent fuel; casks designed for fuel that is at least 10 years old could hold about twice as much spent fuel as current designs (see ch. 3). Thus a legal weight truck cask opimized for unconsolidated older spent fuel could hold two pressurized-water reactor (PWR) assemblies (about 0.9 tonne), or perhaps four boiling water reactor (BWR) assemblies (about 0.75 tonne). Existing casks, by comparison, hold only one PWR assembly or two BWR assemblies.

   This assumption does not add conservatism, but it appears to be quite reasonable in view of the economic incentives to increase cask capacity where possible.
4. ***Ail spent fuel must be loaded into transportation casks using the existing handling facilities the reactor site.*** This is also a conservative consumption, since some technologies for additional on-site storage would allow the stored fuel to be shipped without first returning to the reactor's water basin for loading into transportation casks. If such technologies are used, the result would be a higher total rate at which fuel can be removed from the site.

Using these assumptions, an unloading rate of 100 to 150 tonnes/yr appears technically feasible at most reactors. A recent study of spent fuel transportation options for several Tennessee Valley Authority reactors

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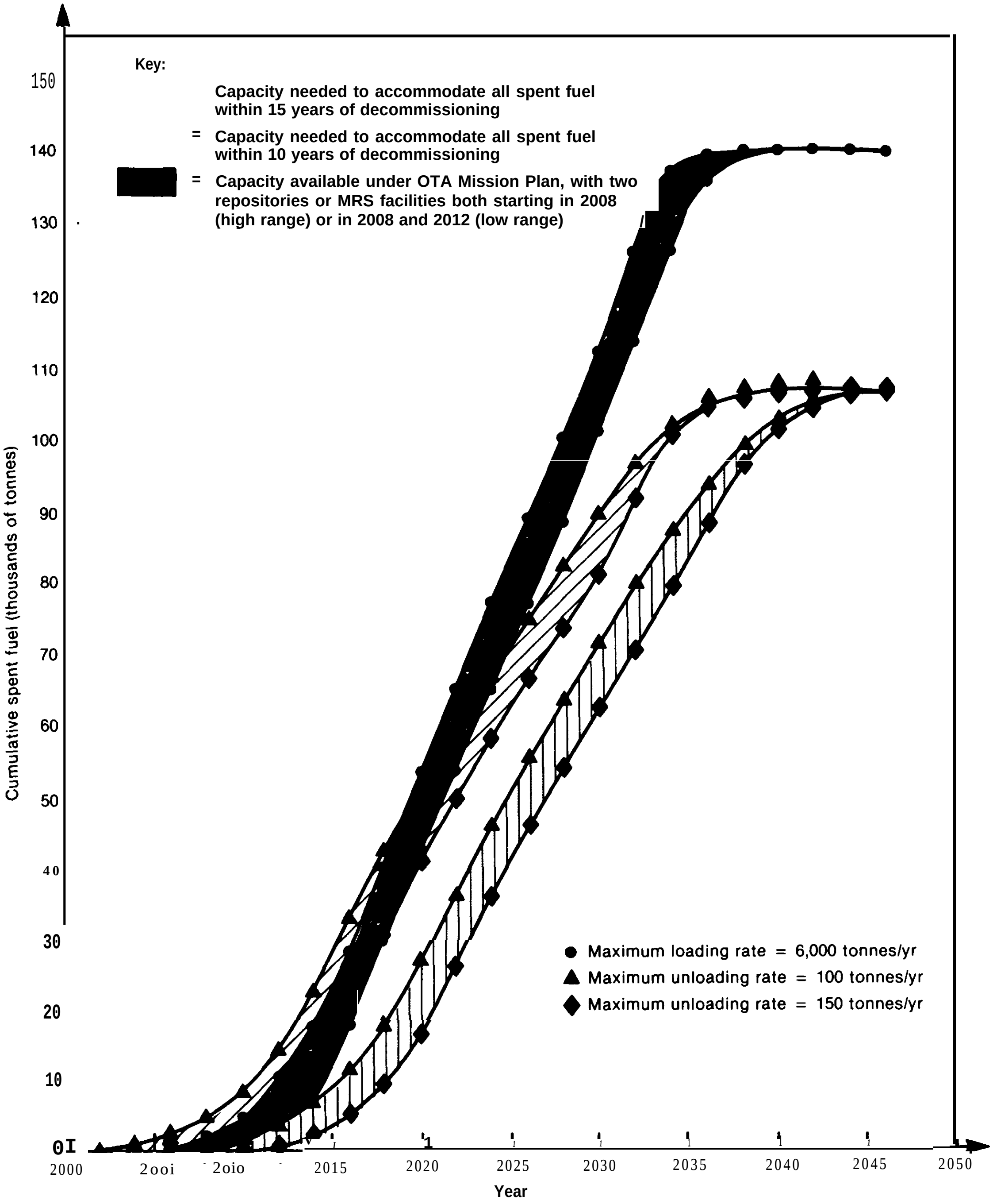
[1] U.S. Nuclear Regulatory Commission, "10 CFR Parts 50 and 51: Waste Confidence Decision, " *Federal Register, vol. 49, No. 171* (Aug. 31, 1984), p. 34660.

Figure G“I.—Spent Fuel Loading Scenarios



Assumptions:

1. Projections are for reactors operating or under construction on June 31, 19S4. Reactor discharge data and estimated dates of decommissioning supplied by U.S. Department of Energy.
2. Shared basins we aasumed to be unloaded after the last reactor using the basin is decommissioned.
3. For 4 reactors raaching end-of-life before 1998, decommissioning is assumed to occur in 1998.
4. Repositories or MRS facilities achieve a loading rate of 3,000 tonnes per year in 4 years, beginning with 375 tonnes the first year, 750 tonnes the second, and 1,500 tonnes the third.
5. Repository or MRS capacity assumed to be 70,000 tonnes each.

SOURCE: Office of Technology Assessment.

(including both BWRS and PWRS) indicates that about 16 hours, or two 8-hour work shifts, would be required to load one truck cask using the existing reactor facilities.[2] If only one truck cask were loaded at a time (in some cases, twp or three could be loaded at once without a proportionate increase in time), and each held about 0.75 tonnes (BWR assemblies), it would take 200 shipments each year to achieve a 150-tonnes/yr unloading rate. While this could not be accomplished using only one shift per day, it appears possible with double-shifting. Since a rate of 100 tonnes/yr would require 133 shipments (or 266 8-hour shifts), that rate might be accomplished with only one shift per day.

Regulations limiting the annual radiation exposure of workers might become a constraint for such large numbers of shipments per year, even if the technical ability exists. If so, this would have to be taken into account in determining the desired unloading rate for those reactors where this problem was encountered. The amount of worker exposure may also depend on whether all spent fuel has to be returned to the reactor's storage basin for loading into transportation casks. Thus, it could be an additional reason why the choice of technologies for out-of-basin storage would significantly affect the achievable reactor site unloading rate, as discussed below.

The curves bounding areas "A" and "B" in figure G-1 show the cumulative amounts of spent fuel that would have to be shipped from reactors to enable all fuel to be removed from each reactor site within 10 years (area "B") or 15 years (area "A") after the currently projected dates of decommissioning of the reactors, using two assumed unloading rates for each reactor {100 tonnes/yr and 150 tonnes/yr) to define the upper and lower bounds. Where two or more reactors share storage facilities, shipment is assumed to begin when the last reactor using the facilities is decommissioned. The lower the achievable unloading rate, the soonerr offsite loading capacity will be required to allow spent fuel to be removed from reactor sites within a specified period.

Area "B" shows that if a 150-tonne/yr average unloading rate can be achieved for each reactor (lower bound), it is not necessary to start removing spent fuel from reactor sites until 2007 in order to complete the process for each reactor within 10 years of expected decommissioning (with the exception of the four reactors reaching end-of-life before 1998). If the maximum achievable unloading rate is 100 tonnes/yr (upper bound), it would be necessary to start shipments in 2001 in order to remove spent fuel from all sites within 10 years of decommissioning. To unload sites within 15 years of decommissioning (area "A"), shipments need not begin until 2006 (at 100 tonnes/yr) or even 2012 (at 150 tonnes/yr).

If a first repository or MRS facility begins loading at the rate of 3,000 tonnes/yr in 2008 ("C" upper bound), by the end of 2009 it will have exceeded the cumulative loading capacity needed to remove spent fuel from reactors within 10 years of decommissioning if the unloading rate is 150 tonnes/yr ("B' lower bound), or within 15 years regardless of unloading rate ("A' '). If the second repository is available by 2012, their combined cumulative loading capacity by 2019 would exceed the amount needed for the most extreme case—unloading all reactors within only 10 years of decommissioning, at an average rate of only 100 tonnes/yr at each reactor ("B" upper bound).

Even if the two 3,000-tonne/yr facilities did not begin loading until 2012 ("C" lower bound), they could still accept the spent fuel from practically all reactor sites within 15 years of decommissioning at an average 150-tonne/yr unloading rate per reactor ("A" lower bound). If reactor sites could only unload at 100 tonnes/yr, by the end of 2015 the two facilities would exceed the cumulative loading capacity required to remove spent fuel from reactors within 15 years of decommissioning ("A" upper bound), although some reactors that would have to begin unloading before that date to meet this goal. Two facilities that begin loading in 2012 would not allow all reactors to be unloaded within 10 years of decommissioning, although their combined capacity would catch up with demand by 2020 or 2025, even in the most extreme case ("B' lower and upper bounds, respectively). Some spent fuel would have to remain in storage at a few reactor sites for 15 or 20 years.

These calculations are intended only as an approximate assessment of the implications of the high-confidence repository loading schedule in chapter 6: geologic repositories available in 2008 and 2012, or two alternative waste management facilities available in 2012 in the event of unexpected problems with geologic disposal. This analysis suggests that the postulated repository schedule would allow spent fuel to be removed from practically all reactor sites within 10 to 15 years of expected decommissioning, and the postulated backup facility schedule would allow removal within about 15 years for most reactors. In either case, it appears possible to remove spent fuel from reactors sites well within the 30-year period during which NRC has determined that spent fuel could safely be stored at the sites after the reactors are decommissioned.

This analysis also indicates that the choice of technologies for out-of-basin storage may have important implications for the achievable annual unloading rate.

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[2] Boeing Nuclear Power Systems, Inc., *Spent Fuel Shipping Cask Design and Transport Study, D275-50002* (prepared for TVA under contract No. TV51222A), March 1981, pp. 54-61.

With some technologies, such as the drywell, fuel assemblies stored outside the basin would have to be returned to the basin to be loaded into shipping casks. As a result, the handling facilities at the basin could become a major bottleneck. With other technologies, such as the horizontal concrete cask concept being demonstrated by Carolina Power and Light in cooperation with the Department of Energy, stored fuel could be moved directly from the storage module into a transportation cask. If combination storage/transportation or ‘ ‘universal’ casks prove feasible, the fuel would be stored in the cask that is ultimately used for transportation, so that no transfer from a storage facility to the transportation cask is required. In such cases, the potential bottleneck of existing handling facilities could be avoided. In addition, such technologies could reduce the worker exposures involved in unloading the stored spent fuel, thus avoiding another potential constraint on unloading rates.

Because these individual storage decisions could constrain the long-term reactor unloading plan, it is important that the analysis of an optimized system design (discussed inch. 6) be completed quickly, before utilities have made irreversible storage decisions. It is also important to complete and evaluate the demonstrations of at-reactor dry storage technologies to determine the feasibility of those concepts that would allow spent fuel to be transported from the site without first returning to the reactor basin.