THE NEED FOR AND FEASIBILITY OF MONITORED RETRIEVABLE STORAGE

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ABSTRACT

The Nuclear Waste Policy Act directs the U.S. Department of Energy to study the need for and feasibility of monitored retrievable storage and to develop a proposal for construction of such a facility. The need for MRS was measured in terms of the relative performance of a system with an MRS facility and a system without an MRS facility. Relative performance was measured in terms of the ease with which all system functions can be developed and implemented, the operating efficiency and reliability of the system, life-cycle cost effects and radiation dose effects. The decision to proceed with the MRS facility involves a tradeoff between improvements in developing and operating the waste management system and an increase in the total cost of the system. Feasibility of MRS was based upon the technical maturity of the design and the level of certainty in the schedule for design, construction and operational testing.

BACKGROUND

The Nuclear Waste Policy Act (NWPA) of 1982 affirmed that the federal government is responsible for the disposal of spent fuel and high-level radioactive waste resulting from civilian nuclear activities. The primary objective of the federal waste management system is to dispose of this waste in a manner that protects the health and safety of the public and maintains the quality of the environment. The NWPA assigned to the U.S. Department of Energy (DOE) the responsibility for operating the waste management system. The NWPA also states that monitored retrievable storage (MRS) is a safe, reliable option for the long-term storage of waste. However, the NWPA does not clearly define the role of an MRS facility nor authorize its construction. Rather, it directs the DOE to complete a detailed study of the need for and the feasibility of such a facility and to develop a proposal for construction of such a facility. This paper summarizes the analysis of the need for an integral MRS facility and the feasibility of deploying the MRS facility in the waste management system.

The primary functions of the waste management system are 1) to accept waste from the owners and generators according to the standard contract with the DOE for disposal services; 2) transport the waste from reactor sites or other locations to disposal sites or other intermediate facilities; 3) prepare the waste for permanent disposal; and 4) provide permanent disposal in geologic repositories. In developing and operating these functions, the health and safety of the public and the quality of the environment must be protected. In addition, the program must operate in a fiscally sound manner with the costs borne equitably by the owners and generators of the waste.

Basis For Assessing The Need For An MRS Facility

The need for and value of an MRS facility derives from its ability to improve the overall performance of the waste management system at acceptable costs. The waste management system could be operated without an MRS facility, but including the facility improves several important performance characteristics of the system. The assessment of need was based on comparisons between a waste management system with an MRS facility and a system without an MRS facility. The no-MRS and MRS systems were compared in terms of their implications for developing and operating the functions of the waste management system. These implications were compared with projected system cost effects and potential changes in radiation exposure to both the public and workers.

The specific factors that were used to compare the MRS and no-MRS systems are defined below:

- System Development--the ease with which all system functions can be developed and implemented.
- System Operations--the operating efficiency and reliability of all system functions, including waste acceptance, transportation, preparation and packaging, and disposal.
- System Cost Effects--the life-cycle cost of developing and operating the system functions including costs incurred by utilities to expand their storage capacity.
- System Radiation Dose Effects--for both the public and occupational workers, the expected radiation exposure effects from system operations.

Basis For Assessing The Feasibility Of An MRS Facility

In this paper, feasibility refers to the ability to carry out or accomplish all components of the MRS system as proposed. The components of the MRS facility were evaluated separately and as a system. One measure of feasibility is the

technical feasibility of the major functions of the MRS facility. Another measure is the confidence in the cost projections and funding analysis, which were largely based on conceptual designs and DOE-sponsored studies and annual reviews. Costs examined included equipment, staffing, operating, and decommissioning costs. The level of certainty of schedule estimates, which includes the schedule for design, construction, and operational testing, is another feasibility measure.

ALTERNATIVE WASTE MANAGEMENT SYSTEMS

In considering the value of MRS in the waste management system, two primary alternative system configurations were evaluated: the reference or no-MRS system; and the integral MRS system. Figure 1 shows the two system options. The no-MRS and MRS options and their essential functions are described in the following sections.

A third option, the backup MRS system, was evaluated in the preliminary need and feasibility study[1]. The primary function of the backup MRS would be to provide contingency spent-fuel receiving and storage if the repository schedule were to change significantly. The preliminary study (DOE 1985) concluded that the backup MRS system would not provide advantages beyond those of the integral MRS facility, but rather had several disadvantages relative to it. For example, the backup MRS facility would duplicate the spent-fuel receiving and consolidation capability of the repository. Both the backup MRS facility and the repository would have very similar capabilities to receive and handle casks from all reactors, whereas the integral MRS facility would allow the repository to have simplified capability for cask receiving and spent-fuel handling.

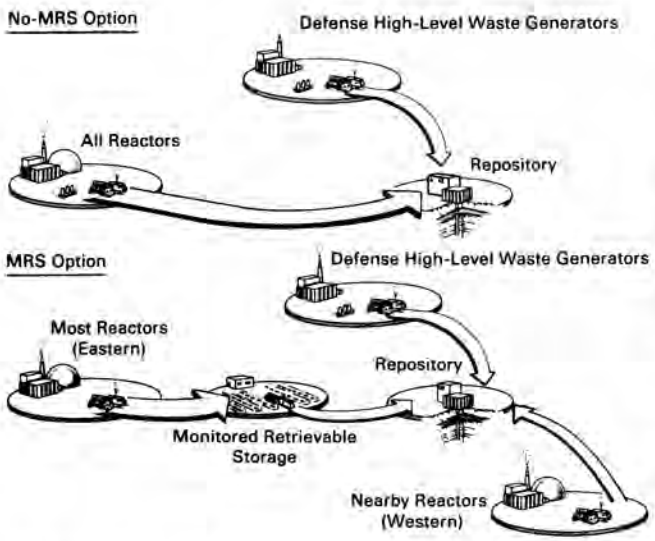

Fig. 1. No-MRS and Integral MRS System Options

No-MRS System

This option is currently authorized by Congress through the NWPA. Utilities would be responsible for the onsite storage of spent fuel until the DOE takes title to the fuel at the reactor site for shipment to the repository. The DOE is to begin accepting spent fuel no later than January 31, 1998, when the first repository is scheduled to begin operations. However, some additional storage capability would be needed, whether at the reactor sites or at the repository, for several years following 1998 because the inventories of spent fuel would continue to grow faster than fuel could be emplaced in the repository.

The no-MRS system was examined by considering options for achieving "MRS-like" system performance benefits. Selected improvements in the no-MRS system were examined to compare their impacts with those described for deploying an MRS facility. The alternatives considered were in three generic categories that align with equivalent improvements of adding an MRS facility to the waste management system:

- expanded lag storage at the repository to provide a buffer between waste acceptance and waste emplacement
- expanded storage at reactor sites, either by adding modular dry storage or in-pool consolidation of spent fuel, to provide contingency storage if repository operations were delayed
- use of larger shipping casks and multicask shipments, thereby increasing the tonnage per shipment and reducing the number of shipments.

MRS System

The construction of an MRS facility would require congressional approval. If approved, the MRS facility would serve as a centralized receiving, preparation, and packaging facility for spent fuel. Starting as early as 1996, spent fuel from commercial nuclear power plants would be shipped to the MRS facility, prepared and packaged for disposal, temporarily stored at the MRS facility, if necessary, and shipped by train to the geologic repository. Almost all of the material handled at the MRS facility would be spent fuel from commercial nuclear power reactors.

Storage could be provided if the quantity of spent fuel received exceeds the amount that can be emplaced at the repository or if the spent fuel is not suitable for immediate disposal. The MRS facility would have capacity to store up to 15,000 MTU of spent fuel but is expected to have a maximum inventory of 12,000 MTU. If temporary storage is required, canisters of consolidated spent fuel would be placed into sealed storage casks.

The tradeoffs resulting from alternative configurations of the MRS system also have been studied in more detail. Alternative configurations considered included the handling of fuel from western reactors, the installation of the final disposal container, and options for configuring the transportation leg between the MRS facility and the repository.

THE NEED FOR MONITORED RETRIEVABLE STORAGE

The MRS and no-MRS systems have two principal differences which lead to their relative advantages and disadvantages:

1. For preparing and packaging spent fuel for disposal, the MRS system would use a site that is separate from the repository and located centrally to the reactors. In the no-MRS system, these operations would be performed at the repository. This separate site would allow the functions of the MRS system to be developed sooner than the repository and independent of uncertainties in the repository program. The MRS system would provide a central location to the reactors for controlling spent-fuel transportation and would reduce the number of cross-country shipments to the repository.

2. The MRS facility would add the capability for storing up to 15,000 MTU of spent fuel (maximum inventory is expected to be 12,000 MTU). This storage capability could be used to decouple the operation of the waste-acceptance and waste-emplacement functions, to increase the quantity of spent fuel accepted in the initial years of system operations, and to provide contingency storage in case of changes in the repository's emplacement schedule.

The two principal differences in the MRS and no-MRS systems affect the waste management system's development, operations, cost and radiation exposure characteristics. Those effects are discussed below.

System Development Effects

System development includes the technology development and testing, and regulatory and institutional activities that are associated with implementing the repositories, the MRS Program, the transportation system, and the federal waste-acceptance process. An important basis for the DOE's proposal to include an MRS facility in the waste management system derives from the opportunity that the facility offers for developing and integrating system functions independently from the uncertainties of siting and licensing the first repository.

Two features distinguish the MRS system from the no-MRS system and affect the development of the waste management system. First, because the MRS site would be approved four to five years earlier than the repository site, greater lead time would be available for route-specific planning for spent-fuel shipments from the reactors and other interactions between the DOE and state and local governments. Second, the MRS facility design would be fully licensed by the NRC at least two years earlier than would the repository's surface facility design. As a result, more complete information on facility designs and schedules would be available for setting waste-acceptance commitments and for defining physical specifications, such as for equipment required to handle and unload casks between the federal and utility portions of the waste management system.

Adding an MRS facility to the authorized system would result in more complete and more certain information with which to implement waste acceptance, transportation, and packaging functions. Separating these functions from repository development would allow their planning and development to proceed at an advanced schedule and independent from the uncertainties of repository siting and geologic site characterization. The MRS site would be selected four to five years before the first repository site is selected. The MRS receiving and packaging facility design would be licensed by the NRC about three years earlier than the repository. As a result, the MRS system would provide earlier certainty about the location for the transportation control point and more definite technical design information for use in planning system interactions, including fuel acceptance and packaging decisions. Although a cost would be incurred in developing and operating an independent facility, the additional cost provides needed functions at a much earlier date than if they were developed at the first repository.

System Operational Effects

Two features distinguish the MRS system from the no-MRS system and affect system operations. First, the MRS facility would provide up to 15,000 MTU of buffer storage, which would decouple the waste-acceptance and waste-emplacement operations. Second, the MRS facility would be located away from the repository site. This difference would divide the transportation of spent fuel from reactors to the repository into two steps, would add another fuel receiving and handling step, and would redistribute spent-fuel packaging operations within the waste management system.

The MRS facility would increase the flexibility of and DOE's control over transportation activities and fuel acceptance and emplacement strategies and thereby increase operating efficiency and reliability relative to the no-MRS system. By centrally locating the MRS facility to the eastern nuclear reactors, the MRS facility would act as a staging area and control point for transporting spent fuel from reactors to the first repository. Having a control point closer to the reactors would simplify the control of the transportation function compared to the no-MRS system. The control point also would

significantly reduce the number of cross-country shipments to the repository through the use of large rail casks and multicask shipments. The overall transportation activities would be reduced, although waste transportation activities would increase in the area immediately surrounding the MRS facility.

Locating storage capability at the MRS site would improve the reliability and efficiency of the waste management system. The MRS facility would permit a larger spent-fuel receipt rate in the initial years of operation. The larger receipt rate would reduce the buildup of stored spent fuel at reactors (see Table I) and improve the efficiency and timeliness of the waste acceptance process. The storage capability at the MRS site would also provide relatively inexpensive contingency storage in case of changes in the repository emplacement schedule. Storage would also provide an operational buffer between waste-acceptance and waste-emplacement operations, which would give the overall system greater flexibility and reliability because operating disruptions would not quickly cascade through the system. The emplacement operation could also be more efficient because waste-package heat loads could be easily tailored to emplacement characteristics of the repository medium.

TABLE I

Annual Additions To At-Reactor Storage Capacity Requirements (MTU)

	No-MRS System			MRS System			
Year	No Federal Waste Acceptance	Maximum Federal Waste Acceptance[a]	Additional Annual Storage Capacity	Eastern Reactors to MRS	Western Reactors to Repos.	Maximum Federal Waste Acceptance[a]	Additional Annual Storage Capacity
1995	2,882[b]	0	2,882[b]	0	0	0	2,882[b]
1996	825	0	825	400	0	400	425
1997	896	0	896	1,800	0	1,800	0
1998	858	400	458	2,500	50	2,550	0
1999	1,292	400	892	2,500	50	2,550	0
2000	1,349	400	949	2,500	75	2,575	0
2001	1,295	900	395	2,500	75	2,575	0
2002	1,873	1,800	73	2,500	100	2,600	0
2003	1,552	3,000	0	2,500	200	2,700	0
2004	1,659	3,000	0	2,500	350	2,850	0
2005	1,918	3,000	0	2,500	450	2,950	0
TOTAL			7,370				3,307

(a) These schedules reflect expected receipt capability and have been used for analytical purposes. Actual spent fuel acceptance schedules will be set beginning in 1991 in accordance with the standard contract with utilities (10 CFR 961).

(b) Cumulative storage requirements through 1995.

System Cost Effects

The DOE is responsible for implementing the safe and environmentally acceptable operation of the federal waste management system in a cost-effective manner. The NWPA requires that the generators of the waste pay all disposal costs. In addition to the federal portions of the system, which are covered by the Nuclear Waste Fund (NWF), the total waste management system includes the storage and handling of spent fuel at reactors. These costs are typically paid by utilities and are in addition to their payment of NWF assessments. The DOE is responsible for executing and managing technically sound and cost-effective programs within the revenue constraints of the NWF and for considering the total effect of its programs on utility costs. Consequently, the following discussion of the cost effects of deploying an MRS facility considers the costs for both the federal and utility portions of the system. The cost effects of adding an MRS facility to the waste management system are summarized in Table II. Capital and operating costs were examined for utility spent-fuel storage, spent-fuel transportation, the MRS facility, and the repository's surface facilities. Each is discussed in the following sections. Development and evaluation (D&E) costs were not estimated.

Adding an MRS facility would result in a net cost increase of $1.4 to $2.0 billion to the federal portion of the waste management system because site-support services would have to be provided at two locations, the MRS and repository sites, instead of one. This cost includes approximately $0.4 billion to provide 12,000 MTU of storage, which would result from the waste-acceptance and facility operating schedules assumed for this analysis. However, the MRS facility would reduce the utilities' storage expenditures. Avoided utility storage costs would range from $150 to $450 million, assuming repository startup in 1998. The MRS system would provide storage capacity which could be used to increase the initial rate of removing spent fuel from reactor storage or to provide contingency storage in case of delays in the repository program. The incremental unit cost of spent-fuel storage at the MRS facility would be $35 to $40 per kilogram. The utilities' unit cost for spent-fuel storage beyond the capacity they can attain with maximum reracking (replacing old racks with new racks that provide greater storage capacity) of existing storage pools would range from $40 to $110 per kilogram. Therefore, the actual cost savings to the ratepayer of storage provided by the MRS facility would depend on the amount of at-reactor storage that would be offset and the utilities' cost for providing that storage.

TABLE II

Total System Costs For Each Fuel Cycle Scenario
(billions of mid-1985 dollars)

System Scenario	System Costs[a] For: Transportation	MRS	Repository Surface Facilities	Total System Cost
		Basalt Repository		
No-MRS	1.1	0	4.6	5.7
MRS	0.9	2.7	3.5	7.1
		Salt Repository		
No-MRS	0.9	0	4.3	5.2
MRS	0.9	2.7	3.3	6.9
		Tuff Repository		
No-MRS	1.1	0	3.5	4.6
MRS	1.1	2.7	2.8	6.6

(a) All facility costs are from DOE/RW-0044[2]. Repository costs are for surface facility construction and operation only.

Radiological Dose

In the MRS system, additional spent-fuel handling operations would slightly increase occupational exposure, although the doses received by individual workers would be strictly regulated in either system. Public radiation exposure, on the other hand, would be reduced slightly because of reductions in exposure from spent-fuel transportation.

THE FEASIBILITY OF MONITORED RETRIEVABLE STORAGE

Feasibility refers to the ability to carry out or accomplish all components of the MRS system as proposed. Measures of feasibility include the technical maturity, level of certainty of cost and scheduling estimates, and the ability to obtain a license from the Nuclear Regulatory Commission (NRC).

Technical Maturity

The three principal technologies needed in the MRS facility are 1) the handling and loading/unloading of large shielded shipping casks, 2) the disassembly, consolidation and canistering of spent fuel, and 3) the storage of spent fuel. Handling and canistering are required regardless of whether there is an MRS facility. Shielded casks have been used in the nuclear industry since its inception and the equipment for handling and loading/unloading these large heavy casks has been regularly demonstrated.

The removal of fuel rods from assemblies has been carried out in reactor storage pools and hot cells for many years, both for fuel rod inspection and for reconstitution of fuel assemblies for further utilization in reactors. Devices and techniques for the consolidation of rods in a canister have been demonstrated for spent fuel in reactor pools and for unirradiated fuel in a dry environment. Inserting inert gas into the canister voids, welding (sealing) the canister, and helium leak testing are operations that have been performed in the nuclear power industry for many years but not at the production rates proposed for the MRS facility. Spent nuclear fuel has been inspected and stored dry in hot cells, casks, and drywells and shipped dry in casks. Encapsulation and storage of radioactive waste is routine practice at federal government nuclear facilities. Ongoing utility, industry and federal government programs are further refining the application of consolidation and dry storage technologies to the production levels anticipated in both the MRS facility and repository.

Design, Licensing, and Construction

The DOE has evaluated the issues involved in the design, and construction of an MRS facility, has completed a preliminary design of the MRS facility, and has developed a schedule for completing the design, licensing, construction and

startup of the MRS facility. Based on these evaluations, it was judged that the design, licensing and construction activities for an MRS facility are similar to, but less demanding than activities for many other nuclear facilities. Site characterization and analyses of impacts on the environment around an MRS facility will be performed for the most part to the same level of detail as analyses for the licensing of a commercial nuclear power plant. Because there are no new technologies involved in the licensing of an MRS facility and because an MRS facility does not contain a self-sustaining nuclear chain reaction, its safety features are much less complex and licensing complexities are expected to be similarly less than those experienced with a nuclear power plant.

It is therefore believed that, starting from the date of congressional authorization of an MRS facility, a license application can be submitted in 2.5 years, an MRS license can be received within 5 years, and the facility can be constructed and be in the startup phase within 10 years.

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