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# Final Version Dry Cask Storage Study

February 1989		_
U.S. Department of Energy Office of Civilian Radioactive Waste I Washington, DC 20585	Management	
	SAIC T & MSS RESOURCE CENTER	
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## FOREWORD

This report on the use of dry-cask-storage technologies at the sites of civilian nuclear power reactors has been prepared by the U.S. Department of Energy (DOE) in response to the requirements of the Nuclear Waste Policy Amendments Act of 1987 (P.L. 100-203). In particular, Section 5064 of the Amendments Act directs the Secretary of Energy to conduct a study and evaluation of using these technologies for the temporary storage of spent nuclear fuel until such time as a permanent geologic repository has been constructed and licensed by the Nuclear Regulatory Commission (NRC). In conducting this study, the DOE is required to consider such factors as costs, effects on human health and the environment, effects on the costs and risks of transporting spent fuel to a Federal facility, and the extent to which the Nuclear Waste Fund can and should be used to provide funds for at-reactor storage. In addition, the DOE is to consult with the NRC, include the NRC's comments in the report, and solicit the views of State and local governments and the public.

The initial version of this report was issued in September 1988 for review and comment by State and local governments, utilities, other interested parties, and the public. It was also submitted to the NRC for review and comment. After comments were received, responses to the comments were prepared, and the report was revised as appropriate. The final report includes synopses of the comments and the DOE's responses; it also reproduces each of the comment letters in full.

Before being formally submitted to the Congress, the final report will again be sent to the NRC for review and comment. The NRC's final comments will accompany the formal submittal of this report to the Congress.

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# Part I REPORT OF THE DRY CASK STORAGE STUDY

#### **EXECUTIVE SUMMARY**

This report was prepared in response to Section 5064 of the Nuclear Waste Policy Amendments Act of 1987 (the Amendments Act—Public Law 100-203), which directs the Secretary of Energy to conduct a study of the use of dry-cask-storage technology for storing spent fuel at the sites of civilian nuclear reactors until a geologic repository is available. In conducting this study, whose results are being reported to the Congress, the Secretary was to consider such factors as costs, effects on human health and the environment, and the extent to which the Nuclear Waste Fund can and should be used to provide funds for at-reactor storage. In addition, the Secretary was to consult with the Nuclear Regulatory Commission (NRC), include NRC comments in the report, and solicit the views of State and local governments and the public.

The study performed in response to these requirements was based largely on data published by the DOE or the NRC or included in documents issued by the DOE. Among the DOE documents are the 1987 MRS proposal to the Congress\* and a subsequent report, prepared to supply the Congress with additional information on the MRS facility.\*\* Because in evaluating dry storage at reactor sites it is necessary to take into account other options for meeting storage needs, this study covered all forms of atreactor storage.

#### EVALUATION OF COSTS AND OTHER IMPACTS

For evaluating costs and impacts the DOE used the following approach:

- 1. The DOE estimated the additional at-reactor storage capacity that would be required to accommodate spent fuel until it is removed from a reactor site. This required projecting how much spent fuel will be discharged, estimating existing storage capacities, and considering the rate at which spent fuel will be removed from reactor sites by acceptance into the DOE's wastemanagement system.
- 2. The DOE identified and evaluated various options for increasing at-reactor storage in terms of design features, spent-fuel-handling operations, costs, and potential effects on the health

<sup>\*</sup>U.S. Department of Energy, Monitored Retrievable Storage Submission to Congress, DOE/RW-0035, Vol. 2, Washington, D.C., 1987.

<sup>\*\*</sup>U.S. Department of Energy, Additional Information on Monitored Retrievable Storage, DOE/RW-0166, Washington, D.C., 1987.

and safety of the public and the reactor workers. The options evaluated included the consolidation of spent-fuel assemblies and several methods for dry storage.

3. The DOE evaluated the potential effects of the various options for at-reactor storage on transportation.

## Estimates of additional at-reactor storage requirements

The additional-storage requirement is defined in this report as the quantity of spent nuclear fuel that exceeds the maximum storage capacity at a given reactor site. In particular, in this report the DOE assumed that the additional-storage requirement is represented by all the spent fuel that cannot be accommodated in spent-fuel pools that have been reracked to provide the maximum possible capacity (while maintaining a full-core reserve) for storing intact (i.e., unconsolidated) spent fuel.

The cumulative aggregate requirements for additional storage range from 12,200 to 20,000 MTHM. The inventory of spent fuel stored at reactor sites peaks within 4 years of the projected start of spent-fuel acceptance by the DOE in 2003. However, after the year 2007 an increase in storage capacity will be required at a number of reactor sites because the rates at which these reactors discharge spent fuel will exceed the rate at which the spent fuel is removed from their sites. As a result, the cumulative additional-storage requirements continue to increase and do not peak until the years 2012 and 2016 for the lower and the upper bounds, respectively. The number of reactor sites requiring additional spent-fuel storage ranges from 54 (in the year 2012) to 67 (in the year 2016). Since some nuclear power stations consist of several reactors located at the same site, the number of reactors requiring additional storage capacity is higher, 83 to 107 in the years 2012 and 2016, respectively. Moreover, the additional-storage requirements are not evenly distributed among reactors. For the lower-bound storage requirements, 29 of the 54 reactor sites with additional-storage requirements need 200 MTHM or less, but a few have much greater requirements. For the upperbound storage requirement, 37 of the 67 sites need more than 200 MTHM. (For comparison, 200 MTHM is about 40 percent of a typical pool capacity, or the equivalent of about 20 typical dry storage casks loaded with intact spent fuel.)

The estimate of additional-storage requirements is affected by a number of factors, including the projections of spent-fuel discharges, the capacity of the storage pools, and the timing and rate of spent-fuel acceptance by the DOE. The uncertainties associated with each of these factors are addressed in the study. The factor that has the most significant effect is the timing of acceptance by the DOE: a 5-year acceleration or delay of the reference date of 2003 respectively decreases or increases the additional-storage requirements by more than 50 percent.

## Evaluation of dry-storage concepts

The technology for dry storage has been demonstrated. Though the concepts examined in this study differ somewhat in technical maturity, no

significant technical problems are expected. The available technologies are metal casks, dual-purpose casks that can be used for both storage and transportation, concrete casks, horizontal concrete modules, and modular concrete vaults.

The identification and evaluation of various concepts for dry atreactor storage were based on published reports as well as experience in both the United States and other countries. The experience of the U.S. utility in- dustry involves the storage of spent fuel in metal casks and concrete modules; the experience in other countries includes storage in metal and concrete casks.

Metal storage casks. The storage of spent fuel in metal casks is the most mature of all the technologies currently available in the United States for dry storage; it has been demonstrated in the United States since 1984, and a cask-storage facility at one reactor was licensed in 1986. Metal casks are large and specially designed for temporary storage. When the spent fuel is to be transported to a waste-management facility, it will be transferred from the dry-storage cask into an NRC-certified transportation cask. It is also conceivable that certain metal-storage-cask designs could be certified by the NRC for one-time shipment of spent fuel to a waste-management facility.

Dual-purpose casks. Dual-purpose casks are similar to the metal casks described above, but they would be used for storage at the reactor site, transportation to a DOE waste-management facility, and possibly lag storage at the DOE facility. Their use would potentially eliminate the handling operations needed to transfer the spent fuel from storage casks to transportation casks. Dual purpose casks have not been implemented in the United States at this time; however, they are being used in the Federal Republic of Germany.

Concrete storage casks. Concrete casks are similar to the metal casks, except that the body is made of heavily reinforced concrete with an inner metal liner for containment. The casks are either ventilated or unventilated. Concrete casks have not been implemented in the United States, but have been used extensively in Canada. Demonstrations involving the heat-transfer and shielding performance of concrete casks are presently in progress in the United States.

Horizontal concrete modules. Horizontal concrete modules are designed to store spent fuel in large stainless-steel canisters that are filled with a cover gas and sealed inside a concrete module. As of December 1988, one dry-storage facility that uses horizontal concrete casks had been licensed and constructed, and at least three other facilities are at various stages of development.

Modular concrete vaults. A modular-concrete-vault system consists of a vertical array of tubes in which intact spent-fuel assemblies are stored. These tubes are shielded and protected on all sides by the surrounding concrete. This concept has been used in the United Kingdom for approximately 17 years. To date, this concept has not been implemented in the United States, but has been approved by the NRC staff for use with nitrogen as the cover gas.

## Evaluation of in-pool storage concepts

Two options are available for increasing the capacity of existing storage pools: reracking the pools and consolidating the spent-fuel rods into more-compact arrays. Reracking involves the storage of intact spent-fuel assemblies closer together. It has been extensively used by the utilities, and the estimates of additional-storage requirements are based on the assumption that reracking has already been used to maximize the capacity of the storage pools. Consolidation involves removing the spent-fuel rods from the hardware that holds them together in an assembly and rearranging them into more-compact arrays. Six demonstrations of inpool rod consolidation have been performed in the United States. These demonstrations achieved a rod-consolidation ratio of up to 2:1, but none has yet achieved effective compaction and packaging of the non-fuel-bearing hardware that is left after consolidation; typically this hardware also takes up pool space, thereby reducing the effective consolidation ratio.

## Licensing of storage-increase options

Under 10 CFR Part 72, a major document to be submitted as part of the license application for a dry-storage facility is the safety analysis report (SAR), whose purpose is to demonstrate the safety of the drystorage facility design under the conditions specific to the reactor site in question. In practice, vendors of dry-storage systems have attempted to enhance the marketability of their designs by submitting topical reports of their designs to the NRC in advance of utility submittals of site-specific license applications. Although the NRC staff's review of a topical report is not a licensing action, topical reports reviewed and approved by the NRC staff may be referenced in the SAR for a sitespecific licensing application. This can shorten the time involved in licensing because the NRC staff can focus its safety reviews during the licensing process to ensure that the site use and proposed facility operations are safe, rather than having to devote a significant effort to review the design. If a site-specific application involves differences or discrepancies with respect to the design described in an approved topical report, additional analyses may be required by the NRC. Despite the potential benefit of using a design whose topical report has already been approved, the site-specific licensing process includes an opportunity for a public hearing and is subject to intervention through litigation. As a result, the process may entail the delays that have been experienced by some utilities in obtaining amendments to their reactor-operating licenses. Limited experience with licensing to date has required 2 to 4 years to obtain a license in the absence of significant intervention. At present, allowing about 2 years for licensing appears reasonable when an NRC-approved technology is involved.

The NRC staff is currently developing a proposed rule for consideration by the Commission; this rule would amend 10 CFR Part 72 to provide a process for the issuance of generic certificates of compliance for drystorage casks. A utility with a nuclear-plant license issued under 10 CFR Part 50 could register with the NRC to store spent fuel in NRC-certified casks and to use these casks for storage without further cask-

certification activities. This proposed rule could significantly reduce the licensing-related activities that are currently required to provide dry storage at a reactor site. It is possible for the NRC to develop a similar rule for dry-storage systems other than casks, but no NRC announcement to this effect has been made at this time.

To date, the NRC has granted licenses for storage in metal casks and in horizontal concrete modules. In addition, the NRC staff has approved a topical report for the use of modular concrete vaults and is evaluating a topical report on concrete casks. Storage in concrete casks has no apparent deficiencies that would preclude its approval by the NRC. However, a potential issue is the structural integrity of concrete at the temperatures expected in the cask.

To use metal casks designed for dual-purpose service, a utility will have to obtain an NRC license for storage under 10 CFR Part 72 and have the cask certified by the NRC under the transportation regulations in 10 CFR Part 71. Some metal-cask vendors have indicated that they plan to apply to the NRC for transportation certificates. Some designers of casks have incorporated features and used materials that may make it possible to certify these casks for transportation under 10 CFR Part 71. However, the licensing and certification of these casks will have to address concerns about using the casks for transportation after extended use for storage.

The licensing process for rod consolidation is different from the one described for dry storage in that dry cask storage involves a new license under 10 CFR Part 72, while consolidation, where it increases the number of assemblies permitted to be stored in the pool, involves an amendment to the 10 CFR Part 50 license. To the extent that utilities have consolidated spent-fuel rods as a demonstration, they have performed these limited consolidations under 10 CFR 50.59. First of all, the technology itself, consolidation, does not need approval from the NRC because the fuel-handling operations involved are typically within the scope of those authorized in the operating license for the reactor. But, in order to increase the capacity of a storage pool, a utility must apply for an operating-license amendment that authorizes such an increase. Storage in the pools is covered under the reactor-operating license issued by the NRC under 10 CFR Part 50. Thus, the license issued under 10 CFR Part 50 must be amended in a formal licensing action. To date, one reactor has obtained such a license amendment.

## Estimated costs

The cost estimates were extracted from cost estimates provided by vendors, utilities that are currently developing storage facilities, and other DOE studies that currently exist in the literature. Cost uncertainties were typically not available but are illustrated by variations in the reported cost estimates. Cost estimates may vary for several reasons, including differences in accounting methods, site-specific differences, and varying estimates of achievable cost reductions due to technology advancements or improvements in production methods. The cost estimates provided in this report are intended only to estimate the

likely system-wide costs resulting from at-reactor storage requirements and are not intended to be used by a utility for the selection of a storage technology.

In this context, the DOE feels that a high degree of certainty is associated with the unit-cost range presented. While site-specific factors may cause some sites to incur higher costs than the high-range cost estimates, and technological evolution may result in the possibility of lower-cost storage at some sites, it is regarded as unlikely that the system-wide average unit costs will be outside the range presented.

The estimates of costs for at-reactor storage are associated with large uncertainties, partly because some of the technologies are not yet fully mature and partly because it is not possible to draw conclusions about which storage methods are likely to be chosen by the utilities. Because it is not possible to determine how much of the additional storage capacity is likely to be provided by a particular storage method, the analyses of costs used assumptions that bound the ranges of unit impacts for all of the storage options.

The estimated unit costs for each option, in dollars per kilogram of heavy metal, are as follows:

Car	Capacity increase			
100 MTHM	300 MTHM	1000 MTHM		
red				
40-75	30-50	NA*		
60-115	55~105	55-100		
50-110	45-95	45-85		
60-80	45-60	40-55		
105-155	70-105	45-70		
	100 MTHM red 40-75 60-115 50-110 60-80	100 MTHM 300 MTHM  red 40-75 30-50 60-115 55-105 50-110 45-95 60-80 45-60		

\*An increase of 1000 MTHM is not applicable to rod consolidation because at a typical reactor not much more than approximately 350 MTHM of additional storage space can be gained through consolidation.

The unit costs of dual-purpose casks are estimated to be slightly higher than those of the metal casks because of such factors as cask modifications and certification requirements. These additional costs are about \$7 per kilogram of heavy metal more than for metal storage casks for unconsolidated fuel and about \$5 per kilogram of heavy metal more than for storing consolidated fuel in metal casks.

In estimating the aggregate costs of at-reactor storage, the application of the unit-cost ranges for each storage technology is not

straightforward, partly because the level of confidence that the lower-bound cost for a technology can be achieved varies among the storage technologies. Several cost estimates were therefore developed for this study. These estimates consist of the unit-cost range for a storage technology that has been fully evaluated and demonstrated in the United States (the current design of the metal storage cask), the cost reductions expected from future technology improvements that are believed to be likely, and the lowest cost believed to be achievable in the future for any of the technologies examined in this report.

In addition to the large uncertainty in unit costs, the aggregate cost of additional at-reactor storage has a source of uncertainty resulting from uncertainties about the aggregate storage requirements and their distribution among reactor sites. For the lower bound of the storage requirements with the spent-fuel-acceptance case used as the "reference case" for the purposes of this study only (a repository-only system that starts spent-fuel acceptance in 2003), the aggregate cost for proven technology is about \$950 million to about \$1.3 billion, the cost with likely technology improvements is about \$700 million, and the lowest cost believed achievable in the future is about \$470 million. For the upper bound of the storage requirements with the reference case, the aggregate cost for the proven technology is about \$1.5 billion to just about \$2.1 billion; the cost with likely technology improvements is about \$1.1 billion; and the lowest cost believed to be achievable is about \$800 million. These estimates of the aggregate costs of at-reactor storage would be decreased or increased by more than 50 percent if spent-fuel acceptance by the DOE, assumed to start in the year 2003 in the reference case, is accelerated or delayed by 5 years because of the effect of such acceptance-schedule changes on additional-storage requirements.

## Health-and-safety impacts

In the "Waste Confidence Decision," the NRC reported finding "reasonable assurance that spent fuel...can be stored safely and without significant environmental impacts" in reactor storage pools or in independent spent-fuel storage installations.\* The NRC's findings were supported by experience in more than 80 individual safety evaluations of spent-fuel storage facilities. A bibliography on this topic is included in Appendix A. For both dry storage and reactor-pool storage, the NRC stated its belief that current storage technologies are capable of providing safe storage for at least 30 years beyond the expiration of the operating license. The NRC also concluded that the possibility of a major accident or sabotage at a spent-fuel-storage facility with radiological consequences for the public is extremely remote.

These findings are supported by the environmental assessments prepared by the NRC for the two dry-storage facilities that have been

<sup>\*</sup>U.S. Nuclear Regulatory Commission, "Waste Confidence Decision," Federal Register, Vol. 49, No. 171, August 31, 1984.

licensed to date in the United States. These facilities are at the sites of the H. B. Robinson reactor in North Carolina and the Surry reactor in Virginia. The annual dose commitment received under normal operating conditions by the "nearest real individual" is estimated at approximately 0.4 millirem for the H. B. Robinson site and about 0.00006 millirem for the Surry site. These dose commitments represent less than 2 and 0.0003 percent, respectively, of the applicable regulatory limit in 10 CFR 72.67. The estimated dose for Surry is lower than that for H. B. Robinson because the nearest real individual is considerably farther away (1.5 miles as compared with 0.3 mile) from the dry-storage facility.

The dose estimates for other reactor sites will depend on various site-specific factors, such as the dry-storage technology that is used, the quantity of spent fuel that is stored, the distance at which the "nearest real individual" is located, the size of the exposed population, and atmospheric conditions. However, the estimates presented above for the H. B. Robinson and the Surry sites support the generic calculations that have been made for the various dry-storage technologies and indicate that the radiation doses expected to result from dry storage at reactor sites are extremely low.

## Transportation impacts

The last of the impact analyses examined potential effects on spent-fuel transportation to a DOE waste-management facility. The results indicate that none of the evaluated dry-storage options would significantly affect transportation unless the spent fuel is consolidated. For transportation, intact spent fuel that is stored in casks or other dry-storage devices must be transferred to the same type of shipping cask that would be used for intact spent fuel stored in pools. Thus, no modifications to the transportation system are needed, and there are no changes in the transportation operations or in the number of shipments required for a given quantity of spent fuel. If the spent fuel is consolidated, some reductions in the number of shipments can be achieved, depending on the design of the transportation casks.

The use of dual-purpose casks for storing and subsequently transporting the spent fuel may decrease the number of transportation-only casks that are required. However, the overall cost and risk impacts on the transportation system would be minimal.

#### USE OF THE NUCLEAR WASTE FUND

The second objective specified for this study by the Amendments Act requires the DOE to consider "the extent to which amounts in the Nuclear Waste Fund...can be used, and should be used, to provide funds to construct, operate, maintain, and safeguard spent fuel in dry cask storage" at reactor sites.

The Nuclear Waste Policy Act of 1982 does not appear to authorize the use of the Nuclear Waste Fund for providing direct financial support

for storage at reactor sites. It specifies (Section 302(d)) that expenditures from the Nuclear Waste Fund may be made only for purposes of radioactive-waste disposal and related activities; the latter specifically exclude short-term, or interim, storage. If interim storage is needed before the DOE begins to accept spent fuel, the DOE is to use a separate fund established for that purpose—the Interim Storage Fund. There are restrictions, however, on the use of the Interim Storage Fund; they require utilities to be certified eligible by the NRC, to enter into contracts with the DOE before January 1990, and to pay the DOE the full cost of providing such interim storage.

The DOE will consider mechanisms whereby the utilities can realize benefits resulting from at-reactor spent-fuel-management activities if such activities can be demonstrated to be beneficial to the overall waste-management system. Systems-integration studies being conducted by the DOE are examining the potential for at-reactor activities to contribute to the goals of the waste-management system. As these efforts proceed, the DOE will discuss them with potentially affected parties and factor them, as appropriate, into program planning, facility design, and future recommendations to the Congress.

## VIEWS OF THE NRC AND THE PUBLIC

The initial version of this study was distributed for review and comment by the NRC, State and local governments, the utilities, other interested parties, and the public. It was then revised as appropriate in response to the comments received (see Part II—Record of Comments and Responses). This final report will also be submitted to the NRC for final review and comment.

## Chapter 1

#### INTRODUCTION

This chapter presents the legislative requirements for this study, states the objectives of the study, and discusses the approach used to achieve the objectives. It also explains the organization of the report.

## 1.1 LEGISLATIVE REQUIREMENTS FOR THE STUDY

The Nuclear Waste Policy Amendments Act of 1987 (the Amendments Act—Public Law 100-203), Section 5064, requires the Department of Energy (DOE) to study and evaluate dry-cask-storage technology for the temporary storage of spent nuclear fuel at the sites of civilian power reactors until a geologic repository is available for receiving the spent fuel. In conducting this study, whose results are to be reported to the Congress, the Secretary of Energy was to consider such factors as costs, effects on human health and the environment, and the extent to which the Nuclear Waste Fund can and should be used to provide funds for at-reactor storage. In addition, the Secretary was to consult with the Nuclear Regulatory Commission (NRC), include the NRC's comments in the report, and solicit the views of State and local governments and the public.

The DOE has been supporting the development of dry at-reactor storage in accordance with the requirements of the Nuclear Waste Policy Act of 1982 (NWPA--Public Law 97-425). Section 218 of the NWPA required the Secretary of Energy to establish a demonstration program, in cooperation with the private sector, for dry storage at reactor sites. The Secretary was also to undertake a cooperative program with the utilities to encourage the development of technologies for consolidating the spent fuel into more-compact arrays to increase the capacity of the storage pools existing at reactor sites.

To meet these provisions of the NWPA, the DOE established a storage program that included participation in cooperative demonstration programs with utilities as well as cost-shared research-and-development programs at Federal facilities. Considerable progress in this program has been achieved. For example, dry-storage demonstrations and research at the DOE's Idaho National Engineering Laboratory and the Pacific Northwest Laboratory contributed to the NRC's granting two utilities licenses to construct and operate dry-storage facilities (independent spent fuel storage installations) at the sites of two reactors. The operation of these facilities will demonstrate the technical feasibility and the economics of adding storage capacity in metal or concrete modules at reactor sites. The feasibility of in-pool consolidation has also been successfully demonstrated, and now the nuclear industry is proceeding independently with its development.

Since both dry-storage and consolidation technologies can be used to increase at-reactor storage capacity, dry-storage concepts as well as rod consolidation for storage in spent-fuel pools are examined in this study.

## 1.2 THE OBJECTIVES OF, AND THE APPROACH USED IN, THIS REPORT

The Amendments Act specifies two principal objectives for the dry cask storage study. This section states those objectives and briefly describes the approaches used to meet them. It also discusses the review-and-comment process for this report.

## 1.2.1 Evaluation of costs and impacts

The first objective of this study is to meet the the following requirement of the Amendments Act: in conducting the study the Secretary is to consider—

The costs of dry cask storage, the extent to which such storage at reactor sites will affect human health and the environment, the extent to which the storage on the sites of civilian nuclear power reactors affects the costs and risk of transporting spent fuel to a central facility such as a monitored retrievable storage facility, and any other factors the Secretary considers appropriate.

To achieve this objective, the following approach was used:

- Estimates were made of the additional at-reactor storage capacity\* that would be required to accommodate spent fuel until a geologic repository becomes available.
- 2. Dry storage methods for at-reactor storage were identified and evaluated in terms of design features, spent-fuel-handling operations, costs, and potential effects on the health and safety of both the public and the reactor workers. These methods include in-pool storage with consolidation and dry storage in casks, modules, or vaults.
- 3. The potential effects of the various at-reactor storage options on transportation were evaluated.

<sup>\*</sup>The requirements projected in this report for <u>additional</u> spent-fuel storage are based on the assumption that the storage pools of all reactors will be reracked to store the maximum number of intact spent-fuel assemblies that can be accommodated in the existing pools.

The consolidation of spent-fuel rods was considered as a method for increasing the capacity of both storage pools and dry-storage designs.

The estimates and evaluations performed in this study were based on existing data. They were largely derived from various analyses and documents published by the DOE and its contractors or included in documents issued by the NRC. Among the DOE documents are the MRS proposal to the Congress and a subsequent report, prepared to supply the Congress with additional information on the MRS facility. The descriptions of various dry-storage methods as well as options for expanding in-pool storage capacity are based on the literature, experience in the United States and in other countries, and the results of research sponsored by the DOE.

## 1.2.2 The use of the Nuclear Waste Fund

The second objective specified for this study by the Amendments Act requires the Secretary to consider--

The extent to which amounts in the Nuclear Waste Fund...can be used, and should be used, to provide funds to construct, operate, maintain, and safeguard spent fuel in dry cask storage at the sites for civilian nuclear power reactors.

This objective was addressed by separately considering two questions:

- 1. Is the DOE authorized under the Nuclear Waste Policy Act of 1982 (Public Law 97-425), which established the Nuclear Waste Fund, to provide monies from the Fund for dry at-reactor storage?
- When and under what conditions would it be appropriate to use monies from the Fund for at-reactor storage?

The first question was addressed by examining the applicable provisions of the NWPA, the legislative history of the NWPA, and records of Congressional hearings. The second question was addressed by considering (1) the circumstances under which monies from the Fund should be authorized and made available for at-reactor storage and (2) reviewing the DOE's policy on support for utility initiatives.

#### 1.2.3 Process for review and comment

As required by the Amendments Act, the initial version of this report was distributed for review and comment by State and local governments, utilities, other interested parties, and the public. It was also submitted to the NRC for review and comment. After the comments were received, the report was revised as appropriate. Synopses of the comments and the DOE's responses are presented in Part II of this report. This final report will again be submitted to the NRC for review and will be submitted to the Congress together with the final NRC comments.

#### 1.3 ORGANIZATION OF THE REPORT

This report consists of three parts. Part I is the body of the report. Part II is a comment-response document that presents synopses of the comments received by the DOE on the initial version of the report and the DOE's responses; it also contains an index of comments and responses. Part III reproduces each of the comment letters.

The remainder of Part I of this report is divided into six chapters. Chapter 2 provides background information, and Chapter 3 presents estimates of the requirements for additional storage. Chapter 4 describes the various options that are available for increasing the capacity of storage pools and for providing dry storage; it also discusses the costs of each option. Chapter 5 presents estimates of the potential aggregate costs for all U.S. reactors with additional-storage requirements, discusses potential effects on human health and the environment, and examines potential effects on the transportation system. Chapter 6 considers the use of the Nuclear Waste Fund for providing additional at-reactor storage. Chapter 7 contains a summary and conclusion. Part I ends with Appendix A, which presents some additional information requested by the reviewers of the initial version of the report.

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## Chapter 2

#### BACKGROUND

To provide background information that may be beneficial in understanding this report, this chapter begins by briefly discussing the storage of spent fuel at reactor sites, including both methods for increasing the capacity of existing spent-fuel pools and methods of dry storage. It then briefly examines the licensing of at-reactor storage.

## 2.1 THE STORAGE OF SPENT FUEL AT REACTOR SITES

After being removed from the reactor, the spent fuel is stored under water in a storage pool at the reactor site. Typically, about one-third of the fuel assemblies in a reactor are removed and replaced by fresh fuel once every fueling cycle. At present, utilities are using fueling cycles of 12 to 24 months, depending on the reactor type, fuel, and operating conditions.

The storage pools at reactors are designed to store a limited amount of spent fuel, with the pools of many older reactors being smaller than those of new reactors. (When the pools at these reactors were designed, it was assumed that the spent fuel would be removed in a few years for chemical reprocessing to recover uranium and plutonium.) The Standard Review Plan¹ used by the staff of the Nuclear Regulatory Commission (NRC) in reviewing reactor-license applications specifies that the minimum design capacity of the storage pool should be sufficient to accommodate one full reactor core and the maximum quantity of spent fuel that is discharged in one fueling cycle. As prudent operating practice, most utilities reserve in each storage pool sufficient space to accommodate one full reactor core. Thus, the term "storage-pool capacity" means the amount of spent fuel that can be accommodated in the pool while maintaining a "full-core reserve."

Ultimately, if there is not enough space in the storage pool to accept a planned discharge of spent fuel, the utility must either remove from the pool some of the spent fuel that has been stored there or stop operating the reactor. In some cases, if the utility is operating nuclear power plants at several different sites, the spent fuel removed from the pool may be shipped to another site for storage in a pool that has sufficient space. Such "transshipment," however, is not available for most reactors, and it provides only a temporary solution for a limited amount of spent fuel. In the past, transshipment has usually encountered significant public resistance. In this study, transshipment is not considered to be an option of choice for those utilities for which it is available.

Since according to the DOE's draft 1988 Mission Plan Amendment<sup>2</sup> a geologic repository for the permanent disposal of the spent fuel is not

expected to be available until the year 2003,\* a number of utilities may be faced with a shortage of storage capacity for their spent fuel. The storage capacity can be increased by increasing the capacity of the storage pools or by providing dry storage outside the pool. In-pool capacity can be increased by changing the racks that hold the spent-fuel assemblies inside the pool and by consolidating the fuel rods into morecompact arrays.

## 2.1.1 Increasing in-pool capacity

Initially, the racks that hold spent-fuel assemblies in the storage pools were not designed to maximize the amount of spent fuel that can be stored in a pool. The storage capacity of a spent-fuel pool can be increased by reracking the pool—that is, changing the configuration of the racks that hold the spent-fuel assemblies in a manner that satisfies criticality and other constraints, as discussed below.

Criticality is the ability of an array of nuclear fuel to sustain a neutron chain reaction. Since it could cause a large increase in the heat-generation rate of the fuel, criticality could result in significant damage to the fuel, an increase in radiation dose rates, and possibly large releases of radioactive material. For this reason, great care is given in the design and the licensing of nuclear facilities to ensure that an inadvertent criticality event will not occur. According to criteria promulgated by the NRC, facilities for spent-fuel storage must be designed to prevent, by a safe margin, the occurrence of criticality even under accident conditions, and this may limit the quantity of spent fuel that can be stored in a given pool as well as the configuration in which it is stored.

In terms of criticality, the amount of fuel that can be stored inside a given storage pool depends on both the geometric configuration of the fuel and on the materials used in the storage racks. Geometrically, the single most important factor is the spacing between the spent-fuel assemblies. Usually the racks provide more spacing than is needed to preclude a potential for criticality, and therefore more spent fuel can be accommodated if the standard racks are replaced with racks providing closer spacing. To provide even closer spacing without creating a

<sup>\*</sup>According to the DOE's draft 1988 Mission Plan Amendment, the Federal waste-management system will include, in addition to the geologic repository, a facility for monitored retrievable storage (MRS), as authorized by the Nuclear Waste Policy Amendments Act of 1987. The integrated schedule for this authorized system shows that the MRS facility will start accepting spent fuel in 2003, but it may be possible to accelerate this schedule.

potential for criticality, it is necessary to use racks that contain neutron-absorbing materials (principally boron carbide)<sup>3,5</sup>, use racks that depend on water and stainless-steel flux traps, or impose fuel-burnup requirements to preclude criticality.

Besides criticality, a number of other factors must be considered in reracking. One of the most important is structural strength—that is, the ability to safely support the weight of the additional spent fuel. Others include ability to meet the NRC's seismic criteria, heat generation and pool cooling, shielding from radiation, water cleanup, and ability to accommodate in-service inspection.

Reracking is usually the initial choice of utilities for increasing storage capacity at reactor sites because the technology for reracking is fully developed and reracking is usually the least expensive of all available options. At the sites of U.S. civilian reactors, high-density racks that permit the minimum spacing between spent-fuel assemblies have been installed in nearly all spent-fuel storage pools where an evaluation shows that the pools can support the additional weight of more fuel assemblies. 5,6. Such reracking has typically increased pool capacities from one and one-third reactor cores up to four and one-third cores.

Rod consolidation, another option for increasing in-pool capacity, involves mechanically removing the fuel rods from the hardware that holds them together in a spent-fuel assembly and rearranging them in a more compact array inside a metal canister. At-reactor consolidation is performed under water in the spent-fuel-storage pools.

Like reracking, the storage of consolidated rods is constrained by the structural strength and seismic characteristics of the storage pool. However, with consolidation the potential for criticality is lower than it is in reracking for the storage of intact spent-fuel assemblies. This is because in an intact assembly the spacing between the fuel rods is carefully designed and maintained to enhance nuclear reactivity while in the reactor core. The closely packed array of spent-fuel rods that results from consolidation has a lower reactivity than intact assemblies, even though the density of the fissile materials is higher.

## 2.1.2 Dry-storage concepts

In addition to expanding in-pool capacity, the capacity of atreactor storage can be increased by providing dry storage in various
types of casks, modules, or vaults located outside the pools. Such drystorage concepts include metal casks, concrete casks, horizontal concrete
modules, modular concrete vaults, and dual-purpose casks. Dry storage
can accommodate either intact spent-fuel assemblies or canisters of consolidated spent fuel. A more detailed description of the concepts and
the operations involved in their use is given in Chapter 4.

The metal casks that could be used at reactor sites are usually large casks designed for temporary storage. When the spent fuel is to be

transported to a waste-management facility, it would be transferred from the storage cask to a shipping cask. However, it is also conceivable that certain metal storage cask designs could be certified by the NRC for a one-time shipment of spent fuel to a waste-management facility.

Concrete storage casks are similar to the metal casks, except that the body of the cask is made of heavily reinforced concrete. Unlike storage in metal casks, storage in concrete casks has not yet been licensed by the NRC at any site; however, a topical report on this technology has been submitted to the NRC staff and is being reviewed.

For storage in horizontal concrete modules, spent fuel is encapsulated in metal canisters that are then emplaced in concrete modules. The use of this dry-storage technology has been licensed by the NRC for use at one reactor site. A license application for another site has been submitted, and there are firm plans to implement this technology on at least two additional reactor sites.

A modular concrete vault consists of a vertical array of tubes in which intact spent-fuel assemblies are stored. These tubes are shielded and protected on all sides by concrete. To date, this concept has not been implemented in the United States, but the NRC staff has approved the topical report submitted for this system by a prospective vendor.

Dual-purpose casks are similar to the metal casks described above, but they would be used for storage at the reactor site, transportation to a DOE waste-management facility, and possibly lag storage at the DOE facility. Their use would eliminate the handling operations needed to transfer the spent fuel from storage casks to transportation casks. However, the dual-purpose concept has not yet been licensed by the NRC, and there are issues still to be resolved before obtaining NRC certification for transportation after extended use for storage.

The spent fuel that will be stored in any of these dry-storage systems will not be fuel that has just been discharged from a reactor: it will be fuel that has been stored in a spent-fuel pool for at least one year (most likely several years) to diminish its radioactivity and the rate of heat generation. All freshly discharged spent fuel will be stored first in the spent-fuel pool. Thus, if dry storage is to be used at a reactor site where the spent-fuel pool is filled to capacity, it will be necessary to remove from the pool spent fuel that has been stored under water for at least a year and transfer it to dry-storage facilities. The spent fuel will be removed by loading it into a storage cask under water, inside the pool, lifting the loaded storage cask from the pool, and transferring the cask to the dry-storage facilities. Alternatively, a transfer cask could be used for removing the spent fuel from the storage pool, moving it to the dry-storage facilities, and loading it into the dry-storage cask, module, or vault. All of these removaland-transfer operations would be scheduled to take place when no other operations are required or are under way in the storage pool. In addition, in scheduling these operations, it would be necessary to ensure that the necessary operating personnel are available.

#### 2.2 NRC LICENSING CONSIDERATIONS

Except for the consolidation and storage of small amounts of spent fuel, the methods discussed in this report for increasing at-reactor storage will require licensing by the NRC. Licensing considerations are important because licensing can be a protracted process. This section briefly discusses the regulations and the processes that are expected to be applied in licensing the various options considered in this report.

A formal licensing action includes an opportunity for a public hearing and is subject to intervention through litigation. As a result, a formal licensing action may entail the delays that have been experienced by some utilities in obtaining amendments to their reactor-operating licenses.

An example of such a delay can be seen in the experience of the Pacific Gas & Electric Company, which wished to rerack the storage pools of its Diablo Canyon plant and in October 1985 applied to the NRC for a license amendment allowing an increase in the quantity of spent fuel stored in the pools. In February 1986, three intervenors asked the NRC to hold hearings on the proposed reracking, but, as allowed by the Atomic Energy Act and the NRC's implementing regulations, the NRC approved the license amendment before holding the hearings. The intervenors asked the Ninth Circuit Court of Appeals to review the NRC's decision, and in September 1986, the court ruled that the NRC had violated its regulations. Public hearings before an Atomic Safety and Licensing Board were then held to address the technical concerns of the intervenors. The board determined that the concerns of the intervenors were unfounded, and in October 1987 the NRC reissued the license amendment. However, one of the intervenors appealed the NRC's decision and asked for a delay in the reracking. In response, both the Atomic Safety and Licensing Board and the Ninth Circuit Court of Appeals agreed to review the NRC's decision but denied the delay request. These decisions allowed the utility to begin reracking the Diablo Canyon storage pools while the appeal proceeds, but by mid-1988 the appeal process had not been completed.

In another instance, a delay was experienced in a licensing action involving an increase in pool storage through consolidation. When the Maine Yankee Power Company submitted in 1979 an application to the NRC for an amendment to its operating license, a local antinuclear group petitioned for leave to intervene and was admitted. By 1980, the necessary supplements were filed, but at that point the State of Maine also successfully petitioned for leave to intervene. By mid-1983 no trial date had been set, and the utility, seeing no end to the licensing process, abandoned the project. The utility currently has no plans to pursue consolidation as a means of increasing its at-reactor storage capacity.

As already mentioned, spent fuel can be stored either in a pool or in dry-storage facilities. Though both types of storage may be used at the same reactor site, they are subject to different NRC regulations. This is because the spent-fuel pool is considered to be an integral part of the nuclear power plant. Dry-storage facilities, on the other hand,

are independent facilities that are considered not to be an integral part of the plant.

Storage in spent-fuel pools is included in the license issued for the nuclear power plant by the NRC under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Dry storage in an independent spent-fuel storage installation (ISFSI) at reactor sites or elsewhere is subject to the regulations contained in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

Consolidation where it increases the number of assemblies permitted to be stored in the spent fuel pool involves an amendment to the 10 CFR Part 50 license. To the extent that utilities have consolidated limited numbers of spent-fuel rods as a demonstration, they have performed these consolidation programs under 10 CFR 50.59.

The NRC staff has indicated that, for demonstration purposes, small quantities of spent fuel (up to 50 fuel assemblies) can be consolidated and stored under the provisions of 10 CFR 50.59 without the need for license amendments or changes in technical specifications. Under 10 CFR Part 50.59, the licensee may "conduct tests or experiments not described in the safety analysis report without prior Commission approval, unless the proposed change, test or experiment involves a change in the technical specifications incorporated in the license or an unreviewed safety question."

In the case of dry at-reactor storage, which is governed by the NRC regulations in 10 CFR Part 72, the process is different from that for an amendment to a license issued under 10 CFR Part 50. Under 10 CFR Part 72, a major document to be submitted as part of the the license application for a dry-storage facility is the safety analysis report (SAR), whose purpose is to demonstrate the safety of the dry-storage facility design under the conditions specific to the reactor site in question. In practice, the vendors of dry-storage systems have attempted to enhance the marketability of their designs by submitting topical reports on their designs to the NRC in advance of utility submittals of site-specific license applications. Although the NRC's review of a topical report is not a licensing action, topical reports reviewed and approved by the NRC may be referenced in the SAR for a site-specific licensing application, thereby offering the possibility for reducing the time involved in the licensing process.

The topical report includes a description of the design and generic applications and operations for which it is to be used. The topical report must provide extensive information about the technology, including a safety analysis report and comprehensive test data. The NRC 's staff review and approval of the topical report does not constitute a formal licensing action and is therefore not subject to intervention.

Upon approving a topical report, the NRC staff issues a letter of approval to the vendor for the dry-storage design and its proposed generic applications as covered by the report. As of mid-1988, the NRC

staff had approved topical reports for three types of metal storage casks and one design each for horizontal concrete modules and concrete modular vaults. A topical report for a concrete storage cask has been submitted to the NRC for review.

Under the current provisions of 10 CFR Part 72, an application for a license to construct and operate an at-reactor dry-storage facility (i.e., an ISFSI) is to include a safety analysis report. This report must contain a detailed description and discussion of the major structures and the operating characteristics of the facility, including a detailed design; an analysis and evaluation of the design and the performance of the structures, systems, and components important to safety; and supporting information and data compiled in prior demonstrations of the performance of the structures, systems, and components important to safety.

If a utility elects to establish an at-reactor dry-storage facility that uses a technology previously reviewed and approved by the NRC staff in a topical report, the license application may reference the NRC-staff-approved design. Morever, many of the additional requirements of 10 CFR Part 72 for technical information in the application can be satisfied by citing the information reviewed and approved by the NRC in licensing the nuclear power plant under 10 CFR Part 50. This information includes the technical qualifications of the applicant, a description and safety assessment of the site, and a description of the applicant's plans for coping with emergencies. Such incorporation by reference significantly simplifies and streamlines the process of obtaining an NRC license for a dry-storage facility that is based on a technology previously approved by the NRC staff.

As of December 1988, two utilities had obtained NRC licenses under 10 CFR Part 72 for dry-storage facilities. One of these facilities uses Castor V/21 metal storage casks approved by the NRC staff, and in the future it may use metal casks supplied by other vendors. The second facility uses the NRC-staff-approved horizontal concrete storage modules. (The latter technology is also proposed for use in a dry-storage license application by a third utility and has been selected for implementation on at least two other reactor sites.)

Most of the design options currently available for at-reactor storage are involved in the ongoing DOE-sponsored demonstration and cooperative programs authorized in Section 218 of the NWPA. The NWPA provides, as an objective of this program, the establishment of "one or more technologies that the Commission may, by rule, approve for use at the sites of civilian nuclear power reactors without, to the maximum extent practicable, the need for additional site-specific approvals by the Commission."

Consistent with this objective, the NRC staff is currently developing a proposed rule for consideration by the Commission; this rule would amend 10 CFR Part 72 by providing a process for the issuance of generic certificates of compliance for metal and concrete dry-storage casks. This process is conceptually analogous to the NRC's certificates of compliance for transportation casks. Such a certification, in contrast to the letter of approval for a topical report, represents a formal regulatory action.

The proposal under development envisions an amendment to 10 CFR Part 72 to specify the following process for the vendors of dry-storage casks and the utilities planning to use the casks:

- The vendor of the storage cask would submit to the NRC an application for a certificate of compliance for the use of its cask in the storage of spent fuel. The content of the application would be similar to that of the topical report that is now required by the NRC.
- A utility with a nuclear-plant license issued under 10 CFR Part 50 could register with the NRC to store spent fuel in NRC-certified casks and use these casks for storing spent fuel at the reactor site without further licensing activities if there are no unreviewed safety issues. The license issued by the NRC under 10 CFR Part 50 would constitute evidence of compliance with other regulatory requirements for dry storage, such as safeguards and security.

If the developers and vendors of casks certified by the NRC for dry storage desire to expand the usefulness of these casks to include spent-fuel transportation, they must obtain NRC certificates of compliance for using the casks in transportation applications regulated under 10 CFR Part 71, "Packaging and Transportation of Radioactive Material." To date no dual-purpose casks have been approved by the NRC staff for the storage and transportation of spent fuel.

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## Chapter 3

## ASSESSMENT OF REQUIREMENTS FOR ADDITIONAL AT-REACTOR STORAGE

The pools that are used to store spent fuel at reactor sites have limited capacities. The cumulative quantity of spent fuel that exceeds the maximum storage-pool capacity for intact spent-fuel assemblies is the additional-storage requirement. In particular, in this report it was assumed that the additional-storage requirement is represented by all the spent fuel that cannot be accommodated in spent-fuel pools that have been reracked to provide the maximum possible capacity for intact spent-fuel assemblies.

This chapter presents estimates of the additional-storage requirements and the basis for this estimate. It briefly examines the principal factors that affect the additional-storage requirements, explains how the requirements were estimated, and shows the geographic distribution of the requirements.

## 3.1 FACTORS AFFECTING ADDITIONAL-STORAGE REQUIREMENTS

Both the magnitude and the duration of additional-storage requirements for each reactor are determined by three basic factors: (1) the cumulative spent-fuel discharge; (2) the number of intact spent-fuel assemblies that can be accommodated in the spent-fuel pool, and (3) the rate of spent-fuel removal from the reactor site. Each of these factors is briefly discussed below.

## 3.1.1 Forecasts of spent-fuel discharges

For a given reactor, the quantity of spent fuel discharged depends on the reactor's energy production and the amount of energy production per unit of fuel. Uncertainties are associated with the projections of both of these amounts.

The amount of energy production per unit of fuel, usually called "burnup," also varies among nuclear power plants and to some extent for a given plant. In recent years, there has been a trend toward higher burnup levels (more energy produced per unit weight of fuel), and economic factors favor the continuation of this trend. The designs and compositions of the nuclear fuel rods are being changed to allow higher burnup levels at most reactors. The extent to which this trend will continue—and hence what the average burnup will be—is subject to some uncertainty.

Each utility that owns a nuclear power plant has operating plans that quantify the factors discussed above. For each reactor, the utilities report operation forecasts to the Energy Information Administration (EIA) of the Department of Energy (DOE) in a mandatory survey that uses a standard form (the DOE Nuclear Fuel Data Form RW-859). Information from these utility reports (submitted in 1987) was used in this study as the basis for developing a forecast of spent-fuel discharges for the future. This forecast, based on plants currently operating or under construction, is referred to as the "aggregate RW-859 forecast."

Since the operating plans for reactors are not always achieved and the time needed to construct a nuclear power plant is generally increasing, the aggregate RW-859 forecast may be an optimistic forecast of nuclear-energy production, with an upward bias in projected spent-fuel discharges. For this reason, the EIA prepares a series of nuclear-energy generation and spent-fuel forecasts that are based on industry-average performance and on slightly more pessimistic assumptions about the completion of plants now under construction. Several forecasts are prepared, differing primarily in the long-term assumptions about U.S. economic growth, electrical energy demand, and the share of electrical energy produced by nuclear plants.

In addition to the aggregate RW-859 forecast, three EIA spent-fuel projections, made in 1987, were considered in this analysis; all three assumed that burnup would continue to increase in the near future. The three forecasts considered are the no-new-orders case, the lower reference case, and the upper reference case (Figure 3-1). Spent-fuel discharges are shown in metric tons of heavy metal (MTHM), a common measure that refers to the heavy-metal content (principally uranium and pluto-

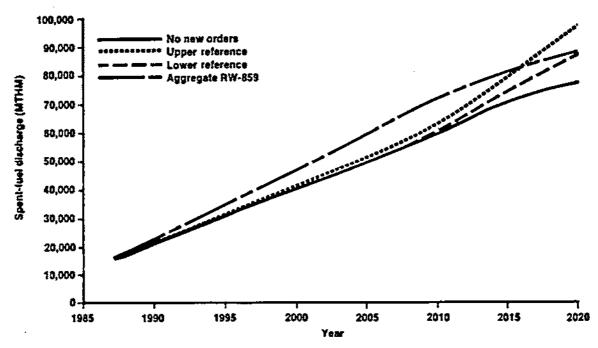


Figure 3-1. Projections of cumulative spent-fuel discharges.

nium). As the name implies, the no-new-orders case, like the aggregate RW-859 forecast, is based only on the plants currently operating or under construction. The lower reference case and the upper reference case are based on different assumptions about the numbers of new reactor orders beginning after the year 2000.

For this study, the 1987 EIA no-new-orders case was used as the lower bound on projections of spent fuel discharges. The aggregate RW-859 forecast was used as the upper bound. Even though forecasts based on EIA's upper reference case show greater spent fuel discharges beyond the year 2013, this difference is due to discharges from reactors not yet ordered. These reactors are commonly assumed to be designed for life-of-plant storage.

## 3.1.2 Maximum pool capacities

In addition to the quantity of spent fuel that is discharged, the projected additional-storage requirements depend on the maximum storage-pool capacities. Like the data on projected spent-fuel discharges, information about current pool-storage capacities and estimates of the maximum achievable pool capacities for intact spent-fuel assemblies were obtained from the utilities in the RW-859 survey. These estimates of the maximum achievable pool-storage capacity are based on studies performed by the utilities. In some cases, additional studies could reveal methods of achieving additional storage capacity in the existing pool space.

The projected requirement for additional storage is assumed to begin when the pool can no longer maintain a full-core reserve. The maximum pool capacities reported in the utility survey were estimated in studies and engineering evaluations that were based on the existing understanding of storage technologies and practices. However, these estimates could change because alternative storage programs and options are being evaluated by utilities as ways of increasing their storage capacity. Consequently, the time at which additional storage capacity is needed by individual utilities may change.

It should be noted that a comparison of the maximum pool capacities estimated by the utilities shows a large variation among reactors in the loading of the storage pools—that is, the metric tons of heavy metal stored per unit of pool floor area. However, the variation may be attributable to the fact that pools of identical design may have different maximum capacities because of site-specific conditions, such as the seismic characteristics of the site.

## 3.1.3 Removal from the reactor sites

All of the spent fuel discharged from reactors and stored at reactor sites will be removed when the DOE accepts the spent fuel and transports it to a Federal waste-management facility (i.e., a facility for monitored

retrievable storage (MRS) or a geologic repository).\* This acceptance will diminish and eventually eliminate the additional-storage requirements. How much and when such acceptance will affect the additional-storage requirements will depend on the acceptance schedule and the criteria for allocating the acceptance among the reactor sites.

Spent-fuel acceptance by the DOE will affect not only the magnitude of the additional-storage requirements but also the timing and the location. The reference spent-fuel-acceptance case that was used solely for the purposes of this study assumes that the spent fuel will be accepted for disposal in a geologic repository, with acceptance beginning at an annual rate of 400 MTHM in 2003 and increasing to 900 MTHM in 2006, 1800 MTHM in 2007, and 3000 MTHM in 2008. In addition, spent-fuel-acceptance allocations are based on assigning the highest priority to the oldest spent fuel on an industry-wide basis, as defined in the Annual Capacity Report. 3 Although an MRS facility was authorized by the Nuclear Waste Policy Amendments Act of 1987 and is an integral part of the DOE's wastemanagement system, the reference case for this study assumes that there is no MRS facility. This assumption was made because the Amendments Act, in its directions for this study, calls for an evaluation of "dry cask storage at the sites of civilian power reactors until a geologic repository is available for receiving spent fuel." Three alternativeacceptance cases were included in this study in order to examine how the time at which spent-fuel acceptance starts and the ramp-up of the acceptance rate affect additional-storage requirements and costs (see Section 3.2.2). These three alternative-acceptance cases do include an MRS facility; they are based on the spent-fuel acceptance rates for the MRS facility and on the start of spent-fuel acceptance in the years 1998, 2003, and 2008. The annual spent-fuel acceptance rates for the MRS facility were assumed to be the same as those given in the draft 1988 Mission Plan Amendment2: 1200 MTHM in the first 2 years of operation, 2000 MTHM in the 3rd and 4th years, 2700 MTHM in the 5th through the 22nd years, and 2620 MTHM in the 23rd year.

#### 3.2 CUMULATIVE REQUIREMENTS FOR ADDITIONAL STORAGE

Since the factors affecting additional-storage requirements (spent-fuel discharges, maximum pool capacities, and acceptance by the DOE) are subject to uncertainty, a realistic projection of the probable overall magnitude and timing of additional-storage requirements must reflect variations in these factors. This section explores potential variations in each factor and the effects of each on the magnitude and timing of additional-storage requirements. This analysis leads to a range of additional-storage requirements—a range that is used to bound the cost impacts discussed in Chapter 5.

<sup>\*</sup>As explained in the draft 1988 Mission Plan Amendment, the authorized waste-management system includes a geologic repository and an MRS facility.

# 3.2.1 <u>Cumulative additional-storage requirements for the reference spent-fuel-acceptance case</u>

Estimates of additional-storage requirements for the reference case were based on the following assumptions for the three factors that influence the magnitude and the timing of these requirements:

- 1. Spent-fuel discharges. It was assumed that the aggregate RW-859 forecast represents the upper bound for spent-fuel discharges in the future and the EIA's no-new-orders case represents the lower bound. These two forecasts were used to develop upper- and lower-bound estimates of additional-storage requirements.
- Maximum pool capacities. The data supplied by the utilities in the EIA surveys were used to estimate the maximum storage capacity available at each reactor for storing intact spent-fuel assemblies.
- 3. Removal from reactor sites. It was assumed that the removal of spent fuel from reactor sites would proceed at the following annual acceptance rates for the repository: 400 MTHM beginning in 2003, increasing to 900 MTHM in 2006 and 1800 MTHM in 2007, and in 2008 reaching the design rate of 3000 MTHM, which would be maintained thereafter.

The cumulative aggregate requirements for additional storage range from 12,200 to 20,000 MTHM (Figure 3-2) for the upper and the lower

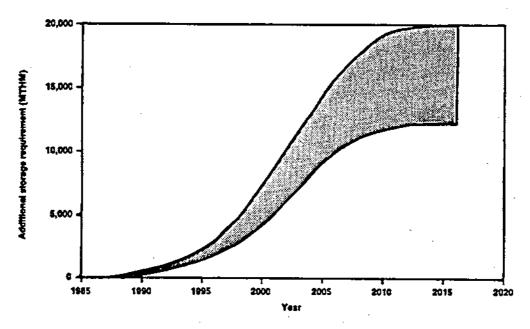


Figure 3-2. Range of additional-storage requirements for the reference spent-fuel-acceptance case (repository starting in 2003).

bounds on the spent-fuel-discharge forecasts, respectively. The storage inventory peaks within 4 years of the start of waste acceptance for permanent disposal (by the time the acceptance rate reaches its full design level). However, after the year 2007 an increase in storage capacity will be required at a number of reactor sites because the rates at which these reactors discharge spent fuel will exceed the rate at which the spent fuel is removed from their sites. As a result, the cumulative additional-storage requirements continue to increase and do not peak until the years 2012 and 2016 for the lower and the upper bounds on the spent-fuel-discharge forecasts, respectively.

As shown in Figure 3-3, the number of reactor sites requiring additional spent-fuel storage ranges from 54 (in the year 2012) to 67 (in 2016). Since some nuclear power stations contain several reactors located at the same site, the number of reactors requiring additional storage capacity is higher, 83 to 107 in the years 2012 and 2016, respectively. Selected data from the projections for additional-storage requirements for the reference case are given in Table 3-1.

The number of reactors requiring additional storage capacity was also recently projected by the National Association of Regulatory Utility Commissioners (NARUC) in a report on a survey conducted in June

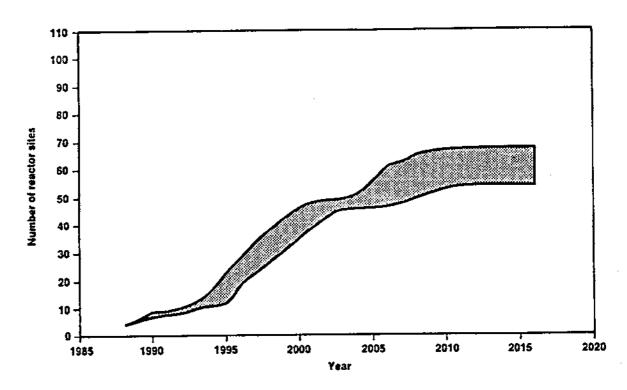


Figure 3-3. Number of reactor sites with additionalstorage requirements with the reference spent-fuel acceptance case (repository starting in 2003).

Table 3-1. Summary of additional-storage requirements for the reference spent-fuel-acceptance case (repository startup in 2003)

Parameter	Low estimate	High estimate	
Cumulative additional-storage		<del></del>	
requirement (MTHM)	12,220	20,000	
Number of reactors	83	107	
Number of reactor sites	54	67	
Year of peak additional-storage	•	•	
requirement	2012	2016	
Year additional storage is eliminated	2032	2036	
Average length of storage (years)	13	15	

and July 1987. The results of the NARUC survey indicate that, if current utility plans for reracking are implemented and spent-fuel acceptance by the DOE does not start until 2003, the spent-fuel pools of 63 reactors will reach capacity in the year 2003. This number is consistent with the projections used in this report for the year 2003.

## 3.2.2 Effects of alternative waste-acceptance schedules

The changes in additional-storage requirements that result from varying schedules for starting the removal of spent fuel from reactor sites were examined for the upper and the lower bounding cases. In these alternative-acceptance cases, the removal of spent fuel from the reactor sites was assumed to start in 1998, 2003, and 2008 at the reference ramp-up rates for the MRS facility. The case where acceptance begins in the year 2003 at the MRS acceptance rate represents the authorized DOE waste-management system as described in the draft 1988 Mission Plan Amendment. To provide perspective, additional-storage requirements were also estimated for the situation where no spent fuel is removed from reactor sites.

The results of these sensitivity analyses are presented in Figure 3-4, which shows that the start of spent-fuel acceptance by the DOE significantly affects additional-storage requirements. Summary data for these analyses are presented in Table 3-2.

How additional-storage requirements are affected by ramping up the annual acceptance rate can be seen by comparing the reference case (a

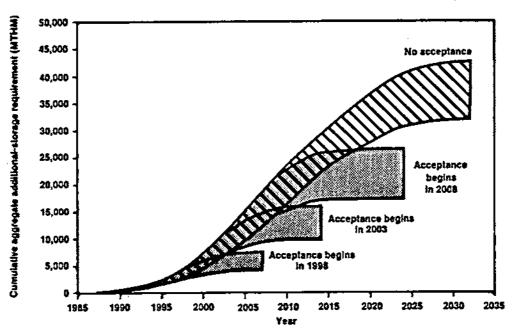


Figure 3-4. Effects of alternative spent-fuel-acceptance schedules on the cumulative aggregate additional-storage requirements.

repository-only system that starts spent-fuel acceptance in 2003) with the alternative-acceptance case where an MRS facility starts acceptance in 2003. In comparison with the reference case, the accelerated MRS ramp-up rate reduces the requirements for additional at-reactor storage by 2440 to 3790 MTHM.

## 3.2.3 Effects of spent-fuel-acceptance allocation

In the reference schedule, the spent-fuel-acceptance allocation is based on assigning the highest priority to the oldest fuel on an industry-wide basis, as defined in the Annual Capacity Report. As a result of using this basis, at some reactor sites the spent-fuel removal will reduce or eliminate requirements for additional storage, while at other sites—sites that do not have the oldest fuel but do require additional storage capacity—the requirements will increase. Thus, the cumulative inventory of spent fuel in additional storage is less than the cumulative requirement for additional storage capacity.

The actual sequence in which spent fuel is accepted by the DOE's waste-management system may differ from the oldest-fuel-first acceptance allocation. There are uncertainties about this sequence, and these uncertainties are related to such factors as the possible trading of ac-

ceptance priorities among the utilities or the priority that may be given to reactors that are decommissioned or shut down. These and similar issues are addressed in the <u>Annual Capacity Report</u>. If the actual acceptance of spent fuel is based on a criterion other than "oldest fuel first," then it may affect not only the additional-storage requirements of individual reactor sites but also the aggregate additional-storage requirements, resulting in either an increase or a decrease in the cumulative additional-storage requirements.

Table 3-2. Summary of additional-storage requirements for alternative-acceptance cases with an MRS facility in the system and MRS ramp-up rates

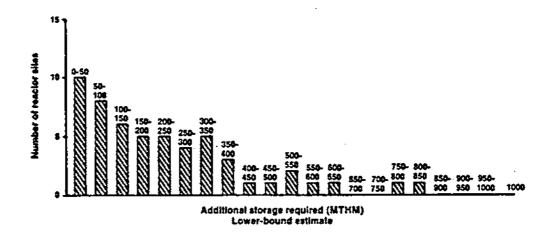
<b>.</b>	Start of acceptance by the DOE				
Parameter	1998	2003	2008	None	
Aggregate additional-storag requirement (MTHM)	e			· · · · · ·	
Low estimate	4530	9780	17,230	32,090	
High estimate	7650	16,210	26,430	42,450	
Year of peak storage invent	ory				
Low estimate	1999	2004	2009	NA	
High estimate	2002	2005	2009	. NA	
Year storage requirement is eliminated					
Low estimate	2025	2030	2035	NA	
High estimate	2029	2034	2039	NA	
Average length of storage (years)					
Low estimate	9	12	14	NA	
High estimate	13	15	17	NA	
umber of reactors		•			
Low estimate	51	73	98	107	
High estimate	68	101	112	115	
umber of reactor sites					
Low estimate	34	49	62	66	
High estimate	43	64	70	71	

<sup>&</sup>quot;NA = not applicable.

## 3.3 DISTRIBUTION OF ADDITIONAL-STORAGE REQUIREMENTS

Because the maximum capacities of reactor pools are not related to the projected cumulative discharges, the additional-storage requirements are not evenly distributed among reactor sites. As shown in Figure 3-5, for the lower-bound storage requirement, 29 of the 54 reactor sites with requirements for additional storage have requirements of 200 MTHM or less, but a few have much greater requirements. For the upper-bound storage requirement, the distribution of requirements among reactor sites is similar, with 37 of the 67 sites having a requirement of more than 200 MTHM. (For comparison, 200 MTHM is about 40 percent of a typical pool capacity, or the equivalent of about 20 typical dry casks of intact fuel.)

The additional-storage requirements were aggregated State by State to illustrate the geographic distribution. Table 3-3 shows the distribution of the range of additional-storage requirements by State for the reference and alternative spent-fuel acceptance cases. The geographic distribution of the maximum additional-storage requirements for the reference case is shown in Figure 3-6.



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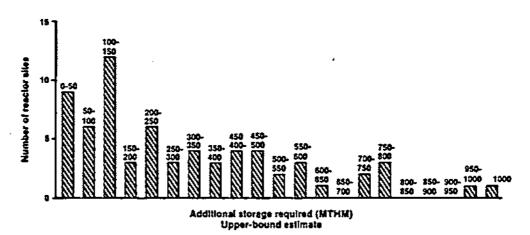


Figure 3-5. Site-by-site distribution of additional-storage requirements for the reference spent-fuel-acceptance case.

Table 3-3. State distribution of the range of additional-storage requirements (Metric tons of heavy metal)

	Reference case <sup>A</sup>	Alternative-acceptance cases <sup>8</sup>			
State	(2003 start)	1998 start	2003 start	2008 Start	
Alabama	180-750	0-10	50-540	420-1210	
Arizona	70-330	0-0	10-230	250-580	
Arkansas	170-300	0-50	100-210	240-350	
California Colorado <sup>c</sup>	650-860	270-450	560-740	800-1020	
Connecticut	380-550	180-230	320-450	500-690	
Florida	370- <del>6</del> 20	200-250	320-490	560-820	
Georgia	240-680	0-20	110-490	500-1010	
Iowa	60-120	0-10	40-90	100-160	
Illinois	2400-3470	1230-1810	2040-2990	3160-4310	
Kansas	0-40	0-0	0-20	10-120	
Loutstana	30-210	0-0	0-140	180-410	
Maine .	100-160	10-40	70-130	140-210	
Maryland	390-520	170-250	320-430	480-620	
Massachusetts	160-230	70-110	130-190	210-260	
Michigan	770-1120	270-470	610-940	1000-1440	
Minnesota	260-350	100-150	210-290	320-420	
Mississippi	280-400	90-170	250-360	360-500	
Missouri	20-130	0-0	10-90	100-200	
Vebraska	210-320	20-90	150-250	270-340	
New York	370-770	50-160	290-600	620-1040	
New Jersey	370-650	70-160	300-500	560-920	
New Hampshire	0-110	0-0	0-50	0-170	
Corth Carolina	550-850	290-380	480-670	750-1100	
Dhio	160-290	70-120	130-230	230-460	
Pregon	0-70	0-0	0-30	50-140	
ennsylvania	1090-1960	190-690	800-1580	1480-2550	
outh Carolina	1010-1280	600-760	880-1100	1250-1540	
ennessee	<b>79</b> 0-11 <b>7</b> 0	240-570	640-1010	1050-1490	
exas	0-0	. 0-0	0-0	0-90	
/ermont	20-60	0-0	10-50	80-130	
/irginia	700- <del>9</del> 40	300-460	590-810	890-1180	
lashington	240-360	80-160	200-300	320-440	
lisconsin	210-350	30-80	150-290	320-520	

ARepository-only waste-management system, with waste-acceptance starting in 2003 at the repository acceptance rates.

Bwaste-management systems with an MRS facility, with waste acceptance starting in 1998, 2003, or 2008 at the MRS ramp-up rates.

CThe high-temperature gas-cooled reactor in Colorado is expected to require a small amount (approximately 10 MTKM) of additional storage capacity.

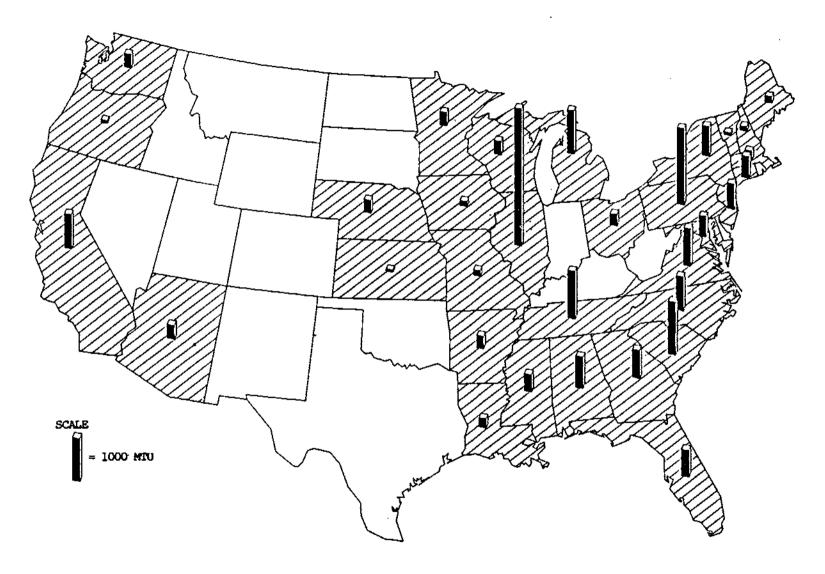


Figure 3-6. Distribution by State of the maximum additional-storage requirements for the reference spent-fuel acceptance case.

#### REFERENCES

- U.S. Department of Energy, <u>World Nuclear Fuel Cycle Requirements</u>, DOE/EIA-0436, Energy Information Administration, Washington, D.C., published annually.
- U.S. Department of Energy, <u>Draft 1988 Mission Plan Amendment</u>, DOE/RW-0187, Washington, D.C., 1988.
- U.S. Department of Energy, <u>Annual Capacity Report</u>, DOE/RW-0146, Washington, D.C., 1987.
- 4. National Association of Regulatory Utility Commissioners, Survey of Spent Nuclear Fuel Storage, Washington, D.C., 1988.

#### Chapter 4

## OPTIONS FOR INCREASING AT-REACTOR STORAGE

The available options for increasing the capacity of spent-fuel storage at reactor sites include reracking at-reactor storage pools, constructing new storage pools, installing dry-storage systems, and performing rod consolidation. Since reracking is widely accepted as a safe, feasible, and economical method, it is assumed that reracking has already been implemented at reactor sites. The construction of new pools is not considered because it is not economically competitive.

This chapter discusses the remaining options for increasing the capacity of spent-fuel storage at reactor sites: dry-storage systems and in-pool rod consolidation. In-pool consolidation can be used to increase the capacity of the storage pool. Furthermore, an available option for increasing storage capacity is consolidating rods for storage in dry-storage systems. Each option is presented by providing a brief description and briefly discussing such topics as demonstration and applications, licensing status, and estimated unit costs. The unit costs are nominally in 1988 dollars, but the costs obtained from some references may have been estimated for an earlier recent year. However, because of the uncertainties in the costs, the costs were not escalated for any inflation.

This chapter ends with a brief review of the various factors that might affect a utility's choice of a particular spent-fuel storage option. Although it is not possible at present to draw conclusions about which storage methods are likely to be chosen, this issue was examined because information on which methods are likely to be chosen would improve the accuracy of the predictions, in Chapter 5, of the aggregate costs of providing additional storage capacity for all U.S. reactors that require it. The last section of this chapter also summarizes utility responses to questions about their plans for providing additional storage capacity and their studies of available options.

## 4.1 CANDIDATE METHODS FOR DRY AT-REACTOR STORAGE

Since 1982 several research-and-demonstration projects have been undertaken, under cooperative agreements between the Department of Energy (DOE), several utilities, and the Electric Power Research Institute to develop dry-storage technologies. Dry storage is particularly attractive to utilities because it does not require large initial capital outlays: all forms of dry storage are essentially modular and can be implemented in steps, one cask or module at a time.

An initial capital outlay is nonetheless necessary. It is needed to construct the dry-storage facility, which entails the preparation of the site, the installation of central monitoring and security systems, and

the construction of concrete storage pads if casks are used or some other supporting structure. Also needed in some cases is the procurement of specialized equipment, such as transporters for moving loaded storage casks to the storage pads.

Described in this section are dry-storage methods based on the use of metal, dual-purpose, and concrete casks; horizontal concrete modules; and modular concrete vaults. Of these methods, metal casks, horizontal concrete modules, and modular concrete vaults have been reviewed by the Nuclear Regulatory Commission (NRC). Concrete casks are being reviewed by NRC. The discussion of each method covers the design and operation, testing and demonstration, licensing status and issues, and the estimated unit costs of at-reactor storage.

#### 4.1.1 Metal dry-storage casks

In the United States, the storage of fuel in metal casks is the most mature of all the methods available for interim dry storage. It involves loading intact or consolidated spent fuel into metal dry storage casks. The metal casks are large and heavy vessels equipped with an internal fuel basket for holding the spent-fuel assemblies. Their use has been tested and demonstrated in the United States since 1984.

#### 4.1.1.1 Description of typical metal dry-storage casks

A typical metal cask for dry spent-fuel storage is shown in Figure 4-1. The cask is approximately 16 feet long and 8 feet in diameter; it

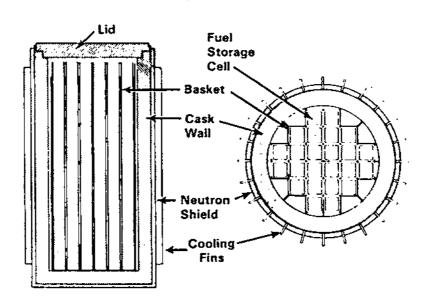


Figure 4-1. Conceptual design for a typical metal storage cask.

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weighs 100 to 125 tons loaded with unconsolidated or consolidated spent fuel from boiling-water reactors (BWRs) or pressurized-water reactors (PWRs). The body of the cask is usually made from forged steel, nodular cast iron, or lead and stainless steel. The walls of the cask are sufficiently thick to provide shielding from gamma radiation. In addition, the body is surrounded by a shield of neutron-absorbing material, which may be polyethylene, or a resin. The external surface of the cask may be either smooth or finned to enhance cooling. Two to four trunnions are usually located on each end of the cask for lifting and rotating.

The inside cavity of the cask contains fuel baskets that can store 21 to 33 PWR spent-fuel assemblies (i.e., about 9 to 14 MTHM) or 45 to 70 BWR spent-fuel assemblies (about 8 to 12 MTHM) or the same numbers of canisters containing consolidated PWR or BWR spent-fuel rods. The baskets are normally fabricated from borated stainless steel, stainless steel clad with borated aluminum plates, borated aluminum, aluminum clad with borated aluminum plates, or various combinations of stainless steel, copper, aluminum, and boron.

The NRC typically uses the conservative assumption that the fuel loaded into the casks for storage is equivalent to fresh fuel (no burnup—see Chapter 3). As a result, the assembly-to-assembly spacing inside the storage cask cannot be minimized and the amount of spent fuel that can be stored in the casks is reduced. The DOE, cask vendors, and utilities are developing methods for verifying the burnup of the spent fuel to get credit for burnup; this would increase the number of assemblies that can be stored in the cask or eliminate the need for a neutron absorber, thereby reducing the unit cost (i.e., the cost per kilogram of heavy metal stored) of the cask.

The metal storage casks are usually closed and sealed with two lids to provide secure containment for the radioactive material in the spent fuel. To provide double-seal containment, the lids normally contain two seals made of metal, an elastomer, or a combination of these materials.

In using metal storage casks, two methods can be used for loading the spent fuel into the storage cask. The usual method, approved by the NRC, is wet loading; it requires using a crane large enough to lift a fully loaded metal storage cask weighing 100 to 125 tons. In this method, a metal storage cask is moved to the cask-loading area of the storage pool. Once the metal storage cask is in the pool, spent fuel, either intact or consolidated, is lifted with remotely controlled equipment from the storage racks and loaded into the fuel baskets in the cask. When the cask is fully loaded, the lid is installed and the cask is drained as it is raised from the pool. The cask is then moved to a decontamination pad, where the lid is secured and the cavity of the cask is vacuum dried. The cask is then filled with a cover gas (e.g., helium or nitrogen), and leaktightness is confirmed. The exterior surfaces of the cask are decontaminated by washing, and the cask is moved to a nearby dry-storage facility. A transporter is used for moving the cask.

The second method, dry loading, has been demonstrated in the United States without actual fuel assemblies in horizontal concrete modules

(Section 4.1.4) and used abroad (Section 4.4.2), but, as discussed in Section 4.1.1.3, it has not been reviewed by the NRC staff or developed and used for metal-cask storage in the United States. Dry loading requires using a transfer cask, which is moved to the cask-loading area of the pool, loaded with spent fuel, vacuum dried, and decontaminated as described above for the storage cask in wet transfer. The transfer cask is then moved to the dry-storage facility, where a metal storage cask has been placed on the storage pad. A fuel-transfer collar is secured to the storage cask, and the transfer cask is positioned on top of the collar. A spent-fuel assembly is lowered from the transfer cask, through the collar, and into the storage cask. This process is repeated until the storage cask is fully loaded. The storage cask is then vacuum dried and filled with a cover gas. When dry loading is used, it may be necessary to first insert the fuel assemblies into canisters, depending on the mechanism for mating the transfer cask to the storage cask.

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Dry loading could be used at reactor sites that do not have cranes large enough for the heavy storage casks. The transfer casks can be custom designed for the cranes available at a particular reactor site.

In terms of storage-pad area, metal casks will typically require approximately 25 square feet per metric ton of heavy metal if positioned in a vertical orientation. A horizontal cask orientation would require significantly more area per metric ton of heavy metal than vertical storage.

## 4.1.1.2 Testing, demonstration, and applications

Since 1984, four types of metal storage cask have been tested in the United States, and storage in one type of cask has been demonstrated at a licensed dry-storage facility at a reactor site. One of the casks was tested with both unconsolidated and consolidated fuel. In general, the objectives of these tests were to (1) determine the operating limits of the cask and provide data for licensing, (2) gain experience in loading and handling the casks, (3) identify potential improvements in cask designs, and (4) evaluate the computer codes used to predict the heat-transfer and radiation-shielding performance of the casks.

Performance tests with unconsolidated fuel. One of the four tested casks was the REA-2023 cask manufactured by Ridihalgh, Eggers, and Associates for the storage of BWR fuel. The test, sponsored by the DOE and the Electric Power Research Institute, was performed in 1984 and 1985 at the General Electric Company's Morris storage facility. The performance test was conducted by loading the cask with 52 assemblies of unconsolidated BWR spent fuel and testing the cask in both vertical and horizontal positions. In some tests the inside cavity contained no cover gases; in others, helium or nitrogen was used. The results showed that the heat-transfer performance was excellent under all conditions. The loading of the cask was performed inside the Morris storage pool, under conditions representative of those found at many reactor sites. The results indicated that the cask could be handled at many reactor sites

and could, with minor design refinements for shielding, be used for the safe storage of spent fuel at a licensed storage facility.

In 1984, the Virginia Power Company entered into a cooperative agreement with the DOE and the Electric Power Research Institute to test, at the Idaho National Engineering Laboratory, the performance of three different metal casks for storing PWR fuel: the Castor V/21 cask marketed by General Nuclear Systems, Inc., the TN-24P cask manufactured by Transnuclear, Inc., and the MC-10 cask manufactured by the Westinghouse Electric Corporation. In addition to the general objectives stated above, these tests were conducted to support the utility's efforts to obtain an NRC license for a dry-storage facility at the site of the two Surry reactors.

The tests, performed in 1985 and 1986, indicated that all three casks could be safely handled and loaded and, with very minor refinements, used at reactor sites for the safe storage of spent fuel. The shielding performance met design expectations, and the heat-transfer performance of the casks was exceptionally good: measured temperatures were lower than predicted in the topical reports.

Performance tests with consolidated fuel. In January and February 1988, the DOE, in cooperation with the Electric Power Research Institute, sponsored a performance test with consolidated fuel. This test, also conducted at the Idaho National Engineering Laboratory, was essentially identical with the test described above except that the cask was loaded with 24 canisters of spent-fuel rods consolidated from 48 PWR assemblies. The canisters of consolidated fuel were loaded into the same TN-24P metal storage cask that had previously been tested with intact (unconsolidated) spent fuel. Preliminary results indicate that the heat-transfer performance of the cask was exceptional, and the shielding performance was satisfactory. When consolidated fuel was used, the neutron-dose rates measured on the exterior surface of the cask surface were slightly higher than those measured with intact fuel, but were generally less than 100 millirem per hour. Minor refinements in neutron shielding could substantially reduce the dose rates if desired. gamma-dose rates were low; they were significantly lower than those for intact fuel because the canisters of consolidated fuel did not contain the major sources of gamma radiation--the end fittings from the assembly hardware, which had been removed during consolidation.

The test confirmed that metal storage casks can be used to safely store consolidated spent fuel. A topical report describing the details of the test will be published in late 1988.

Licensed demonstration. In July 1986, after approximately 4 years, Virginia Power obtained from the NRC a license for dry storage (i.e., an independent spent-fuel storage installation) at the Surry site.<sup>3,4</sup>
Three Castor V/21 casks were subsequently loaded with unconsolidated fuel in the storage pool of the Surry reactor, and their use was successfully demonstrated in 1986 and 1987. Virginia Power also plans to use casks from other vendors in these licensed demonstrations. Up to three casks

from different vendors and possibly with fuel baskets receiving fuel-burnup credit will be demonstrated from 1988 through 1990.

As of mid-1988, Virginia Power had six loaded Castor V/21 casks on the storage pad of the Surry dry-storage installation. The utility plans to place two or three more loaded casks a year on the storage pad.

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#### 4.1.1.3 Licensing issues and status

Topical reports have been approved by the NRC staff for four metal storage casks: the Castor V/21 cask, the MC-10 cask, and the NAC26-ST and NAC28-ST casks (manufactured by the Nuclear Assurance Corporation). The NRC has granted a license to Virginia Power to operate a dry-storage facility at its Surry plant, storing spent fuel in Castor V/21 casks. The Castor IC cask is being used in the Federal Republic of Germany (Section 4.4.1), but its vendor has not submitted the final topical report to the NRC.

Examples of issues addressed during the review of metal casks by the NRC are the ability of the selected materials to retain integrity in service; shielding designs and materials; fuel-basket designs and materials, including neutron absorbers; lid designs and sealing techniques; and lifting-hardware designs. Examples of site-specific issues addressed during the NRC review of the site-specific license application are storage-pad design and safeguards, the detection and correction of leaking cask lids, seismic effects on storage pads and casks, procedures for loading and transporting casks to the storage pad, the radiation doses received by the workers and the public, and maintenance procedures. These issues had been resolved by the time the license was granted or before fuel loading.

As already mentioned, the utilities, the DOE, and vendors are attempting to optimize the design and the capacity of the metal storage casks by eliminating or minimizing the need for neutron poison<sup>7,8</sup> and by minimizing the assembly-to-assembly spacing. To this end, the utilities, the DOE, and vendors of casks are attempting to obtain NRC approval of credit for fuel burnup.

The dry-loading method for metal storage casks has not been licensed or reviewed by the NRC because it has not been proposed in license applications. However, because the handling operations would differ from site to site, it may not be possible to address dry loading generically in a cask topical report (see Chapter 2).

#### 4.1.1.4 Estimated unit costs of at-reactor storage in metal casks

The storage of spent fuel in metal casks is a proven and commercially available technology. Casks have been built, purchased, and loaded

with spent fuel. Although some uncertainty about cost does remain, the uncertainty is associated with manufacturing practices and market considerations rather than technical factors.

The costs for storing spent fuel in metal casks include NRC licensing; the construction of the storage facility, including the concrete storage pads; cask purchase; and the cost of loading and unloading spent fuel from casks. The major contributor to the unit cost of storing spent fuel in metal casks is the cost of purchasing the casks. This cost will depend on the total number of casks that a vendor manufactures and on the extent of competition, both competition between the vendors of metal casks and competition from alternative storage technologies.

Using reported values, the licensing-related costs were assumed to range from \$300,000 to \$1 million. The range for initial facility costs was derived from an estimate of \$1.2 million for a 300-MTHM storage facility with central monitoring and security systems and \$300,000 for a cask transporter. These estimates were used as the mid-point of the cost range, with the low cost one-third lower and the high cost one-third higher. Moreover, the costs were assumed to be evenly divided between initial fixed and quantity-dependent costs, the variable portion depending on the capacity of the storage facility.

Estimates for cask purchase costs are available from several reports in the literature. The DOE currently owns four casks, each one with a nominal cost of \$1 million. The cask-purchase unit cost for these casks therefore ranges from about \$90 to \$105 per kilogram of heavy metal. Barnhart 10 cites \$80 to \$90 per kilogram of heavy metal, but expects a decrease to between \$60 and \$70 per kilogram if sufficient competition develops. Wakeman cites current cask costs of \$70 to \$100 per kilogram of heavy metal; he expects the cost to be between \$50 and \$70 in the future. Other sources cite a wide range of current and potential costs based on competition and cask optimization. Their estimates range from about \$50 to \$100 per kilogram of heavy metal. For this study, the cask costs were estimated to range from \$50 to \$90 per kilogram of heavy metal, on the assumption that a sufficient number of casks will be purchased to reduce the cost by 15 percent below the cost of the four casks owned by the DOE. The low cost is also based on the assumption that the capacity of the casks will increase because credit for burnup will be allowed.

The cost of loading the casks and placing them on the storage pad may vary significantly, depending on utility practices, but are small in comparison with the cost of the cask. In this study, the values used for the loading and placement cost are based on available estimates<sup>8,10</sup> and range from about \$1 to \$2 per kilogram of heavy metal. The cost of unloading the cask at the end of service was assumed to be the same as the loading and placement cost.

As shown in Table 4-1, the total fixed costs, including licensing costs and 50 percent of the initial facility costs, range from \$800,000 to \$2 million, and the total variable costs (i.e., cask costs and oper-

ating costs) range from about \$55 to \$95 per kilogram of heavy metal. For a capacity increase of 100 MTHM, the average unit cost is estimated to range from about \$60 to \$115 per kilogram of heavy metal. At 1000 MTHM, the average unit cost is estimated at about \$55 to \$100 per kilogram of heavy metal, with over 90 percent of this cost being the cask-purchase cost.

## 4.1.2 Dual-purpose storage-and-transportation casks

The dual-purpose cask is a variation of the metal cask. In this method the metal cask that has been used for storage would also be used to transport the spent fuel to a Federal waste-management facility. In order to use the casks for dual-purpose service, a utility must obtain a storage-facility license under 10 CFR Part 72 for storage and have the cask certified by the NRC under the regulations promulgated for transportation in 10 CFR Part 71. The option of loading spent fuel into a cask, storing it for a long period of time, and shipping the fuel to a DOE facility without unloading and transferring the spent fuel to a shipping cask is especially attractive to utilities because of the significant decrease in handling. The potential uses of the cask in the waste-management system (for transportation or lag storage) make the option attractive to the DOE if these casks can be incorporated into the waste-management system in time to preclude the DOE's purchasing other casks.

Table 4-1. Factors used in estimating the unit-cost range for storing intact spent fuel in metal storage casks

	Low cost		High cost	
Factor	Fixed	Variable	Fixed	Variable
NRC licensing	\$300,000		\$1,000,000	
Storage facility Fixed cost	\$500,000		\$1,000,000	•
Variable cost <sup>a</sup>	,	2		3
Cask costs <sup>a</sup>		50		90
Loading and placing the caska, b		1		2
Unloading the cask <sup>a</sup>		1		2
Total costs				
Total fixed cost	\$800,000		\$2,000,000	
Total variable cost <sup>a</sup>		54		97

<sup>&</sup>lt;sup>a</sup>Cost in dollars per kilogram of heavy metal.

bWet loading is assumed.

#### 4.1.2.1 Description of dual-purpose casks

Dual-purpose casks are very similar in concept to metal storageonly casks. Their size and shape will not differ greatly from those of storage-only casks, and the description of a storage-only cask in Section 4.1.1.1 is applicable to a dual-purpose cask.

Some storage-cask vendors have indicated that they plan to apply to the NRC for transportation certificates. Some designers of casks have incorporated features and use materials that may make it possible to certify a cask for transportation under 10 CFR Part 71. However, the difficulties of certifying a large cask for transportation should not be underestimated.<sup>12</sup>

To meet transportation requirements, some storage—only casks may also need slight modifications in the lid and sealing system, even though most of these lid systems are designed to meet transportation requirements. The modifications may be needed to ensure that after long-term storage the condition of the seals will be acceptable. It is desirable to have a sealing system that will not require inspection or replacement.

The spent-fuel basket and the body of the cask may also need changes. Materials with better structural properties may be required to meet the severe accident conditions that a transportation cask must meet under the NRC's regulations.

## 4.1.2.2 Demonstration and applications

Dual-purpose service has not yet been approved in the United States. Dual-purpose casks have been approved for use in the Federal Republic of Germany (see Section 4.4.1).

The DOE is conducting a program to demonstrate dual-purpose service with two casks. Designed by Transnuclear, Inc., these casks will be used to ship PWR and BWR fuel from West Valley, New York, to the Idaho National Engineering Laboratory. The process of NRC certification has been initiated, and the demonstration is scheduled for fiscal year 1989. The demonstration will provide experience for other applications to the NRC for dual-purpose cask certification. However, the demonstration involves using the casks first for transportation and then for subsequent storage and hence will not address the issue of transportation after extended periods of storage (Section 4.1.2.3).

## 4.1.2.3 Certification and licensing

In 1986 and 1987, the vendor of the Castor casks, General Nuclear Systems, Inc., inquired of the NRC about a transportation license for the Castor V/21 storage cask. The NRC immediately identified two issues regarding the Castor V/21 cask: (1) the physical properties and specif-

ications for the fuel baskets (borated stainless steel) and (2) the use of nodular cast iron for the body of the cask. The first issue may be resolved through the development of suitable materials. For example, Carpenter Technology of Reading, Pennsylvania, is advertising borated stainless steel with improved structural characteristics. 13 This material, however, will need to be standardized by the American Society for Testing and Materials (ASTM) and the American Society of Mechanical Engineers (ASME) before it will be accepted by the NRC. In regard to the second issue, a technical review group was set up by the NRC to investigate the acceptability of nodular cast iron for transportation casks. It was concluded that, because of the lack of some critical information, nodular cast iron should not be used at this time as the primary structural material in spent-fuel shipping casks. This conclusion by the review group did not rule out future reconsideration of this conclusion, should the additional information be made available during future caskcertification activities. 54

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The preceding discussion covers the concerns initially identified by the NRC in regard to dual-purpose casks. It is expected that the licensing of these casks will also have to address concerns related to using the casks for transportation after an extended period of storage. Some spent fuel might need storage for 10 to 20 years before transportation to a Federal waste-management facility. The DOE is therefore sponsoring a study to determine the effects of a long-term normal storage cycle on the performance of a storage cask in transportation. Included in this study are the effects of radiation, corrosion, and heat on both the cask and the spent fuel. The objective is to identify the storage-cycle effects that can affect the transportation performance of a cask and options for meeting transportation requirements after the storage cycle. Life-cycle exposure estimates will also be included.

The plans of storage-cask vendors to apply for transportation certificates will depend to a great extent on the demand for large dual-purpose storage-and-transportation casks.

#### 4.1.2.4 Estimated unit costs of dual-purpose casks

In terms of unit cost per kilogram of heavy metal, the cost of a dual-purpose cask is about \$7 more than the cost of a metal storage cask for intact spent-fuel assemblies. The additional cost includes amortization, engineering, design, and licensing and incorporates an allowance of \$1 per kilogram of heavy metal savings resulting from the assumption that the dual-purpose cask would not have to be unloaded and the contained fuel would not have to be inspected and then loaded into a shipping cask. Presumably the dual-purpose cask would be licensed under two different NRC regulations: the regulations promulgated for storage (10 CFR Part 72) and the regulations governing transportation (10 CFR Part 71).

#### 4.1.3 Concrete dry-storage casks

Dry at-reactor storage in concrete casks is similar to storage in metal casks. Conceptual designs 14 for interim- or lag-storage systems indicate that concrete storage casks may be economically and technically competitive with metal casks. At the present time, at least one utility has indicated interest in implementing concrete casks at a reactor site.

#### 4.1.3.1 Description of concrete dry-storage casks

Concrete dry storage casks are similar to metal casks except that the body of the cask is made of heavily reinforced concrete with an inner metal liner for containment. There are two basic conceptual designs for concrete casks: unventilated and ventilated.

A conceptual design for an unventilated concrete storage cask is shown in Figure 4-2. Such a cask can accommodate 9 PWR or 25 BWR intact spent-fuel assemblies or the same numbers of canisters containing consol-

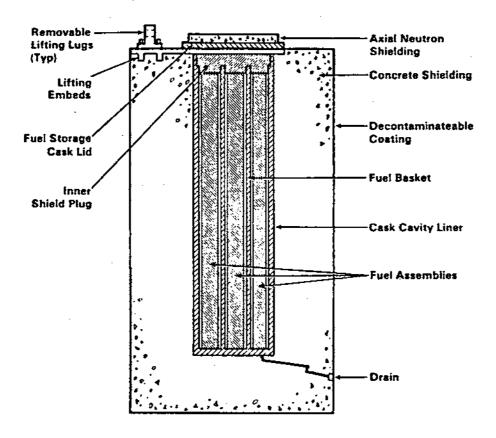


Figure 4-2. Conceptual design for an unventilated concrete storage cask.

idated rods. The cask is approximately 8.5 feet in diameter and 18 feet long; it weighs about 90 tons when loaded.

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The body of the cask is made of heavily reinforced concrete, and its walls are thick enough to provide shielding from gamma radiation. Special concretes have been developed to withstand high temperatures (230°C), freeze-and-thaw conditions (-20 to +30°C), a 961°C fire for 7.5 minutes, and the impact of a cask dropping from a height of 30 feet. Devices like radial rebar and heat pipes can be used to enhance the heat-dissipation capability of the cask. Lugs for lifting the cask are normally attached to the top of the cask.

Concrete casks have an inner steel liner between the concrete body of the cask and the fuel basket. The spent-fuel baskets are similar to those of metal storage casks and are usually made from stainless steel, though aluminum or combinations of copper and other metals may also be used.

The lids of concrete casks may be concrete shield plugs inserted into each storage cell of the fuel basket and covered with a metal lid<sup>14</sup> or thick metal lids bolted to the body of the cask much the same as for metal casks.<sup>15</sup>

Ventilated concrete casks are essentially the same as the unventilated ones, but they contain inlet and outlet air-flow ducts near the

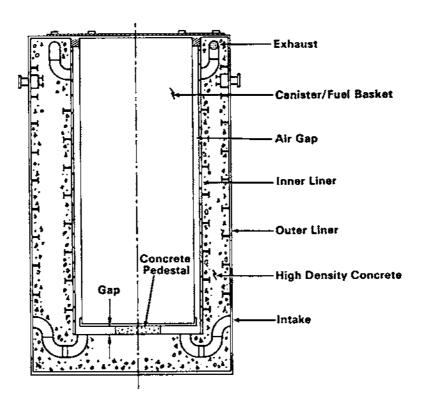


Figure 4-3. Conceptual design for a ventilated concrete storage cask.

bottom and the top. 20 The bottom intake duct (Figure 4-3) opens into an empty space between the concrete and the inner steel liner. Heat from the spent fuel inside the cask is transferred to the air in this space; as its temperature increases, the air becomes less dense and flows up through the space and out the exhaust ducts. The dominant heat-transfer mechanism from the inner metal liner is air convection. This reduces the amount of heat that flows through the concrete and results in a lower temperature in the concrete. A ventilated cask dissipates more heat per unit area than an unventilated cask, and therefore more fuel can be stored in a ventilated cask.

Being designed to store more fuel, ventilated concrete storage casks are larger than unventilated casks. They are approximately 12 feet in diameter and 20 feet long. When loaded with 17 PWR or 50 BWR unconsolidated spent-fuel assemblies or canisters of consolidated rods, they weigh approximately 125 tons.

In the case of concrete storage casks, dry transfer is somewhat more likely to be used than for metal casks (see Section 4.1.2.1) because with the same amount of spent fuel a concrete cask is heavier than a metal cask and because it may be more difficult to decontaminate the surface of a concrete cask than that of a metal cask.

#### 4.1.3.2 Testing and demonstration

Storage in concrete casks has not yet been commercially demonstrated in the United States. However, the casks have been successfully used in spent-fuel storage tests performed in the DOE's E-MAD testing facilities at the Nevada Test Site.

The DOE is currently negotiating to sponsor tests of the heat-transfer and radiation-shielding performance of two concrete casks manufactured by Nuclear Packaging, Inc., and Reedy Associates. The casks are similar to the unventilated and ventilated casks shown in Figures 4-2 and 4-3 and are described in detail in Reference 16. According to current plans, the performance tests will be identical with those described in Section 4.1.1.2 for metal storage casks except that only vertical casks will be tested. The tests are planned to be performed at the DOE's cask-testing facility at the Idaho National Engineering Laboratory and are scheduled to be completed in late fiscal year 1989 or early fiscal year 1990.

## 4.1.3.3 Certification and licensing

Only one vendor of concrete casks, Nuclear Packaging, Inc., has submitted a topical report to the NRC. This report was submitted in

November 1987. The review by the NRC staff started in early 1988 and will take some time to complete; therefore, licensing issues are not known at present. However, the experience from licensing a horizontal concrete module. Indicates that the major issues may be the structural strength of the concrete and the ability to decontaminate the external surface of the cask because the decontamination of concrete is more difficult than that of metal. Experience with using concrete at high temperatures is limited, and this issue received significant attention during that licensing review (see Section 4.1.4.3). Because concrete casks are similar to metal casks, other issues should not be significantly different from those addressed in the NRC staff reviews of metal casks.

## 4.1.3.4 Estimated unit costs of at-reactor storage in concrete casks

Costs for dry concrete casks are still evolving, and the available information indicates a broad range of cost uncertainty. In the United States, the technology of concrete storage casks is not as mature as that of the metal casks. If the development of the technology is successful, the cost of fabricating concrete casks is expected to be less than the cost of fabricating metal casks.

As in the case of metal casks, the costs for storing spent fuel in concrete casks include NRC licensing; the construction of the storage facility, including concrete storage pads; cask purchase; and the cost of loading and unloading spent fuel from casks. The major contributor to the unit cost is the purchase price of the concrete cask. The purchase price will depend on the total number of casks that a vendor manufactures and on the amount of competition, both competition between vendors of concrete casks and competition from alternative storage technologies.

Assuming that the technology is approved by the NRC, the cost of licensing individual concrete-cask-storage facilities should be the same as that of licensing facilities that use metal casks. For this report, the licensing-cost estimates were based on available information and assumed to range from \$300,000 to \$1 million. Several estimates of cask-purchase costs are available. For this report, the cost of the cask was assumed to vary from about \$40 to \$60 per kilogram of heavy metal. The storage-facility costs should be about the same as for metal casks, and the initial facility cost was assumed to be identical with those given in Section 4.1.1.4 for metal storage casks, with a midpoint of \$1.2 million for a 300-MTHM installation and \$300,000 for a cask transporter.

The cost of loading and placing concrete casks on storage pads may vary significantly, depending on utility practices, but are small in

comparison with the cost of the cask. The loading costs will depend on whether the concrete casks can be loaded in the reactor's storage pool or must be loaded dry outside the pool. If the casks can be loaded in the pool, the unit loading and cask-placement cost will be slightly higher than that for metal casks because of the lower capacity of the concrete cask. The cost for wet loading will probably be lower than for dry loading.

For the high cost estimate it was assumed that dry-cask-loading activities will include loading the spent fuel into a canister inside the storage pool, loading the canister into a transfer cask, moving the transfer cask to the storage area, and transferring the canister into the concrete cask. This is a conservative cost assumption for this technology. From recently reported information, it the loading-equipment cost was assumed to consist of a fixed cost of \$250,000 and variable costs, per kilogram of heavy metal, of \$3 and \$1.50 for labor and for equipment leasing, respectively. These variable costs would be incurred during both loading and unloading operations. The cost of the equipment needed for loading the spent fuel into canisters inside the storage pool is estimated at \$150,000, and the variable cost of this operation, including the canisters, is about \$10 per kilogram of heavy metal. Therefore, the wet-loading cost, \$1 per kilogram of heavy metal, was used for the low cost estimate, and the dry-loading cost was used for the high cost estimate.

As shown in Table 4-2, the total fixed costs range from \$800,000 to \$2.4 million, and the total variable costs range from about \$45 to \$85 per kilogram of heavy metal. For a capacity of 100 MTHM, the average unit cost is estimated at about \$50 to \$110 per kilogram of heavy metal; for larger capacities, it is estimated at approximately \$45 to \$85 per kilogram of heavy metal.

#### 4.1.4 Horizontal concrete modules

In horizontal concrete storage modules, the spent fuel is kept inside a sealed stainless-steel canister that is filled with helium or nitrogen, and the canister is protected and shielded by a concrete module. The heat generated by the spent fuel is removed by radiation, conduction, and natural convection through air channels in the concrete module.

One independent spent-fuel storage installation that uses horizontal concrete modules has been licensed and constructed, and at least three additional installations are being designed. All of the systems use the horizontal-modular-storage system (NUHOMS) manufactured by NUTECH and are designated either NUHOMS-07 or NUHOMS-24, depending on the number of assemblies stored in a module.

Table 4-2. Factors used in estimating the unit-cost range for storing intact spent fuel in concrete storage casks

Factor	Low cost		High cost	
	Fixed_	Variable	Fixed	Variable
NRC licensing	\$300,000		\$1,000,000	
Storage facility Fixed cost Variable cost	\$500,000	2	\$1,000,000	3
Dry-loading equipment Fixed cost Variable cost			\$250,000	. 3
Canning cost for dry loading Fixed cost Variable cost <sup>a</sup> Cask costs <sup>a</sup> Loading and placing the cask <sup>a</sup> Unloading the cask <sup>a</sup>		40 1 1	\$150,000	10 61 4 4
Total costs  Total fixed cost  Total variable cost <sup>a</sup>	\$800,000	44	\$2,400,000	85

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## 4.1.4.1 Description of horizontal concrete modules

As shown in Figure 4-4, the major components of the NUHOMS system are a stainless-steel canister, a concrete horizontal storage module, a transfer cask, and a special-purpose trailer. The canister includes an internal basket for maintaining the assemblies in a safe configuration. The transfer cask provides shielding from radiation and protects the canister as it is moved from the storage pool to the dry-storage facility. The special-purpose trailer is used to carry the loaded transfer cask to the dry-storage facility and provides the precise alignment required to mate the transfer cask with the concrete storage module; it contains a hydraulic ram for loading the canister into the concrete module. The module provides radiation shielding and protects the canister in storage. 20,21

<sup>\*</sup>Cost in dollars per kilogram of heavy metal.

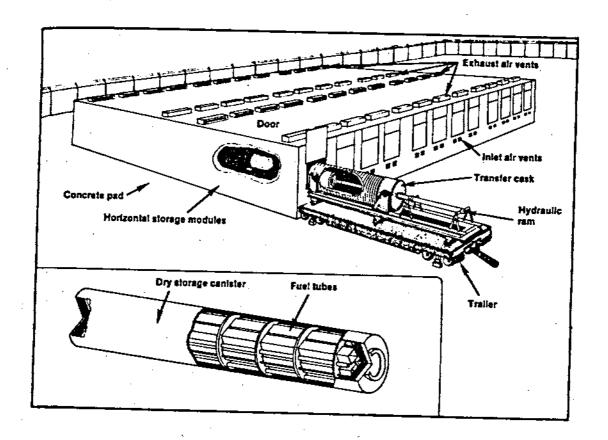


Figure 4-4. The generic horizontal modular storage system (NUHOMS).

The concrete-module dry-storage facility also contains a central monitoring and security system. In terms of storage-pad area, horizontal concrete modules will typically require approximately 50 to 450 square feet per metric ton of heavy metal, depending on the capacity of each module. Typically a 24-PWR-assembly module requires about 50 square feet of area.

In the NUHOMS-07 system, a canister holds seven PWR spent-fuel assemblies. This capacity was based on accepting 5-year-old spent fuel generating 1.0 kilowatt per assembly. The fuel basket inside the canister contains a neutron-absorbing material. In the NUHOMS-24 system, a canister can accommodate 24 assemblies of 10-year-old PWR fuel generating 0.66 kilowatt per assembly, and the fuel basket may or may not contain neutron-absorbing materials. The use of neutron-absorbing materials in the basket assembly will depend on the NRC's acceptance of burnup credit in the canister's criticality analysis (see Section 4.1.4.3).

Spent-fuel assemblies are loaded in the fuel basket of the canister, and a shielding lid is placed on the open end of the canister. The canister is vacuum dried, and the lid is sealed. The canister is filled with helium to prevent fuel oxidation during storage. It is then loaded into a transfer cask, which is placed on a trailer and transported to the dry-storage facility. At the horizontal concrete module, the lid of the transfer cask is removed, the transfer cask is precisely aligned with the docking port on the module, and the canister is pushed into the module by a hydraulic ram. To complete the installation, a 2-inch-thick steel door is lowered and welded in place to cover the docking port on the storage module.

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### 4.1.4.2 Testing, demonstration, and applications

The NUHOMS-07 system was selected by the Carolina Power & Light Company (CP&L) for its H. B. Robinson nuclear power plant. To demonstrate this system, CP&L entered into a cooperative agreement with the DOE in March 1984, other participants in the project being the vendor (NUTECH) and the Electric Power Research Institute. The objective of the demonstration project was to license, construct, and verify the performance of a dry-storage facility. The construction of the first three modules was completed in July 1987. As part of the demonstration program, a data-acquisition system was provided and a pattern of thermocouples was installed in two of the modules and two of the canisters. Before loading spent fuel, electric heaters will be used to perform a series of tests to verify the performance of the system under both normal and accident conditions. After spent fuel has been loaded, performance will be monitored for a predetermined period. The first module was scheduled to be loaded with spent fuel in December 1988, with additional loadings to follow in March 1989.

The NUHOMS system designed for the H. B. Robinson site differs in several respects from the generic system described in the NRC-approved topical report. One difference is a change in the configuration of the concrete storage modules: instead of being arranged in two rows, the modules will be deployed in a single row. This change was made in order to facilitate using the NRC-certified General Electric IF-300 transportation cask as the transfer cask: the change eliminated the need to install a port in the cask. With the modules arranged in a single row, the hydraulic ram can be used from the rear of the module to pull the canister from the transportation cask, whereas in the generic design the canister is pushed into the module through a port in the end of the onsite transfer cask.

The complete installation at H. B. Robinson is licensed for eight modules, three of which have already been constructed. The construction of the remaining five modules is scheduled to start in 1989.

The NUHOMS-24 system has been selected by the Duke Power Company for its Oconee site. The system to be developed at Oconee is essentially the generic system that is described in the topical report. If licensed by the NRC, the Oconee facility will have a capacity of up to 88 horizontal concrete dry-storage modules. Since each module will contain 24 PWR spent-fuel assemblies, the total capacity of the system will be 2112 assemblies, or slightly less than 1000 MTU.

Duke Power plans to begin construction in April 1989, and seven modules are scheduled to be loaded in 1990. Six modules will be loaded in 1991, and four to five modules will be loaded each year until the authorized capacity is reached.

The Baltimore Gas & Electric Company recently selected the NUHOMS-24 system for its Calvert Cliffs facility. Fuel loading is scheduled to begin in 1991, with 24 modules being loaded during the first phase and 8 modules being loaded every other year until the DOE accepts the spent fuel.

## 4.1.4.3 Licensing status and issues

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The Carolina Power & Light Company submitted its license application for the NUHOMS-07 dry-storage facility at the H. B. Robinson site in February 1985. The NRC issued an environmental assessment and a finding of no significant impact<sup>22</sup> in March 1986, and the license went into effect on August 13, 1986. An application for an amendment allowing a reduction in the boron content of the fuel-guide sleeves in the canister was submitted in October 1986 and approved by the NRC in April 1987. The facility is licensed for a total of 56 spent-fuel assemblies (eight modules), and the license is for 20 years.

Examples of the issues addressed during the NRC's review of horizon-tal concrete modules are the ability of the selected materials to retain integrity in service, with emphasis on the concrete and its allowable operating temperature; shielding designs and materials; basket designs and materials, including neutron absorbers; canister-closure designs; and cooling-duct designs. Examples of site-specific issues are storage-pad design and safeguards, seismic effects on storage modules and pads, transfer-cask design, procedures for loading and transferring spent fuel to modules, the radiation dose received by workers and the public; and maintenance procedures, including the inspection of the concrete after the first 5 years of operation. These issues had been resolved by the time the license was granted.

The topical report for the NUHOMS-24P system to be used by Duke Power was submitted to the NRC along with a license application for the

Oconee dry-storage facility in March 1988. 52,53 One of the key licensing issues is predicted to be the criticality analysis, since the analysis takes credit for fuel burnup and the fuel basket of the canister does not contain neutron-absorbing material. This issue was not addressed in the NRC staff's review of the topical report for the NUHOMS-07P system<sup>21</sup> or the Carolina Power & Light Company's license application because Carolina Power & Light did not ask to take credit for burnup. Other significant issues are expected to be similar to those raised by the NRC for the NUHOMS-07 system.

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# 4.1.4.4 Estimated unit costs of at-reactor storage in a horizontal concrete module

The total-system cost for the NUHOMS system to be constructed at Duke Power's Oconee site is estimated at \$40 million for a capacity of almost 1000 MTHM. 23 This was used for the low-cost estimate in this report, and the high cost was set to be one-third higher than the low cost.

A portion of the \$40 million was assumed to be the initial cost. As a result, the unit cost per kilogram of heavy metal will be higher for smaller storage installations. The initial costs were assumed to include licensing-related costs, the costs of a transfer cask equipped with a hydraulic ram and a cask transporter, and the initial-cost portion of the central monitoring-and-security system. The licensing-related costs were assumed to be similar to those for metal storage casks, which are estimated to range from \$300,000 to \$1 million. The transfer cask was assumed to cost \$1 million. Both the cask transporter and the central monitoring-and-security system were assumed to be similar to those required for metal storage casks; their fixed cost is estimated at \$500,000.

These limited cost data were used to develop Table 4-3. The unit costs per kilogram of heavy metal depend on the capacity of the drystorage facility and range from about \$60 to \$80 for a capacity of 100 MTHM and from about \$40 to \$55 for a capacity of 1000 MTHM.

#### 4.1.5 Modular concrete vaults

The modular concrete vaults use sealed metal tubes inside a concrete structure. Inside the sealed tubes, the spent fuel is kept under a cover gas of nitrogen or air. A topical report for such a system was submitted to the NRC by Foster-Wheeler Energy Applications, Inc., in September 1986.<sup>24</sup> The report was approved by the NRC in March 1988 for a system using nitrogen as the cover gas.

Table 4-3. Factors used in estimating the unit-cost range for storing intact spent fuel in concrete modules

Factor	Low cost		High cost	
	Fixed	Variable	Fixed	Variable
NRC licensing	\$300,000		\$1,000,000	
Storage facility (fixed cost)	\$500,000		\$1,000,000	
Transfer cask with a hydraulic				
ram system	\$1,000,000		\$1,000,000	
Overall variable cost <sup>a</sup>	· -	<u>40</u>	·	<u>50</u>
Total	\$1,800,000	40	\$3,000,000	50

aCost in dollars per kilogram of heavy metal.

#### 4.1.5.1 Description of modular concrete vaults

Modular concrete vaults consist of metal fuel tubes vertically arrayed and housed in a concrete structure (Figure 4-5). Each tube will store a single assembly of unconsolidated spent fuel, and each module will store up to 83 PWR or 150 BWR assemblies. Individual modules that can store up to 200 spent-fuel assemblies can also be constructed.

The fuel tubes, made of carbon steel, are shielded and protected on all sides by the surrounding concrete structure. Each fuel tube penetrates the upper concrete shield that opens into the floor of a fuel-handling bay and is sealed by a removable shield plug. Above the array of fuel tubes in the fuel-handling bay, a shielded fuel-handling machine moves on a trolley to transfer a spent-fuel assembly from a cask-handling area at one end of the structure to any fuel tube in the array. Each fuel tube is connected to a common manifold leading to a gas system that fills the tube with the cover gas and subsequently maintains the cover gas. The walls of the concrete structure have built-in cooling channels to promote cooling by convective air flow around the fuel tubes. The cask-handling area is designed to accommodate standard truck shipping casks. The other end of the concrete structure is designed for easy expansion of the system by the construction of more modules.

The minimum installation consists of two module arrays, the cask-handling area, and the shielded fuel-handling machine. The maximum size

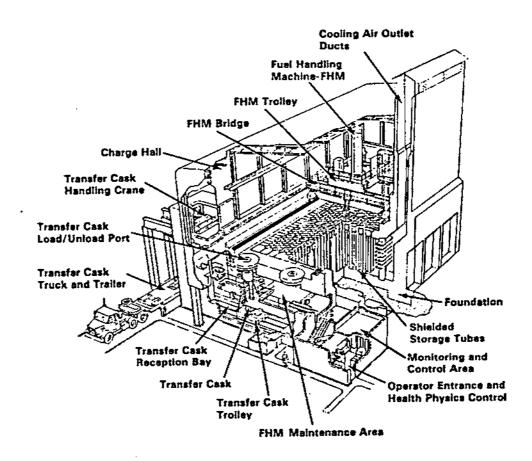


Figure 4-5. Conceptual design for a modular vault storage system.

of the system is technically unlimited, but for the purposes of the topical report, the installation is limited to five modules. The space required for modular concrete vaults is on the same order as that for spent-fuel storage pools.

In operation, the spent fuel from the reactor storage pool is transferred to the modular dry-storage system in a standard transportation cask. The cask is moved into the cask-handling area, its lid is removed, and it is positioned under a loading port in the floor of the fuel-handling bay above. The fuel-handling machine is positioned above the loading port, a docking ring is deployed to mate with the port, and a shielding skirt is lowered to cover the interface. When all is ready, the fuel-handling machine removes the shield plug from the loading port, hoists a fuel assembly into its fuel cavity, and reinstalls the shield plug in the loading port. The fuel-handling machine then traverses the module until the desired fuel tube is reached. When the fuel-handling machine is positioned over the fuel tube and the docking process is com-

pleted, the machine removes the shield plug from the fuel tube, lowers the fuel assembly into the tube, and reinstalls the shield plug. The fuel tube is connected to the gas manifold, purged, and filled with the cover gas. The fuel assembly can be moved from dry storage back to the transportation cask by reversing the sequence.

#### 4.1.5.2 Applications

A dry-storage system similar to that of the Foster-Wheeler vault has been used in the United Kingdom, but not in the United States. At present, no utility has indicated that it plans to implement this dry-storage option.

#### 4.1.5.3 Licensing status and issues

The NRC staff recently (March 1988) approved the Foster-Wheeler modular concrete vault system, provided it is used with nitrogen as the cover gas. The NRC staff ruled that there is insufficient evidence that air is a safe storage medium and no allowable air-storage temperature has been established. However, the NRC staff did not reject the contention that continued research in this area may result in their approval of storage in air. When nitrogen is used as the cover gas, the NRC staff recommended that a 5-year lifetime be assumed for the 0-ring seals in the nitrogen-supply system and recommended that this service life be verified through testing during the operation of a modular concrete vault.

Another technical issue was the criterion used for concrete operating temperatures—criterion ACI-216-R-81 of the American Concrete Institute. The NRC accepts ACI-349-80 as the criterion for concrete operating temperatures, the limit being 150°F, but not ACI-216-R-81. The NRC staff also suggested that the ventilation and offgas systems be enhanced to increase reliability and recovery under abnormal conditions. Because the normal operating temperature of the concrete in the modular vaults is expected to be less than 150°F, meeting the criterion acceptable to the NRC should not be a problem.

The site-specific issues that were identified by the NRC staff and will receive attention in license reviews include the adequacy of operating procedures, the adequacy of acceptance tests and maintenance programs, and predictions of the radiation exposures received by the public and by workers at the dry-storage facility. These issues are of the same type as the issues raised during the NRC staff's review of metal storage casks and horizontal concrete modules. None of these issues was considered to be a serious obstacle to the implementation of a modular concrete vault. The United Kingdom experience with modular vaults (see Section 4.4.3) has led Foster-Wheeler Energy Applications to believe that vaults are a safe, economical interim storage method.

# 4.1.5.4 Estimated unit costs of modular vault storage at reactor sites

There is no U.S. experience with vault storage to substantiate the cost estimates available in the literature. Thus the cost estimates should be considered as more uncertain than those of storage technologies that are more developed in the United States, such as the metal casks. However, there is a great deal of experience in designing, constructing, and operating modular concrete vaults in the United Kingdom.

In a recent presentation, Foster-Wheeler<sup>25</sup> cited total unit costs for developing and operating their system. Assuming 10 years of storage, the total unit cost per kilogram of heavy metal--including licensing, construction, and operation--was estimated at \$110 for a capacity of 100 MTHM, \$55 for a capacity of 500 MTHM, and \$50 for a capacity of 1000 MTHM. These costs were taken as the lower bound for this report; the upper bound was assumed to be 1.5 times the lower estimate.

#### 4.2 IN-POOL ROD CONSOLIDATION

Rod consolidation is an option for a more efficient use of the existing space in spent-fuel storage pools; it could also be used with dry storage. This section discusses the purpose and application of rod consolidation, the process, the operating experience, and licensing issues. The estimated unit costs of rod consolidation are also provided.

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#### 4.2.1 Purpose and application of rod consolidation

The primary purpose of in-pool rod consolidation is to reduce the volume of waste and thereby increase the capacity of pool-storage or dry-storage systems. In consolidation, the spent-fuel rods are removed from the assemblies that hold them together and loaded into canisters in a closer array. The non-fuel-bearing components (NFBC) of the assembly hardware that are left after consolidation (e.g., grid spacers, guide tubes, end fittings) are compacted to reduce their volume. Discussions of consolidation, therefore, often refer to three ratios: the rod-consolidation ratio, which is the ratio of assemblies consolidated to canisters of fuel rods; the hardware-compaction ratio (i.e., the volume-reduction ratio), and the total consolidation ratio, which combines the rod-consolidation ratio and the hardware-compaction ratio.

#### 4.2.2 Description of rod consolidation

In rod consolidation, all the fuel rods are removed from the fuel-assembly hardware that normally maintains a required spacing between the rods and arranged in a close-packed array in a metal canister without any standard fuel-assembly spacer grids (Figure 4-6). The process is per-

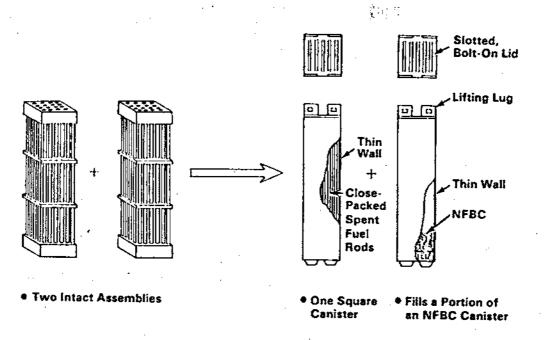


Figure 4-6. Rod consolidation.

formed mechanically. After the fuel rods have been removed, the assembly hardware (the top and bottom end fittings and the other non-fuel-bearing components) are compacted. The compacted components are loaded into a storage canister similar to, or identical with, the canister used for the consolidated rods. Both the fuel-rod and the non-fuel-bearing canisters can then be placed in pool storage racks or a dry-storage system.

Under design conditions, all of the rods from two assemblies would be loaded into one canister, thereby yielding a rod-consolidation ratio of 2:1. Together with a hardware-compaction ratio of 10:1, a 2:1 consolidation ratio would significantly decrease the required number of pool or dry-storage locations. Thus, for example, 10 assemblies would be consolidated into five rod canisters and the non-fuel-bearing hardware compacted into one canister, decreasing the number of required storage slots from ten to six. The resulting ratio of storage-location use is 10:6, or 1.67:1; that is, 1.67 assemblies are stored in the space previously occupied by one unconsolidated assembly.

The technical issues associated with rod consolidation are primarily related to operational considerations that will affect the economics of this technology. They include the difficulties of extracting the rods from the assemblies, loading them into canisters in a tighter array, and compacting and packaging the non-fuel-bearing hardware—and performing all of these operations practically and economically without interfering with the operations of the reactor.

As explained below, the consolidation of spent-fuel rods has been demonstrated on a limited basis in the United States, but no production-scale campaigns have occurred. Rod-consolidation ratios up to 2:1 have

been attained, but there is very little experience in successfully compacting, packaging, and storing the non-fuel-bearing hardware. Further development and demonstration of the practicality and economics of consolidation are needed to make it attractive for large-scale use.

#### 4.2.3 Demonstration

Six rod-consolidation demonstrations with spent fuel have been conducted in the United States. The DOE has participated in most of these demonstrations, which have involved several participants and sponsors, including equipment vendors and utilities.

One of the demonstrations was conducted by the Duke Power Company and the Westinghouse Electric Corporation; it took place during October and November 1982 in the spent-fuel storage pool of the Oconee nuclear power plant in South Carolina. Four spent PWR fuel assemblies were consolidated with Westinghouse equipment. After the top end fitting was removed, all the fuel rods in an assembly were pulled and consolidated simultaneously, achieving a rod-consolidation ratio of 2:1. The non-fuel-bearing components were sheared into small sections and hydraulically compacted, yielding a hardware-compaction ratio of at least 6:1.

A demonstration was conducted by the Maine Yankee Atomic Power Company and the Proto-Power Corporation in August 1983. One PWR spent-fuel assembly from the Maine Yankee reactor was consolidated in the spent-fuel storage pool with Proto-Power Corporation equipment, which was designed for removing individual rods and inserting them into a canister. A rod-consolidation ratio of 1.6:1 was achieved. This demonstration did not include compaction for the non-fuel-bearing hardware.

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The third demonstration, by the Rochester Gas & Electric Company and the Nuclear Assurance Corporation (NAC), was conducted during December 1985-February 1986 in the spent-fuel storage pool of the Western New York Nuclear Service Center in West Valley, New York. This sponsors included the Empire State Electric Energy Research Corporation, the New York State Energy Research and Development Authority, the Electric Power Research Institute, and the DOE. Six assemblies from the R. E. Ginna pressurized-water reactor were consolidated with NAC equipment. All of the assemblies contained some defective fuel rods. The rods were pulled and loaded into a canister one at a time. The highest rod-consolidation ratio obtained was 1.8:1. No rods were dropped or broken, which provides some evidence that rod breakage can be expected to be a relatively infrequent occurrence. This demonstration did not include the compaction of non-fuel-bearing hardware.

Rochester Gas & Electric participated with U.S. Tool and Die, Inc., in a demonstration conducted during August-October 1986 in the spent-fuel storage pool of Battelle Columbus Laboratories in Ohio. This project was an extension of the demonstration described in the preceding paragraph and was sponsored by the same organizations. Five PWR assem-

blies from the R. E. Ginna reactor were consolidated with equipment developed by U.S. Tool and Die. This equipment pulls a row of rods at a time and guides them through a funnel into a canister. All of the fuel assemblies contained some defective rods, but the system was able to achieve rod-consolidation ratios ranging from 1.8:1 to 2.0:1. During this demonstration, one or two rods appeared to release some small gas bubbles, but none of the releases was large enough or radioactive enough to set off detector alarms at the surface of the pool. The non-fuel-bearing hardware was not compacted in this demonstration. Rochester Gas & Electric received a license to store consolidated spent fuel in the storage pool of its Ginna reactor in December 1985.

The Northeast Utilities Service Company and Combustion Engineering, Inc., conducted a demonstration in August and September 1987 in the spent-fuel storage pool of the Millstone Unit 2 reactor in Connecticut. The sponsors of this project included the DOE, the Electric Power Research Institute, and the Baltimore Gas & Electric Company. Six PWR assemblies were consolidated with Combustion Engineering equipment. The rods were pulled a row at a time, and a rod-consolidation ratio of 2:1 was achieved. However, problems were encountered with the compaction of the non-fuel-bearing components. Once those problems are resolved, the demonstration will be completed. As explained in more detail in the next section, in March 1988, Northeast Utilities received from the NRC a license amendment authorizing the storage of consolidated fuel.

The last demonstration was conducted by the Westinghouse Electric Corporation and the Northern States Power Company. It took place in October and November 1987 in the spent-fuel storage pool of the Prairie Island nuclear power plant in Minnesota. Using Westinghouse equipment, the fuel rods from 36 PWR assemblies were consolidated into 18 canisters. In this demonstration, the upper and the lower end fitings were removed and all of the rods were simultaneously pushed out of the assembly and into a transition canister. Intentionally included in the demonstration program was a bowed assembly. The non-fuel-bearing hardware remains to be compacted. The objective of the initial part of this demonstration was to achieve a rod-consolidation ratio of 2:1 (which was achieved) and to provide data needed to support larger-scale efforts. The utility's long-term plan is to consolidate about 250 fuel assemblies each year, starting in 1989 and continuing until 1000 fuel assemblies have been consolidated. A recent article reported that Northern States Power is waiting until the compaction of the non-fuel-bearing components is complete before it decides to go ahead with the 1000-assembly consolidation program.

In summary, the consolidation of irradiated spent-fuel rods has been demonstrated on a limited basis in the United States, but no production-scale campaigns have been conducted. Rod-consolidation ratios of up to 2:1 have been attained with irradiated spent fuel. There is very limited experience in treating, packaging, and storing the NFBC waste resulting from the consolidation process. Even though the Northeast Utilities Service Company recently received a license to store consolidated fuel in the Millstone storage pool, further development and demonstration of the practicality and economics of consolidation systems is needed to make

them attractive for large-scale uses. There has been no large-scale experience with extended wet or dry storage of consolidated fuel rods, but problems are not expected. The world's first storage experience with consolidated spent fuel is represented by the in-pool storage of the consolidated fuel rods (with consolidation ratios of up to 2:1) from four assemblies at the Oconee Nuclear Station; these consolidated rods have been in wet storage since late 1982.

In August 1987, the Electric Power Research Institute (EPRI) issued a request for proposals for the treatment, packaging, and storage of non-fuel-bearing scrap from rod consolidation in reactor pools. EPRI has stated that cost, operational practicality, and overall consolidation efficiency are likely to be highly dependent on the manner in which the non-fuel-bearing waste is treated, packaged, and stored. To date, the range of alternative methods that may be used for this purpose has not been well quantified. This initial work was awarded, in February 1988, to the Rochester Gas & Electric Company and addressed only concept development and the evaluation of technologies for handling the non-fuel-bearing waste. Future work is expected to continue into an in-pool demonstration phase.

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# 4.2.4 Licensing status and issues

As explained in Chapter 2, if consolidation is used to increase the number of assemblies stored in the spent-fuel pool, an amendment to the utility's license under 10 CFR Part 50 is required. To the extent that utilities have consolidated rods as a demonstration, they have performed these limited consolidations under 10 CFR 50.59. The application for the amendment must include a safety analysis for review and approval by the NRC staff. This analysis must cover all the potential impacts of storing the consolidated fuel, including such factors as the potential for nuclear criticality, the structural strength of the pools and the racks, seismic design, thermal-hydraulic characteristics, and radiation safety.

The criticality analysis for storing consolidated fuel must use conservative assumptions, including worst-case values for mechanical parameters like the center-to-center spacing of the fuel or the thickness of the neutron-absorbing material. The factors of concern in the structural and seismic area include the load on the floor of the pool, local stresses on the racks, and the stresses the racks may experience (if struck by a canister when an earthquake occurs during loading). The thermal-hydraulic analysis must demonstrate that no bulk boiling may occur in the pool and that the design heat load of the pool-cooling system is not exceeded. The radiation-safety analyses are to include the effects of various postulated accidents, such as the accidental dropping of a transportation cask into the pool or a fuel-handling accident.

Included among the licensing issues are those related to safeguards. The safeguards issues pertinent to rod consolidation have been reviewed in a 1982 report. A major concern involves the ability to (1)

accurately establish the amount of nuclear fuel present in each container of consolidated rods and (2) provide a means of verifying, on a routine basis at appropriate intervals, that the fuel continues to reside in the container.

As already mentioned, the Maine Yankee Power Company did experience a licensing delay after submitting an application to the NRC for an operating-license amendment allowing the storage of additional fuel after consolidation. The delay, due to intervention first by a local antinuclear group and later the State of Maine, caused the utility to abandon the consolidation project.

Rochester Gas & Electric received a license to store consolidated spent fuel in the storage pool of its Ginna reactor in December 1985. Constraints on the total number of consolidated assemblies to be stored are imposed by the capacity of the pool's cooling system.

The Northeast Utilities Service Company recently (March 1988) received a license amendment <sup>42</sup> allowing the storage of consolidated fuel in the spent-fuel pool of Millstone Unit 2. The license amendment, issued under 10 CFR Part 50, authorizes the storage of consolidated fuel in 688 locations in the storage pool. The utility's goal is to eventually consolidate all the fuel that is stored in the pool. That operation could begin as soon as 1990 and will have to start by 1997, when a full-core reserve can no longer be maintained in the spent-fuel pool of Millstone Unit 2.

# 4.2.5 Estimated unit costs of rod consolidation

This section discusses the estimated costs of consolidating spent fuel for storage in reactor spent-fuel pools. Although consolidation has been demonstrated, a significant technical uncertainty remains about the compaction and disposal of the non-fuel-bearing hardware. A fairly broad range of costs has been cited by proponents and by utility representatives interested in rod consolidation. The costs are likely to retain a large measure of uncertainty until significantly large demonstrations under at-reactor conditions have been completed. The costs associated with the treatment, packaging, and storage of the non-fuel-bearing hardware are highly uncertain at present and are being investigated by the Electric Power Research Institute and the utilities. The costs for consolidating spent-fuel rods must be better known than they are today before utilities are likely to implement consolidation on a large scale.

The cost for at-reactor consolidation includes the cost of complying with NRC licensing requirements, the acquisition and installation cost of consolidation and compaction equipment, the cost of consolidation operations, and the cost of canisters for the consolidated rods and the compacted non-fuel-bearing hardware. For this report it was assumed that the hardware canisters are the same as those for the consolidated rods

and that they will be stored and disposed of in the same manner as the canisters of consolidated rods.

The currently available information 9,43,44 indicates that the cost of the license-amendment action would range from \$200,000 to \$500,000. Equipment costs are expected to vary directly with the level of complexity and automation. For this report, a cost of \$1.5 million to \$2.5 million was derived from available information on the designs and the cost estimates developed to date. Operating costs will depend somewhat on the type of fuel. The unit cost is higher for BWR spent fuel because, though the consolidation operation is similar for both BWR and PWR fuel, a typical BWR assembly contains much less uranium (only about 40 percent) than a typical PWR assembly, and hence the cost per kilogram of heavy metal is higher. For this analysis, operating costs per kilogram of heavy metal were assumed to range from \$5 to \$7 for PWR assemblies and from \$6 to \$8 for BWR fuel.

The final cost item is the cost of canisters for the consolidated rods and the non-fuel-bearing components. These canisters will be sized to fit into the existing spent-fuel storage racks. According to the available information, the cost of a canister for PWR fuel is expected to range from \$2400 to \$3600, and the cost of a BWR-fuel canister is assumed to vary between \$1800 and \$2700. Canisters for BWR fuel cost less than canisters for PWR fuel because they are smaller.

The unit costs of storage space gained by consolidation are highly dependent on the total consolidation ratio that is attained. In this report, the low-cost estimates were based on total consolidation ratios of 1.67 and 1.54 for PWR and BWR fuel, respectively. These ratios were assumed to represent high consolidation ratios and would be obtained by attaining a consolidation ratio of 2:1 for the spent-fuel rods, a compaction ratio of 10:1 for the non-fuel-bearing components, and a compaction ratio of 20:1 for BWR fuel channels. Assuming that the PWR-to-BWR weight ratio is the same as in the general spent-fuel population (i.e., a ratio of 2:1), the weighted-average consolidation ratio is 1.63. However, there is significant uncertainty as to whether compaction ratios of 10:1 can be achieved for the non-fuel-bearing components. Thus, to obtain the high-cost estimates, a weighted average ratio of 1.50 was assumed for the low consolidation ratio; this ratio is based on a 50-percent increase in the number of canisters loaded with non-fuel-bearing components.

As indicated in Section 4.2.3, efforts have been started by EPRI and the utilities to look at other methods for the disposal or storage of non-fuel-bearing components so that the consolidation ratio of the spent fuel is truly 2:1. The costs associated with these other disposal or storage alternatives would be included in the consolidation costs. These studies have not been completed, but the identification of economical alternatives could lead to lower consolidation costs.

The cost factors described above are summarized in Table 4-4. The fixed costs range from \$1.7 million to \$3 million, and the variable costs

per kilogram of heavy metal consolidated range from \$9 to \$14 (weighted-average for PWR and BWR fuel).

The costs discussed above apply to the quantity of spent fuel that is consolidated, but for storing the consolidated rods in a spent-fuel pool, the important consideration is the unit cost, in dollars per kilogram of heavy metal, of storage-capacity expansion. This quantity is highly dependent on the consolidation ratio. With the high consolidation ratio for PWR fuel (20:12), 20 PWR assemblies can be consolidated and stored in 12 storage slots, for a gain of 8 slots. Thus, to gain one slot, it is necessary to consolidate 2.5 PWR assemblies. For BWR fuel, with the high consolidation ratio of 20:13, it is necessary to consolidate 2.86 assemblies for a gain of one storage slot; this is equivalent to a weighted average of 2.6. With the low consolidation ratio, three times as many assemblies must be consolidated on a weighted-average basis. As shown in the table, the fixed-cost range remains \$1.7 million to \$3.0 million, but the variable unit cost, per kilogram of heavy metal,

Table 4-4. Factors used in estimating the unit-cost range for consolidating spent fuel for in-pool storage

	Low	High cost		
Factor	Fixed	Variable	Fixed	Variable
NRC licensing	\$200,000		\$500,000	
Equipment and installation	\$1,500,000	\$1	2,500,000	
Total fixed cost	\$1,700,000 \$3,000,000			
Operating labor <sup>a</sup>		**	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
PWR fuel		5		7
BWR fuel		6		8
Cost of canisters b	* .	Ū		0
PWR fuel		\$2400		\$3600
BWR fuel		\$1800		\$2700
Total variable costs		, =		42,00
Per kilogram of heavy metal				
consolidated	1			
PWR fuel		8		12
BWR fuel		12		15
Weighted average		9	•	14
Per kilogram of heavy metal		•		14
gained				
PWR fuel		20		34 '
BWR fuel		34		60
Weighted average		25		43

<sup>&</sup>lt;sup>a</sup>Cost per kilogram of heavy metal. <sup>b</sup>Cost per canister.

of storage-capacity expansion ranges from \$25 to \$43, or 2.6 to 3 times the original range for variable costs.

The unit cost, per kilogram of heavy metal, for storing consolidated rods in the pool ranges from about \$40 to \$75 for capacity expansions of 100 MTHM and from about \$30 to \$45 for an expansion of 350 MTHM. The latter quantity, 350 MTHM, is essentially the maximum amount of additional storage that can be gained with the high consolidation ratio for a pool with an unconsolidated-fuel capacity of 1100 PWR assemblies (509 MTHM) or 3500 BWR assemblies (638 MTHM). With the lower consolidation ratio of 1.5, the maximum storage gain is about 270 MTHM. The high-cost estimates for expansions of more than 270 MTHM are based on higher consolidation ratios with the high cost factors.

# 4.3 DRY STORAGE OF CONSOLIDATED FUEL

Some proponents of dry storage propose the storage of consolidated fuel in dry modular storage. In early 1988, the DOE and the Electric Power Research Institute sponsored a performance test that confirmed that consolidated PWR spent fuel can be successfully stored in metal casks (see Section 4.1.1.2). A formal report is scheduled for late 1988.

The economic benefit of storing consolidated fuel comes from a more effective use of the storage modules because their capacity is increased. The least cost for each unit of storage would be realized by a utility that has already installed consolidation equipment but cannot accommodate all of its spent fuel in the storage pool and must provide some dry storage.

If a utility has not already installed consolidation equipment, the fixed cost of consolidation would also need to be recovered in order for consolidation to be cost effective for dry storage. A cost-benefit analysis would be needed for each specific case, and the cost benefit would depend on the amount of storage required at the specific site.

### 4.4 DRY-STORAGE EXPERIENCE IN OTHER COUNTRIES

Four foreign countries--Canada, the Federal Republic of Germany, Switzerland, and the United Kingdom--have undertaken major efforts in dry storage, and these efforts have directly influenced the implementation of dry-storage technology in the United States. Canada is demonstrating the use of concrete storage casks for both storage and transportation. The Federal Republic of Germany tested and demonstrated two types of metal cask for dual-purpose service in the early 1980s. These casks were the Castor I cask marketed by General Nuclear Systems, Inc., and the TN-1300 cask of Transnuclear, Inc. Switzerland tested and demonstrated the use of metal storage casks in 1983 and is currently using a Castor cask for

storing spent fuel from an experimental reactor. The United Kingdom has been storing spent fuel in modular concrete vaults for approximately 17 years. Each of these programs is briefly discussed below.

# 4.4.1 Cask tests and demonstrations in the Federal Republic of Germany

The Federal Republic of Germany has conducted several tests and demonstrations of several Castor casks (Castor IA, IB, and IC; Castor AVR; Castor KRB-MOX; and Castor WWER 1000) and a TN-1300 cask. The objective was to verify the performance of dual-purpose storage-and-transportation casks, optimize cask-handling procedures, and expand the data base on the integrity of spent fuel. The results confirmed both the performance of the casks and the maturity of the technology. The Germans are now concentrating on optimizing the casks.

As a result of the successful tests and demonstrations, the away-from-reactor storage facility at Gorleben received a license to store fuel in the Castor I casks, which will first be used to transport the fuel to Gorleben.

The Federal Republic of Germany plans to store the spent fuel at central facilities for approximately 40 years. During that time, the fuel would either be reprocessed or converted to some other waste form. Eventually the fuel will be encapsulated in containers designed for permanent disposal 46 and emplaced in a geologic repository.

The German cask tests and demonstrations were partly responsible for the Castor IC and Castor V/21 casks being the first casks to be approved by the NRC for spent-fuel storage in the United States.

# 4.4.2 Dry cask storage in Switzerland

In 1979, the Swiss started a dry-cask-storage program for spent fuel from an experimental reactor. The reactor was being decommissioned, and an alternative to pool storage was required for a complete shutdown of the reactor. Mainly because of the short time needed to provide dry cask storage and the small quantity of spent fuel (one cask load), a Castor I metal cask was selected.

The experimental-reactor fuel was consolidated with a 1.5 reduction in volume. Since the weight and the size of the Castor cask did not allow the cask to be lowered into the spent-fuel pool of the experimental reactor, the consolidated fuel was loaded into the Castor cask by the dry-loading method described in Section 4.1.1. A 2-year monitoring period followed the dry loading, and, after its successful completion, a license to transport and store the fuel at a nearby away-from-reactor storage facility was granted. The cask was transported to the storage facility in 1985.

### 4.4.3 The Canadian dry-storage program

In 1974, Atomic Energy of Canada Limited (AECL) began a development-and-demonstration program for dry storage in concrete casks at its Whiteshell Nuclear Research Establishment (WNRE). 48,49 Analyses and experimental tests have confirmed that concrete casks have wide margins of safety in shielding from radiation, that the concrete retains its integrity after repeated freeze-and-thaw cycles, and that the cask meets both safety requirements under potential accident conditions and safe-guards requirements. In addition, the use of dry loading with a transfer cask eliminates the need to load the casks in reactor pools. Because of their excellent performance, AECL has decided to use concrete casks for storing all the spent fuel from the WR-1, Gentilly Unit 1, and Douglas Point reactors. The concrete-cask storage facility at Gentilly Unit 1 has been given a license.

More recently, Ontario Hydro has undertaken a program to assess the feasibility of using concrete casks for storing, transporting, and possibly disposing of spent fuel from the CANDU heavy-water reactors. A concrete integrated cask (CIC) was designed. The cask will be approximately 8 feet in diameter and 12 feet long; when loaded, it will weigh 75 tons. The walls of the cask will be made from a special high-density concrete mix with rebar reinforcement. The reinforced-concrete body will be lined on both the inside and the outside with carbon steel. Trunnions will be attached to the body for lifting. A lid, also made from the reinforced concrete, will be bolted to the body of the cask and sealed with conventional elastomer and metal seals.

Ontario Hydro believes that the concrete integrated cask is feasible and could become an important alternative method for spent-fuel storage, transport, and possibly disposal. A two-phase demonstration program for the concrete integrated cask has been started. Two such casks will be built for storage demonstrations starting in 1988. Two additional casks are planned for transportation testing in 1989.

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Experience with licensing foreign technologies in the United States (see Section 4.1.2.3) indicates that it may be very difficult to obtain a transportation certification for concrete casks.

# 4.4.4 Modular-concrete-vault storage in the United Kingdom

Two types of modular concrete vault have been used at the Wylfa Magnox power station in North Wales to provide temporary storage for spent fuel before reprocessing. The first three vaults, with a capacity of 83 MTHM each, have been operating for approximately 17 years. Fuel elements are placed in tubes backfilled with carbon dioxide, and the heat generated by the fuel is removed from the tubes by the natural convection of air across the exterior surfaces of the tubes. This completely passive system has proved to be very reliable, and no degradation of the fuel has been detected. The maintenance and operation of the facility require very limited personnel support.

The second type of modular concrete vault (350 MTHM each) used at Wylfa has a forced-air cooling system. The design of this modular concrete vault eliminates the need for the carbon dioxide cover gas. The atmosphere inside the vaults is maintained at a slightly negative pressure by means of an exhaust fan discharging to the atmosphere. A filter system, with redundancy, is provided to ensure that atmospheric contamination does not occur. The maximum temperature of the fuel in air is less than 150°C under normal operating conditions. Newly discharged spent fuel whose temperature would exceed 150°C is first stored in a modular concrete vault that is filled with carbon dioxide and then transferred to the air-cooled system when the decay heat has decreased to an acceptable value. The modular concrete vault with the forced-air cooled system has been effectively operated since 1979. The activity levels of the discharged air have been at background levels. Maintenance requirements are minimal, and the radiation exposures of the workers have been very low.

The United Kingdom's Central Electricity Generating Board, in conjunction with the South Scotland Electricity Board, is in the process of completing the final design for a new centralized vault system. This vault system will store spent fuel from the British advanced gas reactors for periods of up to 50 years.

# 4.5 FACTORS THAT MIGHT AFFECT CHOICES OF STORAGE OPTIONS AND THE ATTITUDE OF THE UTILITIES

It is possible to identify the factors that utilities are likely to consider in choosing among the various dry-storage concepts, but the results cannot be generalized. It is also possible to compare some of the concepts in terms of some factors, though it is not possible to do a systematic comparison, nor is it possible to confidently generalize these comparisons for the electric-utility industry at this stage of technology development and implementation.

In addition to briefly reviewing the most important of these factors, this section discusses the results of surveys questioning utilities about their plans for providing additional storage capacity and their studies of available options.

# 4.5.1 Factors affecting the choice of a storage concept

In choosing from among the various dry-storage methods, a utility is likely to base its decision on such factors as the maturity of the concept, the time needed to implement the concept, economics, site-specific conditions and limitations, its operating philosophy, its corporate experience, and public opinion. These factors are briefly reviewed in this section.

### 4.5.1.1 The maturity of the concept

Although the basic technical feasibility of almost all of the concepts described in this chapter has been demonstrated, there are differences in the maturity of the concept. In terms of maturity, dry storage at present has an advantage over in-pool rod consolidation, as discussed in Chapter 4. Therefore, for utilities requiring large-scale relief in the near term, the relative maturity of the dry-storage concepts offers an option with less technical risk. However, because of the recent demonstrations of in-pool rod consolidation, the perceived advantage of dry storage may be temporary and thus relevant only to the utilities that must provide additional at-reactor storage capacity in the near future.

### 4.5.1.2 Time needed for implementation

Even for concepts with comparable technical maturities, the time needed for implementation will differ. The activities requiring the most time include planning and various associated analyses, the design of the dry-storage facility, obtaining an NRC license, and the development of the dry-storage facilities.

The planning, analysis, design, and licensing of a storage system are likely to take at least 2 years, depending on the degree of intervention. Once all of the technologies have been accepted and licensed, no technology is likely to have a significant advantage in this regard. Because they have been approved, metal storage casks, horizontal concrete modules (NUHOMS), or modular concrete vaults offer more certain implementation schedules.

Whatever the dry-storage option, it will be necessary to construct a dry-storage facility at a designated part of the reactor site. This facility must have an adequately prepared site with adequate access and utilities; a central monitoring and security system and other safeguards that may be needed; equipment like cranes and transporters; and, in the case of storage in casks or concrete modules, concrete storage pads. Although the dry-storage facilities are not complex, their planning, design, site preparation, and construction can be expected to require about a year.

Rod consolidation would require the design, licensing, fabrication, and installation, in or near the storage pool, of the equipment needed for removing the rods from the assembly hardware, loading the rods into canisters, and controlling the operation. Monitoring equipment in addition to that already present in the pool may also be needed. At the current stage of its development, it is impractical to estimate a "typical" schedule for acquiring and installing this equipment. Moreover, the installation of the equipment in an area that is used in reactor operations would probably complicate the installation. Difficulties in scheduling the installation so as to minimize interference with reactor operations and the actual time required for the installation are expected to vary with the site.

A possible option would be to use the services of vendors who would provide temporary consolidation services when needed, using equipment that is moved from site to site. This option might considerably simplify and shorten the process of installing the consolidation facilities, and it might make consolidation attractive in terms of implementation.

### 4.5.1.3 Rate of processing

The rate at which the spent fuel can be processed for storage (i.e., the rate at which a cask, horizontal concrete module, or modular concrete vault can be loaded or spent fuel consolidated) might favor one method versus another. In general, at the current phase of concept maturity, cask loading can be performed at a higher production rate (about 2 MTHM per day) than consolidation (less than 1 MTHM per day). This operating advantage could be important for those utilities that must accommodate significant amounts of spent fuel on a tight schedule or where access to the pool is limited. It is also possible that certain conditions that are specific to a particular reactor site, such as the absence of large cask-handling cranes or an insufficiently large storage-pool building, would require the use of small casks, in which case the consolidation rate may exceed the cask-loading rate.

### 4.5.1.4 Interference with reactor operations

Being in the business of efficiently generating power, the utilities are reluctant to undertake any secondary activities that could interfere with the operation of their nuclear power reactors—that is, the production of electrical power. Thus, in selecting a storage concept, the degree of interference with reactor operations may dominate the other factors.

# 4.5.1.5 Costs

Given that all safety requirements are met, the utilities will attempt to minimize the costs of additional at-reactor storage. As already discussed, the unit costs of providing additional storage capacity may differ significantly among the various storage options, and significantly lower costs may lead to systematic preferences for certain concepts.

When an attempt is made to predict what storage methods the utilities would choose if cost were the main consideration, the results are largely indeterminate. First, as already discussed, there is substantial uncertainty in the unit costs of each concept. Thus the capacity "breakpoint" where the unit costs of one technology become lower than those of another is not well known. Even if it is assumed that all utilities would seek to minimize costs, ignoring other factors, the uncertainty

of unit costs and the distribution of quantities over sites prevents meaningful conclusions about which storage methods are most likely to be chosen.

### 4.5.1.6 Public opinion

Public opposition may cause significant delays in the implementation of a concept when implementation requires an NRC license for an independent storage installation or an amendment to the operating license for the reactor. Both of these licensing actions provide opportunities for participation by the public through hearings and comments, and opponents can extend the process through appeals. Although there is very little direct experience with the licensing of dry at-reactor storage (see, however, Sections 2.2 and 4.2.4), the experience with the licensing of nuclear power plants and with license amendments indicates that public opposition can be easily incited and intervention can cause considerable delays in formal licensing actions. In addition to wishing to avoid licensing delays, a utility may choose a storage method that has less potential for public opposition in the interest of maintaining good public and community relations.

### 4.5.2 Results of surveys

Two recent surveys have attempted to collect information about the current at-reactor-storage practices of the utilities as well as their plans for dry at-reactor storage and consolidation. One of these was the annual survey conducted by the DOE's Energy Information Administration (EIA) to collect information on storage-pool capacities and spentfuel inventories (see Chapter 3). The other was a survey conducted in June and July 1987 by the National Association of Regulatory Utility Commissioners (NARUC). The NARUC survey obtained data for 118 nuclear reactors.

The principal conclusions of these surveys 50,51 can be summarized as follows:

 A large portion of the responding utilities whose storage pools will reach full capacity before 1998 have not extensively studied options for increasing capacity and have no current plans to increase their at-reactor storage capacity.\*

<sup>\*</sup>Many of the reactor sites owned by these utilities will not fully use up their current storage capacity until the middle to late 1990s, and the planning and implementation of an increase in storage capacity are not expected to take more than 5 years. Thus, it is not unreasonable that these utilities have not yet developed any definite plans.

- The majority of the utilities that have studied storage-increase options have considered both dry storage and rod consolidation.
- Very few utilities report having reached firm conclusions about preferred storage technologies.

### 4.5.3 Summary,

Though it is possible to identify various factors that utilities are likely to consider, it is not possible to draw conclusions about which storage methods are likely to be chosen. At present, dry-storage methods have an advantage in technical maturity and schedule, but the long-run economics for many sites with additional-storage requirements of between 100 and 350 MTHM may ultimately favor consolidation. However, there is considerable uncertainty about unit costs, which control the relative economics, and even greater uncertainty about other site- or utility-specific factors that may be involved. These uncertainties appear to be reflected in the responses of utilities to questions about their plans and studies on storage methods.

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### Chapter 5

# POTENTIAL IMPACTS AND COSTS OF DRY CASK STORAGE AT REACTOR SITES

In directing the Department of Energy (DOE) to perform this study of dry cask storage at reactor sites, the Nuclear Waste Policy Amendments Act of 1987 specifically required the Secretary of Energy to consider costs, the extent to which such storage will affect human health and the environment, the extent to which such storage will affect the costs or risks of transporting spent fuel to a central waste-management facility. such as a facility for monitored retrievable storage, and any other factors deemed appropriate. This chapter addresses these requirements by presenting bounding estimates of costs and potential impacts on transportation. These quantities represent the aggregate costs and impacts expected to result from providing additional storage capacity for all U.S. reactors that need additional capacity. Aggregate impacts on human health and the environment are not presented because the information needed to calculate these impacts is not available. However, it is possible to conclude from the information available for individual storage technologies and particular reactor sites that the aggregate impacts on human health and the environment will be so small as to be negligible, representing only a small fraction of the doses received from natural background radiation. Furthermore, the impacts of at-reactor storage on human health and the environment have been examined by the Nuclear Regulatory Commission (NRC), which found that no significant impacts are expected.

The cost estimates presented here are associated with large uncertainties, partly because some of the technologies are not yet fully mature and partly because it is not possible to draw conclusions about which storage methods are likely to be chosen by the utilities. It is possible to identify the factors that utilities are likely to consider in choosing among the various dry-storage concepts. It is also possible to compare some of the concepts in terms of some factors, but it is not possible to do a systematic comparison, nor is it possible to confidently generalize these comparisons for the electric-utility industry at this stage of technology development and implementation. As a result, because it is not possible to determine how much of the additional storage capacity is likely to be provided by a particular storage method, the analyses of costs and impacts used assumptions that bound the ranges of unit impacts (costs and radiation doses) for all of the storage options.

# 5.1 ESTIMATED AGGREGATE COSTS OF PROVIDING ADDITIONAL AT-REACTOR STORAGE

This section presents bounding estimates of the aggregate costs of providing additional at-reactor spent-fuel storage at all U.S. reactors that will need additional storage capacity. These estimated overall costs do not include any of the costs to be incurred by the DOE's waste-

management system, such as the cost of transporting the spent fuel to waste-management facilities or the costs of permanent disposal in a geologic repository.

As discussed in Chapter 4, the cost analysis was largely based on cost estimates reported by utilities and storage-equipment vendors at various meetings and seminars. No new engineering-cost estimates were developed for this report. Since most of the cost estimates are for developing technologies with little operating experience, the uncertainty in the actual costs of implementing these technologies is quite large. This uncertainty is illustrated by the large range of unit-cost estimates presented for the various technologies in Chapter 4.

The bounding estimates of aggregate costs are based on the high- and low-cost estimates of the unit cost of providing at-reactor storage for a given increase in storage capacity. The unit cost is an average based on the unit costs given in Chapter 4 for the various storage options and is shown in Table 5-1.

Table 5-1. Range of unit-cost estimates for additional-storage requirements (Costs in dollars per kilogram of heavy metal)

	Cap	Capacity increase					
Storage technology	100 MTHM	300 MTHM	1000 MTHM				
Consolidated fuel stor	red						
in reactor pool <sup>a</sup>	40-75	30-50	NA <sup>5</sup>				
Metal cask	60-115	55-105	55-100				
Concrete cask	50-110	45-95	45-85				
Horizontal concrete							
module	60-80	45-60	40-55				
Modular concrete							
vault	105-155	70-105	45-70				

<sup>&</sup>lt;sup>a</sup>The unit costs are based on the cost for an additional storage slot created in the storage pool. From 2.6 to 3 spent-fuel assemblies must be consolidated for each additional storage slot.

<sup>\*</sup>An increase of 1000 MTHM is not applicable to rod consolidation because at a typical reactor not much more than 350 MTHM of additional storage space can be gained through consolidation.

In estimating the aggregate costs, the application of the unit-cost ranges for each storage technology is not straightforward. First, it is expected that in selecting a storage technology the utilities will consider cost, and therefore the most expensive technologies are probably not representative of those likely to be implemented. However, the choice of technology is not likely to be based solely on cost, and therefore the lowest unit costs will not always be applicable. Finally, the level of confidence that the lower-bound cost for a technology can be achieved varies among the storage technologies. For these reasons, several cost ranges were developed for this study, as explained below. The bounds of the unit-cost ranges are shown in Figure 5-1 as a function of storage-capacity increase.

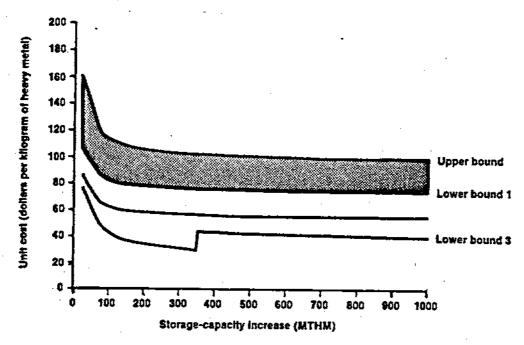


Figure 5-1. Aggregate unit-cost ranges as a function of storage-capacity increase.

The shaded region in Figure 5-1 represents the unit-cost range for a storage technology that has been fully proved and demonstrated in the United States. This technology is the current design of the metal storage cask—that is, a cask designed without taking credit for fuel burnup (Section 4.1.1.4). Assuming that several hundred casks will be required, the cask-purchase price should range from \$70 to \$90 per kilogram of heavy metal (Section 4.1.1.4). This price is about 15 percent lower than the price paid for the casks used in cooperative—agreement demonstrations cosponsored by the DOE. The resulting unit costs range

from about \$75 to \$100 per kilogram of heavy metal for storage-capacity increases of more than 300 MTHM. For convenience, the lower bound for the proven-technology range is labeled "lower bound 1" in the discussion and tables that follow.

Just below lower bound 1 in Figure 5-1 is a curve that represents the cost reductions expected from technology improvements that are believed to be likely. For metal storage casks, these likely improvements include the increased capacities and less-expensive fuel baskets that would result from the NRC's allowing credit for fuel burnup; they also include the successful demonstration of other technologies, such as concrete modular storage components, but not necessarily at their lowest current cost estimates. This lower bound is represented by the lowest cost estimate for dry storage in metal casks and a middle range for concrete technologies. For convenience, this lower bound is labeled simply "lower bound 2."

The lowest curve in Figure 5-1 further reduces the lower bound to the lowest cost estimated for any of the technologies discussed in Chapter 4. This lower bound has two components: for storage-capacity increases of 70 to 350 MTHM, it represents the lowest cost estimated for storing consolidated spent fuel in pools, whereas for storage-capacity increases of less than 70 or more than 350 MTHM, it represents the lowest cost estimated for horizontal concrete modules. As discussed in Section 4.2.5, at reactors with typical storage-pool capacities, 350 MTHM is approximately the maximum additional in-pool capacity that can be gained by consolidating the fuel rods. This bound is labeled "lower bound 3" in Figure 5-1.

To determine the dependence of the unit cost on storage-capacity expansion, the four unit-cost bounds discussed above were used to estimate costs for the midpoints of 50-MTHM capacity intervals. For example, the unit-cost point estimates for a 25-MTHM capacity increase were used for all sites with additional-storage requirements of less than 50 MTHM, the unit-cost point estimates for 75 MTHM were applied to sites with additional-storage requirements of 50 to 100 MTHM, etc.

The costs thus estimated for the additional-storage requirements of all U.S. reactors are summarized in Tables 5-2 and 5-3 for two different assumptions about the aggregate additional-storage requirements (Chapter 3). Table 5-2 presents the estimated unit costs for the lower-bound additional-storage requirement, and Table 5-3 gives the estimates for the upper-bound requirement. The estimates in both tables are based on the reference case used for this study—spent-fuel acceptance by the Federal waste-management system starts in 2003 for disposal in a repository (i.e., there is no MRS facility in this system). For each 50-MTHM capacity interval, the tables show the number of sites whose additional storage requirement falls within that interval, the total additional capacity required by all sites whose requirement is within that interval, and the four point estimates of cost.

Table 5-2. Estimated aggregate costs of providing at-reactor storage to meet the minimum projected additional-storage requirements with the reference spent-fuel-acceptance case

	Storag	e requirement						
Capacity	Number	Total	Estimated aggregate cost <sup>A</sup>					
increase	of	increase	Upper	Lower	Lower	Lower		
(MTHM)	sites	needed (MTKM)	bound	bound I	bound 2	bound		
0-50	10	190	35	20	16	14		
50-100	8	590	73	50	38	- 28		
100-150	6	800	90	64	48	31		
150-200	5	840	91	66	50	29		
200-250	5	1120	118	87	65	37		
250-300	4	1100	115	85	63	34		
300-350	5	1630	168	124	91	49		
350-400	3	1110	113	84	62	48		
400-450	3	430	43	33	24	18		
450-500	7	490	49	37	27	21		
500-550	2	1090	110	83	61	45		
550-600	1	590	59	44	32	24		
600-650	1	630	63	47	35	26		
650-700	0							
700-750	0							
750-800	1	780	77	59	43	31		
800-850	1	820	81	62	45	33		
850- <del>9</del> 00	<b>Q</b>		-==	<del></del>	==	==		
Total	54	12,220	1285	94\$	701	468		
Average ui	nit cost	per						
kilogi	ram of	heavy metal	\$105	\$77	\$57	\$38		

Afor a discussion of the minimum projected requirements, see the discussion of the no-new-orders case in Chapter 3.

\*\*Aggregate cost in millions of dollars.\*\*

In addition to the large uncertainty in unit costs for at-reactor storage increase, the aggregate cost of providing additional at-reactor storage has an additional source of uncertainty resulting from the uncertainty about the aggregate additional-storage requirement and its distribution among reactor sites. As discussed in Chapter 3, the storage-requirement uncertainty is affected by uncertainties in future spent-fuel discharges, the maximum capacities of at-reactor spent-fuel pools, and the start and rate of spent-fuel acceptance by the DOE. With the reference case for spent-fuel acceptance, the requirement for additional at-reactor storage ranges from about 12,200 MTHM at 54 sites to about 20,000 MTHM at 67 sites. For the lower bound of the storage requirement with the reference spent-fuel-acceptance case, the aggregate cost with the proven-technology range (i.e., the upper bound and lower bound 1 in Figure 5-1) is about \$950 million to \$1.3 billion. Lower bound 2 is about \$700 million, and lower bound 3 is about \$470 million. For the upper bound of the storage requirements with the reference spentfuel-acceptance case, the aggregate cost with the proven-technology range is between about \$1.5 billion and just about \$2.1 billion. Lower bound 2 is about \$1.1 billion, and lower bound 3 is about \$800 million. These

cost estimates for the reference spent-fuel-acceptance case are shown in Figure 5-2.

The time and the rate at which DOE waste-management facilities begin accepting spent fuel significantly affect additional-storage requirements in terms of the timing and the magnitude of the peak requirement; this in turn affects the aggregate cost of increasing at-reactor storage capacity to satisfy the requirements. The estimated aggregate costs of additional at-reactor storage for the three alternative-acceptance cases are given in Table 5-4. These alternative cases are based on the assumption that an MRS facility is included in the waste-management system and that spent-fuel acceptance starts in 1998, 2003, or 2008 at the ramp-up rates of the MRS facility.

Table 5-3. Estimated aggregate costs of providing at-reactor storage to meet the maximum projected additional-storage requirements with the reference spent-fuel-acceptance case<sup>a</sup>

		<u>requirement</u>						
Capacity	Number		Estimated aggregate cost <sup>B</sup>					
increase	of	increase	Upper	Lower	Lower	Lower		
(MTHM)	sites	needed (MTHM)	bound	bound 1	bound 2	bound 3		
0-50	9	270	47	29	23	21		
50-100	6	420	52	36	27	20		
100-150	12	1510	171	121	91	20 59		
150-200	3	520	56	41	31			
200-250	6	1340	141	105 .	78	18 44		
250-300	3	810	84	62	46	25		
300-350	4	1280	133	97	72			
350-400	3	1090	111	83	. 61	. 38		
400-450	4	1660	170	126	93	47		
450-500	4	1940	196	147	109	70		
500-550	2	1030	104	78	109 58	81		
550-600	3	1700	171	128	94	42		
600-650	1	610	. 61	46	34	70		
650-700	¢				- ·	25		
700-750	2	3420	142	107	78			
750-800	3	2340	233	176		57		
800-850	0	~		175	129	94		
850-900	0				~-			
900-950	ð	-1-						
950-1000	t	980	97	74		<del></del>		
000-9999	_1	1080	107	74 <u>81</u>	54 <u>59</u>	39 43		
otal	67	20,000	2026	1535	1135	793		
verage un								
kilogr	am of h	eavy metal	\$104	\$77	\$57	\$40		

AFor a discussion of the maximum projected requirements, see the discussion of the no-new-orders case in Chapter 3.

Baggregate cost in millions of dollars.

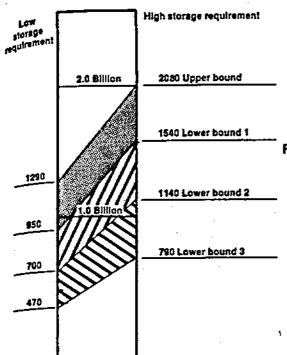


Figure 5-2. Estimated aggregate costs (in billions of dollars) of increasing at-reactor storage capacity with the reference spent-fuel-acceptance schedule (repository startup in 2003). The cost estimates are given for the upper bound and for lower bounds 1, 2, and 3 for the low estimate of storage requirements (left) and the high estimate of storage requirements (right).

Table 5-4. Estimates of the aggregate costs of at-reactor storage for the alternative-acceptance cases with an MRS facility in the waste-management system and MRS ramp-up rates (Costs in millions of dollars)

Start of spent-fuel acceptance			Aggregate cost						
	Storage requirements Description	irement MTHM	Upper bound	Lower bound 1	Lower bound 2	Lower bound 3			
1998	Minimum	4,530	500	360	270	180			
	Maximum	7,650	830	600	450	310			
2003	Minimum	9,780	1040	760	560	390			
	Maximum	16,210	1700	1250	930	640			
2008	Minimum	17,230	1800	1330	980	680			
	Maximum	26,430	2720	2010 .	1480	1040			

For the given ramp-up rate, if acceptance begins 5 years before 2003, the aggregate cost of additional at-reactor storage may be reduced by about \$200 million to about \$900 million, depending on the assumptions about the aggregate additional-storage requirements and the unit cost of additional storage. If acceptance begins in 2008, the cost may be \$300 million to \$1 billion higher than the cost for acceptance in 2003. The cost ranges for each of the bounds are shown in Figure 5-3.

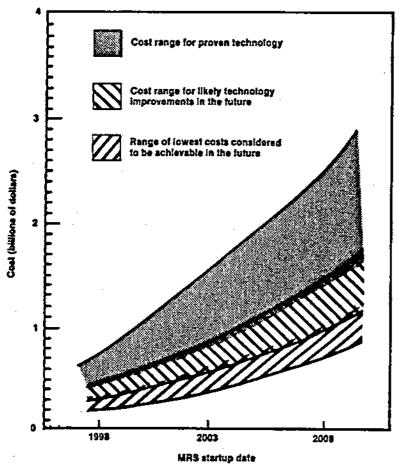


Figure 5-3. Estimated ranges of the aggregate costs increasing at-reactor storage capacity for three alternation spent-fuel-acceptance schedules (i.e., three different MRS startup dates). The overlap of ranges is derived from the high and low ranges in storage requirements.

# 5.2 IMPACTS ON HUMAN HEALTH AND THE ENVIRONMENT

This section discusses the potential impacts on human health and the environment of providing additional storage capacity at reactor sites. No significant impacts are expected from at-reactor storage under normal operating conditions or under the conditions of various accidents that can be postulated to involve spent fuel. The finding of no significant impacts was made by the NRC in its Waste Confidence Decision, and it is supported by more recent data on at-reactor storage technologies.

In its Waste Confidence Decision of August 31, 1984, the NRC¹ stated that "the Commission finds reasonable assurance that, if necessary, spent fuel...can be stored safely and without significant environmental impacts" in reactor storage pools or in "independent spent-fuel storage installations." For dry storage, the NRC expressed confidence that "dry storage installations can provide continued safe storage." The NRC also concluded that the possibility of a major accident or sabotage with offsite radiological impacts at a spent-fuel storage facility is extremely remote.

The aggregate impacts on health and the environment are not quantified in this report because the calculations require data that are not available, such as the location of the person defined as the "nearest real individual" for each reactor site and the total number of people that might be affected. However, this section does present the radiation doses that were estimated by the NRC in environmental assessments prepared for the two reactor sites at which dry-storage facilities have been licensed and installed, and the estimates are compared with the applicable regulatory limits and the exposures resulting from natural background radiation and from normal reactor operations. Although radiation doses are affected by various site-specific factors, the estimates for these two sites can be used to draw general conclusions about the potential radiological effects of dry storage.

### 5.2.1 Radiological impacts

This section begins by briefly explaining why no significant radiological impacts are expected from the storage of spent fuel and then reviews the safety of pool storage, dry storage, and consolidation. The potential risks of accidents and acts of sabotage are also included. The discussion is largely based on the NRC's findings in the Waste Confidence Decision and the final generic environmental impact statement on the handling and storage of spent fuel.

The NRC has specified in 10 CFR Part 72 limits for the radiation exposure that the public may receive from dry-storage facilities (i.e., independent spent-fuel storage installations); these limits are the same as the standards promulgated by the U.S. Environmental Protection Agency in 40 CFR Part 190. In addition, the NRC has specified that the limits for exposures received by workers at the reactor site are the same as those specified in 10 CFR Part 20. To protect the workers at the reactor site, consideration is given in both the design and the operation of drystorage facilities to keeping radiation exposures as low as reasonably achievable (ALARA). The NRC requires that the topical report include a discussion of how the ALARA criterion has been met in the design of the storage technology.

# 5.2.1.1 The safety characteristics of spent fuel

Spent-fuel storage either in spent-fuel pools or in dry-storage systems does not pose significant risk to workers at the reactor site or to the general public. The factors that contribute to the safety of storage include the physical characteristics of the spent-fuel rods as well as the design and construction of the storage facilities and the equipment used in handling the fuel. As a result, multiple barriers are provided against the release of radioactive material.

The first barrier against the release of radioactive material is found in the form of the spent fuel itself: the fuel pellet is a ceramic.

oxide that has a very low solubility in water, and it provides a substantial impediment to the dispersion of radioactive material.

The second barrier is the metal cladding that encapsulates the fuel pellets. In addition to housing and protecting the fuel pellet, the cladding provides containment for the gaseous radionuclides that are engendered during irradiation in a reactor. These gaseous nuclides include carbon 14, iodine 129, krypton 85, and tritium. The cladding used for most nuclear fuel in the United States is Zircaloy—a zirconium—based alloy that is resistant to corrosion under both reactor operating conditions and pool—storage conditions. The extent to which the fuel cladding can be relied on as a barrier depends on its integrity, and inspection techniques are available for detecting most spent fuel rods with cladding defects, though the detection of every defective fuel rod cannot be ensured.

### 5.2.1.2 The safety of storage in spent-fuel pools

In the case of storage in spent-fuel pools, additional barriers against the release of radioactive material are provided by the structure of the pools (concrete walls lined with stainless steel), the water in the pool, the water-purification system of the pool, the building that houses the pool, and the ventilation system through which all air released from the building is filtered. During reactor licensing, the spent-fuel pools must be shown to meet various NRC criteria pertaining to design, structural strength, nuclear criticality, shielding, etc. In addition to providing a containment barrier, the water in the pool provides shielding against gamma radiation. Though a depth of 7.5 feet of water is sufficient to maintain the radiation-dose rate at the surface of the pool below the limit specified in regulations, approximately 10 feet of water is maintained over the fuel during fuel-handling operations to further reduce radiation exposures. Typically, about 25 feet of water is maintained above the spent fuel when it is in the storage racks. These pools have been operated for many years at hundreds of reactor sites throughout the world without significant risk. 17

In its Waste Confidence Decision, the NRC concluded that spent fuel can be stored safely and without significant environmental impacts for at least 30 years beyond the expiration of the operating licenses of the reactors. This finding was supported by the NRC's experience in conducting more than 80 individual safety evaluations of spent-fuel storage. In particular, the NRC noted that the cladding of the spent fuel is highly resistant to failure under the conditions of pool storage, and the NRC cited up to 18 years of continuous-storage experience for Zircaloy-clad fuel.

At the end of the plant operating life, the reactor operating license may be amended to allow continued storage of spent fuel in the reactor pool under a "possession-only" license pursuant to 10 CFR Part 50.

### 5.2.1.3 The safety of dry at-reactor storage

In the case of dry storage, barriers against release are provided by the structure of the storage device (e.g., a thick-walled concrete cask) and the seals used in the storage system. As a result, dry storage systems are designed to prevent gaseous as well as particulate and liquid releases. Three separate components must fail before radioactivity can escape to the atmosphere: (1) the cladding of a fuel rod, (2) the inner or primary seal, and (3) the outer secondary seal. The dry-storage systems are also provided with thick concrete or metal shielding to reduce the external-radiation-dose rate to extremely low levels.

Numerous investigations of the behavior of spent fuel in dry storage have been or are presently being undertaken in the United States and other countries. These investigations include performance tests that were conducted to demonstrate that various dry-storage casks can be satisfactorily handled and loaded. Other investigations have focused on the demonstration of dry storage where the spent fuel is kept under an inert atmosphere and under air as well as the establishment of temperature limits for extended storage in these environments.

In the Waste Confidence Decision, the NRC stated its belief that current dry-storage technologies are capable of providing safe storage for spent nuclear fuel for at least 30 years beyond the expiration of the operating license. The NRC pointed out that, though the experience with dry-storage sys-tems is less than that with pool storage, the understanding of the material-degradation processes experienced in pool storage should be applicable to dry storage. Moreover, dry storage involves a simpler storage technology than does pool storage. Pool storage relies on active systems—pumps, renewable filters, and cooling systems—to maintain safe storage, and on maintaining a chemical composition of the water that inhibits corrosion. Dry storage, on the other hand, requires little or no reliance on active systems and does not need water. The NRC also noted that the modular character of dry-storage installations facilitates maintenance or the correction of mechanical defects, if any should occur.

Although spent-fuel-storage systems are designed to minimize radioactivity releases to the atmosphere and no significant quantities of radioactivity are released under normal operating conditions, there is a potential for releasing small quantities of the gaseous radionuclides. This would occur when a fuel rod becomes perforated as a result of rough handling, mechanical damage, or random failure.

To protect the general public from radiation exposures related to dry at-reactor storage, the NRC has specified in 10 CFR Part 72 a minimum distance (about 330 feet (100 meters)) that must be established and maintained between a dry-storage facility and the nearest boundary of the controlled area. (A controlled area is established at every nuclear power plant to protect the public from exposure to radiation and radio-active materials. No member of the public may reside within the controlled area, and access to the area is restricted at all times.) To

provide a greater margin of safety, the NRC requires that estimates of the potential radiation doses that may be received by a member of the public under accident conditions be based on the assumption that the person receiving the dose is at the boundary of the controlled area.

For at-reactor storage, the NRC has established in 10 CFR 72.67 and 72.68 the following regulatory limits for exposing members of the public to radiation:

- 1. During normal operating conditions and "anticipated occurrences," the annual radiation-dose equivalents received by the
  nearest "real individual" (as opposed to a hypothetical person)
  are not to exceed 25 millirem to the whole body, 75 millirem to
  the thyroid, and 25 millirem to any other organ.
- 2. Under the conditions of a "design-basis accident," any individual located on or beyond the nearest boundary of the controlled area is not to receive a radiation dose greater than 5 rem to the whole body.

In the case of the radiation exposures received from at-reactor storage by workers at the reactor site (i.e., individuals in restricted areas), the following radiation-dose limits specified in 10 CFR Part 20 apply:

- 1. No more than 1.25 rem per calendar quarter to the whole body, the head and trunk, active blood-forming organs, the lens of the eyes, or the gonads.
- 2. No more than 18.75 rem per calendar quarter to the hands and forearms or the feet and the ankles.
- No more than 7.5 rem per calendar quarter to the skin of the whole body.

As examples of the potential radiation doses that have been calculated for actual dry-storage facilities at reactor sites, the paragraphs that follow present estimates made by the NRC of (1) the annual dose commitment received by a member of the public under normal operating conditions, (2) the collective annual dose received by the exposed population, and (3) the collective occupational dose. These estimates are given in the environmental assessments prepared by the NRC for the only two drystorage facilities that had been licensed by the end of 1988: a drystorage facility at the H. B. Robinson site, 12 which uses a horizontal modular concrete system, and the facility at the Surry site, 13 which uses metal storage casks. Although these estimates are site specific, they are believed to be reasonably representative of the doses that would be received from the use of these technologies at other reactor sites. (The estimated doses that would be delivered to a member of the public under accident conditions are discussed in Section 5.2.1.4.)

For the H. B. Robinson site, which is located in North Carolina, the annual dose commitments received under normal operations by nearby resi-

dents and site workers were calculated under conservative and design-basis assumptions: maximum radiation-dose rates at the surface of the storage module of 31 millirem per hour for neutrons and 81 millirem per hour for gamma rays, a maximum fuel burnup of 33 gigawatts-days per metric ton of heavy metal, spent fuel that has been out of the reactor for at least 5 years before storage, and the emplacement of five dry-storage canisters per year. Under these assumptions, the annual dose to the nearest real individual from air-scattered radiation from eight dry-storage canisters is estimated at about 0.4 millirem<sup>12</sup> (see also Section 5.2.1.4). The nearest real individual in this case is located 0.3 mile away from the boundary of the controlled area, and the estimated dose represents less than 2 percent of the applicable regulatory limit in 10 CFR 72.67.

The population living within 1 mile of the dry-storage facility at the H. B. Robinson site consists of about 500 people. The collective annual dose commitment for this population from the dry-storage facility was estimated at about 0.009 man-rem. This calculation was made for the persons living within 1 mile of the dry-storage facility because both direct radiation and air-scattered radiation are rapidly attenuated with distance, and hence people living farther away receive much less exposure. The estimated radiation dose represents less than 0.3 percent of the radiation dose received by the same population from the operations of the H. B. Robinson reactor and less than 0.02 percent of the radiation dose received by the same population from natural background radiation. Natural background radiation in the region of the United States in which the H. B. Robinson site is located averages about 100 millirem per year.

The NRC environmental assessment 2 also analyzed the maximum collective occupational doses for both the operation of the dry-storage facility and the construction of additional modules. The results show that the maximum collective occupational dose received from operations is 27 man-rem per year, which is less than 3 percent of the annual occupational dose from reactor operations. From the construction of additional modules, the maximum collective occupational dose is much smaller, 0.1 man-rem per year.

For the Surry site, 13 which is in Virginia, the NRC estimates a maximum annual dose commitment to the nearest real individual of about 0.00006 millirem, or less than 0.0003 percent of the limit specified in 10 CFR 72.67. The dose estimates were calculated under the following assumptions: maximum radiation-dose rates at the surface of the storage module of 7.8 millirem per hour for neutrons and 22.3 millirem per hour for gamma rays, a maximum fuel burnup of 35 gigawatts-days per metric tone of heavy metal, spent fuel that has been out of the reactor for at least 5 years before storage, and the emplacement of four casks per year. The estimated dose is lower than the estimate for the H. B. Robinson reactor because the nearest real individual is considerably farther away (1.5 miles as compared with 0.3 mile) from the dry-storage facility than the individual at the H. B. Robinson site. The collective dose commitment for the 48 persons living within 2 miles of the Surry site is estimated at 0.000003 man-rem per year. This is less than 1 percent of

the radiation dose delivered by normal reactor operations and more than 10,000 times less than the dose received by the same population from natural background radiation. (The natural background radiation in the region of the Surry site is about 100 millirem per year.) The maximum occupational exposure at Surry is estimated at 23 man-rem per year for normal operations (about 1 percent of the dose received from normal reactor operations) and about 64 man-rem for slab construction.

The dose estimates for other reactor sites will depend on various site-specific factors, such as the dry storage technology that is used, the quantity of spent fuel that is stored, the distance at which the "nearest real individual" is located, the size of the exposed population, atmospheric conditions, etc. However, the estimates presented above for the H. B. Robinson and the Surry sites support the generic calculations that have been made for the various dry-storage technologies and indicate that the radiation doses expected to result from dry storage at reactor sites are extremely low: they represent a very small fraction of the regulatory limits, a small fraction of the doses delivered by natural background radiation, and a small fraction of the doses received by the public and workers from normal reactor operations.

### 5.2.1.4 Potential risks of accidents and acts of sabotage

The NRC has examined the potential risk experienced by the public from major accidents or acts of sabotage at spent-fuel storage facilities. In its Waste Confidence Decision, the NRC concluded that the possibility of such accidents is extremely remote because of the characteristics of spent-fuel storage, including the benign nature of the storage environment and the absence of any conditions that would provide a driving force for the dispersal of the radioactive material in a manner that would allow it to reach the public.

The upper-bound radiation doses that would be delivered by accidents at dry-storage facilities have been calculated for both the H. B. Robinson and the Surry sites. For the H. B. Robinson site, the upperbound dose at the boundary of the controlled area is estimated at 1.2 millirem to the whole body and the thyroid, whereas the nearest resident, who lives 1600 feet south of the postulated accident site, would receive 0.4 millirem to the whole body and the thyroid. These estimates were calculated under the assumption that the accident would release 60 percent of the noble gases and 5 percent of the particulates present in the spent fuel. These doses are less than 0.03 and 0.01 percent, respectively, of the regulatory limit specified in 10 CFR 72.68. For the Surry site, the upper-bound doses delivered by an accident to a person at the boundary of the controlled area, assuming that all of the noble-gas inventory (e.g., krypton 85) is released, would be 4 millirem to the whole body and the thyroid, 13 or less than 0.08 percent of the regulatory limit.

### 5.2.1.5 Safety of rod consolidation

The safety and environmental acceptability of consolidating and storing canisters of fuel rods in storage pools have been demonstrated on a limited scale in safety analyses, NRC safety evaluation reports, and experience. However, since at-reactor consolidation is at a less-advanced stage of development than dry storage, there are few publicly available documents on the occupational doses (and other radiological impacts) associated with at-reactor consolidation.

# 5.2.2 Nonradiological impacts on the environment

No significant additional nonradiological impacts that could adversely affect the environment are expected from at-reactor storage, even if spent fuel is stored beyond the expiration of the reactor's operating license. The nonradiological environmental impacts associated with site preparation and the construction of storage facilities are and will be considered by the NRC at the time the license application for a storage facility is received.

### 5.3 IMPACTS OF AT-REACTOR STORAGE OPTIONS ON TRANSPORTATION

In the Nuclear Waste Policy Amendments Act, the Congress directed the DOE to evaluate the extent to which storage at reactor sites would affect the costs and risks of transporting spent fuel to central waste-management facilities, such as a facility for monitored retrievable storage. This evaluation was performed by comparing potential effects on transportation costs and radiation exposures against those of a reference system.

The reference transportation system was assumed to consist of a fleet of legal-weight truck casks and standard-weight (100-ton) rail casks used in a shipping campaign of approximately 35 years. The spent fuel would be accepted as intact assemblies at the reactor site. The average shipping distance for each shipment was calculated for distances of 1000 and 2000 miles.

The results of the evaluation, briefly summarized in this section, indicate that most of the dry-storage options described in this report (metal storage casks, concrete casks, horizontal concrete modules, and modular concrete vaults) would have no effect on transportation. If these storage options are used, the stored fuel will be transferred to a transportation cask for shipment, and the transportation system will be virtually identical with the reference system.

The remaining two options for expanding at-reactor storage, the use of dual-purpose metal casks and rod consolidation, could affect transportation, and their effects are summarized in the sections that follow.

In terms of transportation risk to the general public, neither option would have a significant effect, because in all cases the radiological risk from transportation is so low as to be negligible.

# 5.3.1 Potential effects of using dual-purpose casks

As described in Section 4.2, if certain technical and licensing issues can be resolved, metal casks could be used for the dual purpose of storing spent fuel at reactor sites and for transporting the fuel by rail to a Federal facility if the NRC certifies such casks for transportation. Such dual-purpose use could reduce the number of transportation casks required for the DOE's transportation fleet.

It was assumed that dual-purpose casks could be used for transportation from the reactor sites that have direct access to a railroad and rail-handling capabilities or barge. If dual-purpose casks are used to accommodate all of the additional-storage requirements at these reactors. up to 1150 such casks (10,700 MTHM) would be needed for the upper-bound storage requirements of these reactors. The maximum benefit from using these casks for transportation would be realized if a sufficient number of utilities agree to transfer the ownership of their dual-purpose casks in time to preclude the purchase of transportation casks by the DOE. resulting savings could reach approximately \$25 to \$35 million dollars over the lifetime of the transportation system. To achieve this savings only 28 to 34 casks would need to be transferred to the DOE over the life of the system. Further cost savings could be realized if, in addition to using some of these casks in its transportation fleet, the DOE will use other dual-purpose casks at its waste-management facilities for lag storage. The economic advantages and disadvantages of these casks are discussed in a recent report.

The transportation risk to the general public, in terms of both radiological and nonradiological effects would not be affected by the use of dual-purpose casks.

# 5.3.2 Consolidation effects on transportation

After consolidation, the spent-fuel rods and the compacted non-fuel-bearing components are loaded into canisters. These canisters are fewer in number, and their physical and radiological characteristics differ from those of the original assemblies. For example, a canister that contains the consolidated rods from two assemblies will be slightly less than twice as heavy and contain a larger source of neutrons than an assembly, and canisters of compacted non-fuel-bearing components will contain a larger source of gamma radiation than the consolidated-fuel canisters. The higher-energy gamma source (primarily resulting from cobalt-60 activation of the end fittings) will result in higher gamma-dose rates at the surface of the cask. The isotopic characteristics of the non-fuel-bearing hardware from PWR spent fuel have been summarized by Luksic. 16

In evaluating the potential effects of consolidation on transportation, it was assumed that the consolidated fuel rods and the compacted non-fuel-bearing hardware components are shipped in the same casks as those used in the reference system, with capacities adjusted as appropriate for consolidated fuel rods and hardware. Because of the weight limit for unrestricted rail transport (263,000 pounds), the maximum weight-adjusted rail-cask capacity for spent fuel allows an increase of 33 to 50 percent in the quantity of spent fuel that can be shipped, depending on the type of fuel. (For PWR fuel, the capacity increases from 21 to 28 assemblies; for BWR fuel, the capacity increases from 48 to 72 assemblies.)

For the transportation of consolidated spent fuel, the present design capacities of truck casks are limited by weight; that is, if canisters of consolidated fuel are loaded into all available basket locations inside the cask, the resulting gross vehicle weights will exceed the allowable weight limits for trucks (i.e., 80,000 pounds). Thus, the weight-adjusted capacity for the legal-weight truck cask remains unchanged. The present designs for truck casks are limited by weight to only three PWR or seven BWR assemblies regardless of the form-intact or consolidated—in which they are transported. Thus, weight restrictions will allow a truck cask to carry no more than one canister of consolidated PWR fuel and one unconsolidated PWR assembly or three canisters of consolidated BWR fuel and one unconsolidated BWR assembly.

In the case of the compacted hardware, the limitations are related not to weight but to the radiation characteristics. It is possible that, because of the high gamma content of these materials, cask capacities will be limited beyond the weight limits.

However, if consolidation is extensively used for at-reactor storage, it is assumed that the casks used by the DOE to transport spent fuel from reactor sites will be modified to increase their capacities and to optimize the design in other ways. The increase in the capacities of the casks will reduce the number of shipments. The reduction in the number of shipments will be accompanied by a proportional reduction in the radiation exposure received by the general public from transportation under normal conditions, although, as already mentioned, this exposure will be negligible.

The DOE is currently conducting studies to determine the magnitude and the nature of the modifications to be considered in designing transportation casks for consolidated fuel. These studies are directed at optimizing the cask designs, determining the weight limitations, and determining the magnitude of gamma-ray sources in compacted hardware.

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#### Chapter 6

# USE OF THE NUCLEAR WASTE FUND TO SUPPORT ADDITIONAL AT-REACTOR STORAGE

Section 302(c) of the Nuclear Waste Policy Act of 1982 (NWPA--Public Law 97-425) established in the Treasury of the United States a separate fund, to be known as the Nuclear Waste Fund. This fund is to consist mainly of revenues realized through the collection of fees for waste disposal. The fees are to be paid by the owners and generators of civilian spent fuel and high-level radioactive waste and are to be sufficient to ensure full recovery of the costs of waste management. The NWPA specifies the fees to be paid into the Nuclear Waste Fund, gives directions for its management, and directs the Secretary of Energy to report annually to the Congress on the adequacy of the fee collected for the Fund. None of these requirements was changed by the Nuclear Waste Policy Amendments Act of 1987 (the Amendments Act--Public Law 100-203).

One of the objectives of this study, as required by the Amendments Act, is to consider the extent to which amounts of the Nuclear Waste Fund "can be used, and should be used, to provide funds to construct, operate, maintain, and safeguard spent nuclear fuel in dry storage at reactor sites." This objective was addressed by separately considering two questions:

- 1. Is the DOE authorized under the NWPA to provide monies from the Nuclear Waste Fund for dry at-reactor storage?
- When and under what conditions would it be appropriate to use monies from the Nuclear Waste Fund for dry at-reactor storage?

The first question was addressed by examining the applicable provisions of the NWPA, the legislative history of the NWPA, and records of Congressional hearings. The second question was addressed by considering (1) the circumstances under which monies from the Nuclear Waste Fund should be authorized and made available for at-reactor storage, including the potential advantages and disadvantages of using the Fund for this purpose, and (2) reviewing the DOE's policy on support for utility initiatives.

# 6.1 CAN THE NUCLEAR WASTE FUND BE USED FOR AT-REACTOR STORAGE?

The NWPA requires the DOE to develop, obtain a license for, and operate geologic repositories for the permanent disposal of spent fuel and high-level radioactive waste\* in a manner that protects the health

<sup>\*</sup>For convenience and brevity, the term "waste" will henceforth be used in this chapter to mean both spent nuclear fuel and high-level waste.

and safety of the public, maintains the quality of the environment, and is cost effective. To ensure that the cost of such disposal is borne by the persons responsible for generating spent fuel and high-level radio-active waste, Section 302 of the NWPA established the Nuclear Waste Fund.

The Secretary of Energy is to report annually to the Congress on the adequacy of the fee collected for the Nuclear Waste Fund. This annual appraisal has been published in a series of documents entitled Nuclear Waste Fund Fee Adequacy: An Assessment. The fee is deemed adequate if the analyses show a reasonable range of scenarios in which the fees paid by the utilities over the life of the waste-management system and any interest earned on funds that are invested will be sufficient to cover all the costs incurred for the disposal of the waste. If an adjustment in the fee is deemed advisable, the Secretary of Energy is to advise the Congress and recommend a change.

As stated in the NWPA, expenditures from the Nuclear Waste Fund are to be made "only for purposes of radioactive waste disposal activities under titles I and II of the Act...." According to Section 302(d) of the NWPA, these activities include the following:

- (1) the identification, development, licensing, construction, operation, decommissioning, and post-decommissioning maintenance and monitoring of any repository, monitored retrievable storage facility or test and evaluation facility constructed under this Act;
- (2) the conducting of nongeneric research, development, and demonstration activities under this Act;
- (3) the administrative cost of the radioactive waste disposal program;
- (4) any costs that may be incurred by the Secretary in connection with the transportation, treating, or packaging of spent fuel or high-level radioactive waste to be disposed of a repository, to be stored in a monitored retrievable storage site or to be used in a test and evaluation facility;
- (5) the costs associated with acquisition, design, modification, replacement, operation, construction of facilities at a repository site, a monitored retrievable storage site or a test and evaluation facility site and necessary or incident to such a repository, monitored retrievable storage facility or test and evaluation facility.
- (6) the provision of assistance to States, units of general local government, and Indian tribes...."

Section 302(d) of the NWPA also stipulates that "no amount may be expended by the Secretary under this subtitle for the construction or

expansion of any facility unless such construction or expansion is expressly authorized by this or subsequent legislation."

Since activities related to waste disposal are not specifically limited to those listed in Section 302 of the NWPA, the DOE has some discretion in making expenditures from the Nuclear Waste Fund. However, no express authority is provided in the NWPA for the use of the Nuclear Waste Fund to support short-term, interim storage. Instead, the NWPA states in Section 131(a)(1) that—

Persons owning and operating civilian nuclear power reactors have the primary responsibility for providing interim storage of spent nuclear fuel from such reactors, by maximizing, to the extent practical, the effective use of existing storage facilities at the site of each civilian nuclear power reactor, and by adding new onsite storage capacity in a timely manner where practical.

The apparent intent of the Congress not to use the Nuclear Waste Fund for interim storage is also supported by the legislative history of the NWPA. For example, acceptable uses of the Fund were summarized in the House of Representatives by Representative Udall as follows:

The Nuclear Waste Trust Fund will be isolated from other Federal programs, and will not be used to finance any activities other than repository development. Even nuclear fuel cycle activities such as spent fuel reprocessing, or interim spent fuel storage, which may relate indirectly to permanent disposal, are prohibited from being paid for by the Trust Fund.

In the event that Federal assistance is required for the interim storage of spent fuel, a separate Interim Storage Fund is to be established under Section 136(c) of the NWPA. The Interim Storage Fund is to consist of fees paid by the owners and generators of spent fuel that require assistance for interim storage and from appropriations made by the Congress. Limited DOE assistance, supported by expenditures from the Interim Storage Fund, is to be provided only if the NRC determines that—

- (A) adequate storage capacity to ensure the continued orderly operation of the civilian nuclear power reactor at which such spent nuclear fuel is generated cannot reasonably be provided by the person owning and operating such a reactor at such site, or at the site of any other civilian nuclear power reactor operated by such person, and such capacity cannot be made available in a timely manner through any method described in paragraph (B); and
- (B) such person is diligently pursuing licensed alternatives to the use of Federal storage capacity for the storage of spent nuclear fuel expected to be generated by such a person in the future...[Section 135(b)].

The licensed alternatives include the expansion of storage facilities at the site of the reactor; the construction of new or additional storage facilities; the acquisition of modular or mobile equipment, including storage casks; and and shipment of spent fuel to the site of another reactor owned by the generator of the spent fuel.

If the need for interim storage is supported by such an NRC finding, Section 136(a) of the NWPA authorizes the DOE to enter into contracts with the owners and generators of the spent fuel to provide storage for the spent fuel. According to Section 135(a), storage is to be provided through (1) the use of available capacity at Federal facilities, (2) the acquisition of any modular or mobile storage equipment (e.g., storage casks) for use at the site of the reactor or at a Federal facility, and (3) the construction of storage capacity at any site of a civilian reactor.

However, the total capacity of such interim storage is not to exceed 1900 metric tons of heavy metal. The interim-storage option is further limited in that the DOE cannot contract for such storage after January 1, 1990 (Section 136(a) of the NWPA). To date, no applications for interim storage have been received.

In summary, it was the apparent intent of the Congress that the Interim Storage Fund—and not the Nuclear Waste Fund—should be used by the DOE where necessary to provide assistance to qualified utilities entering into contracts before 1990 for the interim storage of limited quantities of spent fuel during the period before the DOE is able to dispose of the waste.

The expansion of at-reactor storage capacity is addressed in Section 218 of the NWPA, which requires the DOE to "establish a demonstration program, in cooperation with the private sector for the dry storage of spent nuclear fuel at civilian nuclear power reactor sites, with the objective of establishing one or more technologies that the Commission may, by rule, approve for use at the sites of civilian nuclear power reactors without, to the maximum extent practicable, the need for additional site-specific approvals by the Commission." In addition, the DOE is to enter into cooperative agreements with utilities and to establish a research-and-development (R&D) program. Under Section 218(d), the DOE may contribute no more than 25 percent of the total costs of the demonstration program. All remaining costs of the program are to be paid by the utilities involved or from the Interim Storage Fund.

The DOE fulfills these requirements of the Act by supporting generic R&D activities and cooperative programs with the utilities to develop and demonstrate licensable technologies. The generic R&D program is conducting research directed at establishing the technical bases needed to license new concepts for spent-fuel storage. The cooperative demonstration program is performing demonstrations of dry and wet storage at reactor sites. The DOE's Office of Civilian Radioactive Waste Management has entered into cooperative agreements with the Carolina Power and & Light Company, the Northeast Utilities Service Company, the Rochester Gas &

Electric Corporation, and the Virginia Power Company for licensed demonstrations of dry-cask-storage technologies or rod consolidation.

In conclusion, the NWPA does not appear to authorize the DOE to use the Nuclear Waste Fund for providing interim storage, and, as stated in Section 111(a)(5), "the generators and owners of high-level radioactive waste and spent nuclear fuel have the primary responsibility to provide for, and the responsibility to pay the costs of, the interim storage of such waste and spent fuel until such waste and spent fuel is accepted by the Secretary of Energy in accordance with the provisions of this Act." It is the DOE's position that the utilities are responsible for storing spent fuel at reactor sites until an operating Federal facility is available to accept the fuel.<sup>2</sup>

# 6.2 SHOULD THE NUCLEAR WASTE FUND BE USED FOR AT-REACTOR STORAGE?

As explained above, the DOE is not currently authorized to use monies from the Nuclear Waste Fund for providing spent-fuel storage at reactor sites. However, the DOE could seek such authorization if appropriate.

The Nuclear Waste Fund consists mainly of revenues collected through fees levied on the generators and owners of spent fuel and high-level waste. Established by Section 302(a) of the NWPA, the fees are to produce sufficient revenue for the full recovery of costs for the development and operation of the waste-management system. The fee specified in Section 302(a) for electricity generated in nuclear reactors is 1.0 mil per kilowatt-hour, and the utilities have been permitted to charge this cost to their ratepayers. These fees are to be evaluated and adjusted as necessary to maintain their adequacy to supply the above-mentioned revenues.

The primary issue that needs to be considered is equity among utilities. Providing funds to enhance the spent-fuel storage capabilities of one or even several utilities may represent limited benefits for the total population of reactors, raising concerns about the feasibility of using the Nuclear Waste Fund for this purpose. The Congress seems to have anticipated this by the provisions of Sections 135 and 136 of the NWPA for interim storage. The NWPA specifies that, if Federal interim storage is approved in a particular instance, the participating utility must pay for such storage on a full-cost-recovery basis. As explained in Section 6.1, such payments are made into the Interim Storage Fund.

Whether the costs of dry at-reactor storage are paid directly by utilities or by the Nuclear Waste Fund, they will invariably be paid by the ratepayers. An important factor to consider, however, is cost efficiency. Using the Nuclear Waste Fund to cover the costs of at-reactor storage would entail administrative costs incurred by the Federal Government. Consequently, the overall cost for dry at-reactor storage would be increased by the amount of the additional administrative burden.

The DOE has expressed its willingness to consider support for atreactor spent-fuel-management activities that provide significant demonstrable savings to the Nuclear Waste Fund. After examining the possible
circumstances under which it would be appropriate to use the Nuclear
Waste Fund to provide funds to construct, operate, and maintain spentfuel storage facilities and safeguard spent fuel in storage at reactor
sites, the DOE has determined that the Nuclear Waste Fund should be used
to support at-reactor storage only when such storage provides overall
benefits to the waste-management system and not as a means of providing
direct assistance to utilities in their at-reactor storage activities.

Systems-integration studies being conducted by the DOE are examining the potential for at-reactor activities to contribute to the goals of the waste-management system. As these efforts proceed, the DOE will discuss them with potentially affected parties and factor them, as appropriate, into program planning, facility design, and future recommendations to the Congress.

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#### Chapter 7

#### SUMMARY AND CONCLUSION

The preceding chapters of this report have examined the expected requirements for dry cask storage at reactor sites, the various technologies that are available for such storage, potential costs and other impacts, and the extent to which monies from the Nuclear Waste Fund can and should be used for such storage. This chapter briefly summarizes the main results reported in this document. It also identifies some additional factors that should be considered in evaluating at-reactor storage.

# 7.1 ESTIMATED REQUIREMENTS FOR ADDITIONAL AT-REACTOR STORAGE

The cumulative aggregate requirements for additional storage range from 12,200 to 20,000 MTHM for the upper and the lower bounds on the spent-fuel discharge forecasts, respectively. For the reference case (spent-fuel acceptance by the repository begins in 2003), the storage inventory peaks within 4 years of the start of spent-fuel acceptance by the DOE. However, after the year 2007 an increase in storage capacity will be required at a number of reactor sites because the rates at which these reactors discharge spent fuel will exceed the rate at which the spent fuel is removed from their sites. Consequently, the cumulative additional-storage requirements continue to increase and do not peak until the years 2012 and 2016 for the lower and the upper bounds, respectively. The number of reactor sites requiring additional spent-fuel storage ranges from 54 (in the year 2012) to 67 (in the year 2016). Since some nuclear power stations contain several reactors located at the same site, the number of reactors requiring additional storage capacity is higher, 83 to 107 in 2012 and 2016, respectively.

For the three alternative-acceptance cases examined in this report, the removal of spent fuel from the reactor sites was assumed to start in 1998, 2003, and 2008 at the reference ramp-up rates for the MRS facility. The case where acceptance begins in the year 2003 at the MRS acceptance rate represents the authorized DOE waste-management system. A comparison of this case with the reference case (repository-only system) shows that the accelerated MRS ramp-up rate would reduce the additional-storage requirements by 2440 to 3790 MTHM.

Because the maximum storage capacities of reactor pools are not related to the projected cumulative discharges, the additional-storage requirements are not evenly distributed among reactor sites. For the lower-bound storage requirement, 29 of the 54 reactor sites needing additional storage in the reference case need 200 MTHM or less, but a few need much more. For the upper-bound storage requirement, 37 of the 67 sites need more than 200 MTHM. (For comparison, 200 MTHM is about

40 percent of a typical pool capacity, or the equivalent of about 20 typ-ical dry casks of intact fuel.)

#### 7.2 TECHNOLOGIES FOR AT-REACTOR STORAGE

This study examined the options that could be implemented at the sites of U.S. civilian reactors for storing spent fuel, including rod consolidation to increase the capacity of existing storage pools. The dry-storage options are metal casks, concrete casks, horizontal concrete modules, modular concrete vaults, and dual-purpose casks that can be used for both storage and transportation. Although the various options differ somewhat in their technical maturity, no significant technical problems are expected. Both intact and consolidated spent fuel can be stored in these devices. To date, storage in metal casks and storage in horizontal concrete modules have been licensed by the NRC. In addition, the NRC staff has approved a topical report on the use of modular concrete vaults and is reviewing such a report on the use of concrete casks.

#### 7.3 ESTIMATED COSTS

The estimated aggregate costs of providing additional at-reactor storage capacity for the reference case (spent-fuel acceptance by the repository begins in 2003) range from about \$500 million to \$2 billion. For the three alternative-acceptance cases (start of acceptance by the MRS facility in 1998, 2003, and 2008 at MRS ramp-up rates), the estimated aggregate costs range from \$200 million to \$2.7 billion. The cost estimates, however, are associated with considerable uncertainty.

#### 7.4 IMPACTS ON HEALTH AND SAFETY AND THE ENVIRONMENT

In its Waste Confidence Decision of August 31, 1984 (Federal Register, Vol. 49, No. 171), the NRC stated that "the Commmission finds reasonable assurance that, if necessary, spent fuel...can be stored safely and without significant environmental impacts" in reactor storage pools or in "independent spent-fuel storage installations." The NRC's findings were supported by experience in more than 80 individual safety evaluations of spent-fuel storage facilities. For dry storage, the NRC stated its belief that current technologies are capable of providing safe storage for spent nuclear fuel for at least 30 years beyond the expiration of the operating license. The NRC also concluded that the possibility of a major accident or sabotage at a spent-fuel storage facility with radiological consequences to the public is extremely remote.

The NRC's findings are supported by the results of the radiationsafety analyses conducted for this study, which show that the typical radiation-exposure risk for the public is negligible. As an example, the public dose commitment from dry storage at one particular reactor site is only 0.02 percent of the annual dose received by the same population from natural background radiation.

#### 7.5 TRANSPORTATION IMPACTS

None of the dry-storage options would significantly affect transportation unless the spent fuel is consolidated. For transportation, intact spent fuel that is stored in casks or other dry-storage devices may be required to be transferred to the same type of shipping cask that would be used for intact spent fuel stored in pools. Thus, no modifications to the transportation system are needed, and there are no changes in the transportation operations or in the number of shipments required for a given quantity of spent fuel.

The use of dual-purpose casks, if approved by the NRC for transportation, would have the advantage of eliminating the loading of spent fuel into shipping casks and reduce the number of shipping casks needed for the transportation fleet. The overall impacts on the transportation system would be minimal. Additional cost savings may be realized by using these casks for lag storage at a DOE waste-management facility. These benefits to the waste-management system would depend on the timely availability of these casks to the utilities as well as to the DOE's transportation system.

Spent-fuel consolidation can increase the payload per shipping cask, which could reduce the number of shipments required for transporting a given quantity of spent fuel. The reduction in the number of shipments depends on optimizing cask capacities. This potential benefit, however, would represent a small portion of the overall cost of waste management.

# 7.6 USE OF THE NUCLEAR WASTE FUND FOR AT-REACTOR STORAGE

The Nuclear Waste Policy Act of 1982 (NWPA), which established the Nuclear Waste Fund, does not authorize the DOE to use the Nuclear Waste Fund to provide direct financial support for storage at reactor sites. The DOE will consider mechanisms whereby the utilities can realize benefits resulting fromat-reactor spent-fuel-management activities if such activities can be demonstrated to be beneficial to the overall waste-management system. However, it would be difficult at present to identify and quantify the benefits because the design and the development of the overall waste-management system are still in a preliminary stage and it is not clear which technologies the utilities are likely to select; nor is it clear which technologies would be of benefit to the waste-management system, because of the developmental status of the system. System-integration studies being conducted by the DOE are examining the potential for at-reactor activities to contribute to the goals of the waste-management system. As these efforts proceed, the DOE will discuss

them with potentially affected parties and factor them, as appropriate, into program-planning and facility-design activities.

#### 7.7 CONCLUSION

The DOE concludes that these existing technologies are technically feasible, safe, and environmentally acceptable options for storing spent fuel at the sites of civilian nuclear reactors until such a time as a Federal facility is available to accept the spent fuel.

# Appendix A

#### ADDITIONAL BACKGROUND INFORMATION

In considering some comments on the initial version of the report, it was deemed appropriate to reformat some of the information provided in the text of the report in order to provide easily usable and accessible information on the background and current status of the various storage technologies as well as sources of additional data. This material is presented in this appendix. It consists of a tabular summary and a bibliography.

The tabular summary was prepared in response to several comments requesting a summary of the discussions on the research, development, and demonstration work that has been performed for storage technologies as well as the current licensing or certification status of each technology. Table A-l identifies the specific technology, the organization or place where it is used, its principal characteristics, the period of time over which the particular research-and-development work has been performed, and the licensing or certification status.

The bibliography was prepared in response to comments requesting references that provide detailed information about the development and testing of the storage technologies, health-and-safety considerations, and demonstrations conducted to support licensing efforts.

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TABLE A-1. SUMMARY OF DEVELOPMENT AND LICENSING STATUS FOR SPENT FUEL STORAGE METHODS

	Technology/Method	Organization - Locations	Description	Time Period	Certification/ Licensing Status
	DRY STORAGE			•	·
	Metal Casks				• .
	REA-2023	DDE -GE-Morris	REA-2023 BWR; 52 Cooper assemblies; approx. 15kW decay heat; fuel/cask temp. & cask surface dose rate meas.	1983-1985	Certification activities discontinued by MHI who had purchased the design from REA
1 107	CASTOR-IC	GNSI	16 assemblies	1985	Topical report approved by NRC in 1985, subject to vendor clarifications; vendor elected not to pursue further
	CASTOR-V/21, TN-24P, MC10	VP/DOE/EPRI -INEL	CASTOR-V/21, TN-24P, & MC-10 PWR casks: 21 to 24 Surry assemblies; 13 to 28 kW decay heat; fuel/cask temp. & cask surface dose rate meas.	1984-1987	CASTOR-V/21 and MC-10 approved by NRC; TN-24P being reviewed by NRC
	CASTOR-V/21. MC-10, NAC, GNS×33	VP/DOE/EPRI -Surry	3 CASTOR-V/21: 21 Surry assemblies per cask; 1 MC-10; 24 Surry assemblies planned for 1990 1 NAC: 31 Surry assemblies planned for 1990 1 GNS-x33: 33 Surry assemblies planned for 1990	1986-1990	Issued July 1986 for ISFSI w/CASTOR-V/21s; planned to amend for NAC and Westinghouse casks in 1990 (as necessary)
	CASTOR-V/21	VP -Surry (ISFSI)	5 CASTOR-V/21: 21 Surry assemblies per cask; other casks to be added as needed	1987-1988	Issued July 1986 for ISFSI w/CASTOR- V21s; planned to be amended for other casks in 1990
	TN-24P	VP/DOE/EPRI -INÉL	TN-24P consolidated PWR; 36 Surry & 12 Turkey Point assemblies consolidated into 24 canisters; 23kW decay heat; fuel/cask temp. meas. & cask surface dose rate meas.	1987-1988	No application submitted for consol. fuel in TM-24P
	NAC 26-ST NAC 28-ST	NAC	NAC 26-ST: 26 PWR assemblies NAC 28-ST: 28 PWR assemblies or 28 canisters of consol, fuel rods	1987-1988	Approved by NRC

TABLE A-1. SUMMARY OF DEVELOPMENT AND LICENSING STATUS FOR SPENT FUEL STORAGE METHODS (cont.)

Technology/Method	Organization - <u>Locations</u>	Description	Time Period	Certification/ Licensine Status
<u>Horizontal Concrete</u> <u>Modules</u>		· .		·
NUHOMS/NUTECH	CP&L/ODE/EPRI -H.B. Robinson	Three NUHOMS modules: 7 PWR assemblies each; 5 kW decay heat per module: fuel/canister/module/air temp., air flow and module surface dose rate meas: 5 add'l modules to be added as needed	1984-1988	Issued August 1986 for 8 module ISFSI
NUHOMS/NUTECH	Duke/NUTECH -Oconee	88 module licensed ISFSI; each module contains 24 assemblies for total of 2112 assemblies	1988 Open	Notice of intent for 88 module ISFSI submitted to NRC in Sept. 1987; license application submitted March 1988
NUHOMS/HUTECH	BG&E/NUTECH -Calvert Cliffs	24 modules plus 8 every other year; each module will store 24 assemblies	1989-Open	Application to be submitted in 1989
<u>Modular Vaults</u>				
ioster Mueler	loster Wheeler	Vault modules store 83 PWR and 150 BWR assemblies; minimum facility consists of 2 modules, cask handling area, and shielded fuel handling machine	1986-Open	Approved by NRC in March 1988 for nitrogen storage only; note that NRC did not approve the system for air storage until sufficient oxidation data are obtained
Concrete Casks				·
CP-9/VSC-17/ · NUPAC/REEDY	DDE/NUPAC/REEDY EPRI/WEPCO -INEL	One 9 assembly/canister PWR cask and one 17 assembly/canister PWR cask; Surry and Turkey Point consolidated fuel; fuel/can temp. & cask surface dose rate meas.	1987-1989	9 assembly/canister PWR cask being reviewed by NRC

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# TABLE A-1: SUMMARY OF BEVELOPHENT AND LICENSING STATUS FOR SPENT FUEL STORAGE METHODS (cont.)

Technology/Method	Organization -Locations	<u>Description</u>	Time Period	Certification/ Licensing Status		
IN-POOL ROO CONSOLI	IN-POOL ROO CONSOLIDATION					
Westinghouse	Duke -Oconee	Removes all rods at once: max. consolidation ratio of 2:1 for 4 assemblies: NFBCs compacted 6:1	1982	Utility's Plan modified: Rod consolidation replaced by dry storage		
Proto-Power Corp.	Maine Yankee Atomic Power Co. -Maine Yankee	Removes all rods at once: max. 1.6:1 consolidation ratio for 1 assembly	1981-1984	Delayed to 1990s		
NAC	RG&E/DOE/EPRI/ NYSERDA -West Valley	Removes PWR rods one at a time; 1.8:1 max. consolidation ratio for 6 assemblies	1985-1986	Ginna license issued December 1985		
UST&D	RG&E/DOE/EPRI/ NYSERDA -Battelle Columbus	Removes one row of PWR rods at a time; known damaged rods; 1.85:1 to 2:1 consolidation ratio for 5 assemblies	1986	Ginna license issued December 1985		
CE	NUSCO/BG&E/DOE/ EPRI -Millstone	Removes one row of PWR rods at a time; 2:1 consolidation ratio for all 6 assemblies; NFBCs awaiting compaction	1983-1988	Millstone license issued March 1988		
Westinghouse	NSP -Prairie Island	Removes all rods at once; 2:1 consolidation ratio for 36 assemblies (most rods consolidated in a demo to date); NFBCs to be compacted by WasteChem	1987	Planned for 1989 (as of Jan 1988)		

# Part II RECORD OF COMMENTS AND RESPONSES

#### Part II

#### RECORD OF COMMENTS AND RESPONSES

#### A. INTRODUCTION

In September 1988, the U.S. Department of Energy (DOE) distributed the initial version of the Dry Cask Storage Study report to the Congress, the U.S. Nuclear Regulatory Commission (NRC), State and local governments, and the public, with a solicitation for comments. The comment period closed on October 28, 1988. This part of the report identifies the comments received by the DOE, presents synopses of the comments and the DOE's responses, and ends with an index of comments and responses. The 46 comment letters that were received are presented in Part III.

As comments on the initial version of the study report were received, each letter was assigned a number to identify it and its originator. Where an organization or individual commenter submitted comments on various topics, the comments were separated, given a sequential identifying number, and then assigned to common topical groupings. Altogether, in the 46 letters of comment, 301 single-subject comments were identified. The identifying numbers assigned to individual comments appear in the left-hand margins of the letters.

The grouping of comments into topical categories served as the format for presenting comments and the DOE's responses in the next section (Section B of Part II). Because of the topical grouping, it was possible to prepare synopses of comments that address a particular topic, but in doing so care was taken to include specific concerns of the commenters in the general synopses. This approach to presenting comments and responses should facilitate the readers' understanding of the concerns and issues related to a common subject. Moreover, this approach minimizes redundancy in responding to the comments.

Section C presents and addresses the comments of the Nuclear Regulatory Commission (NRC). Because the Nuclear Waste Policy Amendments Act specifically directs the DOE to consult with the NRC and to include the views of the NRC in the report, each of the NRC comments is presented separately, and each comment is answered in turn. The NRC will also be requested to review the final report, and any additional comments received from the NRC will be submitted to the Congress.

Section D is an index of all comments and responses. It identifies each comment by a two-part number, with the first part consisting of the number assigned to the whole set of comments (the letter) and the second part consisting of the number assigned to the particular comment. The index shows the subsection of Section B that contains a response to a specific comment.

Listed on the next three pages are the organizations and individuals who submitted comments on the initial version of the Dry Cask Storage Study.

			<b>v</b>
	Name of organization	Name of correspondent	<u>Title</u>
1.	United States Senate	Timothy E. Wirth	U.S. Senator
2.	State of Alabama	Guy Hunt	Governor
3.	State of Vermont, Dept. of Public Service	G. Sterzinger	Commissioner (for Governor Kunin)
4.	State of Maryland, Dept. of the Environment	Martin W. Walsh, Jr.	Secretary
5.	State of Wisconsin, Dept. of Administration	James R. Klauser	Secretary
6.	State of New Jersey Board of Public Utilities	Christine Todd Whitman	President
7.	Commonwealth of Penn- sylvania, Department of Environmental Resources	Thomas M. Gerusky	Director
8.	State of Washington Energy Facility Site Evaluation Council	Curtis Eschels	Chairman
9.	Georgia Public Service Commission	Ford B. Spinks	Vice-Chairman
10.	New York Power Authority	J. Phillip Bayne	President and Chief Operating Officer
11.	Vermont Yankee Nuclear Power Corporation	J. Gary Weigand	President & Chief Executive Officer
12.	Middle South Utilities Inc.	W. Cavanaugh III	Senior Vice Presi- dent
13.	Southern Company Services, Inc.	B. E. Hunt	Manager, Nuclear Fuel
14.	Pacific Gas & Electric Co.	James D. Shiffer	VP, Nuclear Power Generation
15.	Pennsylvania Power & Light Co.	Robert K. Campbell	Chairman, President CEO
16.	Baltimore Gas & Electric	Joseph A. Tiernan	VP., Nuclear Energy
17.	Duke Power Co.	T. C. McKeekin	Vice-President. Design Engineering

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	Name of organization	Name of correspondent	<u>Title</u>
18.	Public Service Company of Colorado	D. W. Warembourg	Manager, Nuclear Engineering
19.	Long Island Lighting Co.	W. J. Catacosinos	Chairman & CEO
20.	Sacramento Municipal Utility District	David A. Boggs	General Manager
21.	Niagara Mohawk	J. M. Endries	President
22.	The Light Company (Houston Lighting & Power)	J. Robert Wordan	Manager, Nuclear Fuel Division
23.	Virginía Power	W. L. Stewart	Sr. Vice-President Power
24.	Environmental Defense Fund	Melinda Kassen	Senior Attorney
25.	Southern Research & Information Center	Caroline Petti	
26.	Transnuclear, Inc.	Bill R. Terr	Senior Vice- President
27.	Nutech	W. J. McConaghy	Vice-President Waste Management Business Group
28.	Gessellschaft fuer Nucklear Service	Dr. Klaus Janborg	
29.	FW Energy Applications Inc.	B. K. Agarwal	Program Manager
30.	Ebasco Services Inc.	Harold L. Rothstein	Manager, Nuclear Fuel Storage Systems
31.	Chem-Nuclear Systems Inc.	Victor J. Barnhart	President
32.	B&W Fuel Co.	Thomas R. Stevens	Manager SF & Waste Technology Services
33.	Utility Nuclear Waste Management Group	S. P. Kraft	Director
34.	U.S. Council for Energy Awareness	J. Siegel	Vice-President Technical Program
35.	Individual (Nevada)	Frank Clements	

	Name of organization	Name of correspondent	Title
36.	State of Nevada, Agency for Nuclear Projects	Robert Loux	Director Nuclear Waste Project Office
37.	Florida Power & Light	W. F. Conway	Senior Vice-President Nuclear
38.	Arizona Nuclear Power Project	Paul Crawley	Manager, Nuclear Fuel Management
39.	Yankee Atomic Electric Co.	J. M. Buckheit	Senior Nuclear Fuel Eng.
40.	Individual (Pasco, Wash.)	J. R. Young	
41.	Boston Edison	R. G. Bird	Senior Vice-President Nuclear
42.	Duquesne Light Co.	J. J. Carey	Executive Vice- President, Operation
43.	National Association of Regulatory Utility Commissioners	Ronald C. Callen	Chairperson, Staff Subcommittee on Nuclear Waste Disposal
44.	State of New York Public Service Commission	Peter Bradford	Chairman
45.	U.S. Nuclear Regulatory Commission	Lando W. Zech, Jr.	Chairman
46.	State of Nebraska, Department of Health	Gregg F. Wright	Director of Health

# B. SYNOPSES OF COMMENTS AND RESPONSES

This section presents synopses of the comments submitted on the initial version of the Dry Cask Storage Study report and the responses of the DOE. It consists of 11 subsections on the following topics:

- 1. General comments.
- 2. Comparison of at-reactor storage to the MRS facility.
- 3. Use of the Nuclear Waste Fund for at-reactor storage.
- 4. Waste acceptance.
- 5. Storage technologies.
- 6. Transportation.
- 7. Dual-purpose casks.
- 8. Cost considerations.
- 9. Health and safety.
- 10. Licensing.
- 11. Miscellaneous comments.

In the synopses of comments, each comment bears a two-part number that identifies first the organization or the person submitting the comment and then the particular comment. For example, comment 5 in comment letter 34 is represented as 34-5. A list of commenters and the numbers assigned to their comment letters is given in the preceding section, and the comment letters, marked with the numbers assigned to each comment, are reproduced in full in Part III of this report.

#### B.1 GENERAL COMMENTS

A number of comments received by the DOE were general observations requiring no response. However, since they reflect views and attitudes about the quality, utility, and scope of the study, they are briefly summarized here.

Middle South Utilities, Inc. and Southern Company Services, Inc. (on behalf of the Alabama Power Company and the Georgia Power Company) supported the report's conclusion that at-reactor dry storage is a technically feasible, safe, and environmentally acceptable option for the management of spent fuel pending the development of Federal facilities.

The following organizations commented to the effect that, in general, the Dry Cask Storage Study report is very informative and thorough with respect to the status of spent-fuel-storage technologies and will serve as a useful reference to the utility industry and other organizations involved in the application of these technologies: Pennsylvania Power & Light Company; Baltimore Gas & Electric; Public Service Company of Colorado; Long Island Lighting Company; Virginia Power; Southwest Research and Information Center; Ebasco Services, Inc.; Chem-Nuclear Systems, Inc.; B & W Fuel Company; Edison Electric Institute, the Utility Nuclear Waste Management Group, and the Eletric Utility Companies' Nuclear Transportation Group; and Yankee Atomic Electric Company.

The National Association of Regulatory Utility Commissioners said that, in general, the Dry Cask Storage Study represents a responsible and responsive effort by the DOE to provide the information required by the Congress in Section 5064 of the Amendments Act. The U.S. Council for Energy Awareness expressed a similar view, stating that the overall scope and depth of the document are excellent.

Boston Edison noted that the DOE, in cooperative projects with the Electric Power Research Institute and participating utilities, has developed technology for the dry storage of spent fuel and said that the DOE's aggressive action in this connection is encouraging. It urged the DOE to continue to support work on dry storage and similar storage measures to assist the industry in accommodating delays in the development of the Federal waste-management system.

Senator Timothy E. Wirth observed that the Dry Cask Storage Study could play an important role in the development of a national strategy for radioactive-waste disposal in the United States. He felt that the study contains a thorough and thoughtful analysis of the various drystorage technologies.

The Duquesne Light Company (42-1) urged the DOE "to complete the program which was enacted under the Waste Policy Act of 1986 as rapidly as possible." In addition, the utility observed that no increases in assessed costs should ever be required since the 5-year delay in the program will result in significant increases in project funding prior to incurring major development and operating expenses.

The National Association of Regulatory Utility Commissioners (NARUC) stated (43-2) its agreement with "the general tone of the study"—namely, the configuration of temporary at-reactor spent fuel storage as a reasonable option until a repository or an MRS facility is available. However, the NARUC was not satisfied that "indefinite at-reactor storage is a low-impact, cost-effective interim alternative to the failure to develop a high-level radioactive waste disposal capability on a timely basis." In this connection, the NARUC felt that extended at-reactor storage, even if operated without accident and without substantial public protest, will represent a further expense to utility ratepayers and will also raise the cost and complicate the decommissioning of many reactors.

The U.S. Nuclear Regulatory Commission represented the study as providing a well-balanced presentation of spent-fuel storage requirements, of in-pool consolidated-fuel storage, and dry-storage technologies available to address these requirements in at-reactor storage and of the impacts and costs of such storage.

Most of the above-mentioned commenters also provided critical comments or recommendations on specific aspects of the study; for example, Senator Wirth expressed concern that the study does not provide a comparison of the impacts of at-reactor dry storage with a system containing an MRS facility. These comments are addressed in the sections that follow.

# B.2 COMPARISON OF AT-REACTOR STORAGE WITH THE MRS FACILITY

# synopsis of comments

Senator Wirth felt (1-1 through 1-4) that the study should evaluate at-reactor storage as an alternative to an MRS facility by considering the full costs and other impacts of these options in relation to one another. He said (1-5) that this type of analysis would benefit the Congress by showing whether at-reactor dry cask storage would cost rate-payers more or less than the alternative of storage at an MRS facility.

The Environmental Defense Fund (EDF) stated similar views (24-2), asserting that the study "is supposed to have presented an analysis of an alternative to the authorized system." The EDF further stated that the DOE must compare the "pre-repository" costs, risks and impacts of the "reference" case of the study (which includes at-reactor storage and a repository, but no MRS facility) to those of the authorized case (a Federal waste-management system with an MRS facility). This theme is continued in EDF comment 24-4. In addition, the EDF proposed (24-1) that the study consider an alternative scenario in which the spent fuel is retained in storage at the reactor sites until after decommissioning and then shipped directly to the repository. Before decommissioning, spentfuel transfers to the DOE would occur only in those cases where the reactors did not have sufficient onsite storage capacity for the entire service life of the reactor.

The State of Nevada said (36-2) that the study, in conflict with the requirements of the Nuclear Waste Policy Amendments Act (Amendments Act), took liberties in its selection of scenarios for analysis and suggested that at least two additional "conservative" scenarios be analyzed: (1) a case in which there is no MRS facility in the DOE system and spent-fuel acceptance at the repository is delayed 10 or more years beyond 2003 and (2) a case in which the spent fuel is stored at the reactors up to 30 years beyond the expiration of their operating licenses.

In summary, this group of commenters believes that the study should address at-reactor storage as an alternative to the MRS facility or other system options and should include an expanded set of scenarios and associated impact evaluations.

#### DOE responses

The DOE considers the information requested by the commenters to be outside the scope of the legislative mandate for the Dry Cask Storage Study. However, as explained below, comparisons of storage at reactor sites and at an MRS facility are to be made in the report to be prepared by the MRS Review Commission. Furthermore, information of the type requested by the commenters is available in another DOE report.\*

<sup>\*</sup>U.S. Department of Energy, Additional Information on Monitored Retrievable Storage, DOE/RW-0166, Washington, D.C., 1987.

The Amendments Act requires in Section 5064 that the DOE "conduct a study and evaluation of the use of dry cask storage technology at the sites of civilian nuclear power reactors for the temporary storage of spent nuclear fuel until such time as a permanent geologic repository has been constructed and licensed by the Nuclear Regulatory Commission." In conducting this study, whose results are to be reported to the Congress, the DOE is to consider the costs of dry-cask-storage technology; the extent to which at-reactor storage of spent fuel will affect human health and the environment; the extent to which such storage affects the costs and risk of transporting spent fuel to a central facility, such as an MRS facility; and any other factors the DOE considers appropriate. The only further direction in the Amendments Act in regard to the scope of the study is related to the use of the Nuclear Waste Fund.

The Amendments Act does not require the DOE to evaluate dry cask storage as an alternative to the MRS facility. Instead, the Amendments Act explicitly mandates an entity other than the DOE to perform this evaluation. More specifically, Section 5021 of the Amendments Act (Section 143 of the Nuclear Waste Policy Act (NWPA) as amended) establishes an MRS Review Commission and directs it, in Section 143(a)(2) of the NWPA as amended, to "compare such a facility [the MRS] to the alternative of at-reactor storage of spent fuel prior to disposal of such fuel in a repository under this Act."

Other provisions of the Amendments Act introduced uncertainties as to the role and timing of an MRS facility by specifying the following constraints: (1) the MRS Review Commision is to report to the Congress on the need for an MRS facility (Section 143(a)(1)(c) of the NWPA as amended); (2) the DOE cannot begin a survey and evaluation of potentially suitable sites for an MRS facility until the MRS Review Commission submits its report to the Congress (Section 144 of the NWPA as amended); and (3) the construction of the MRS facility may not begin until the NRC has authorized the construction of the repository (Section 148(d)(1) of the NWPA as amended).

In view of these uncertainties, as well as those associated with the repository schedule, it is understandable that the Congress requested information about the potential impacts on the utilities and the Federal waste-management system resulting from extended and expanded at-reactor storage. Moreover, a comparative evaluation of at-reactor storage versus storage at an MRS facility, as suggested by some commenters and as the Amendments Act requires of the MRS Review Commission, necessitates the development of an information base on the current status of storage technologies and the economic and technical impacts of their use at reactor sites requiring additional spent-fuel-storage capacity. It was in this context that the Dry Cask Storage Study was undertaken. This study was not intended to replace or negate the need for comparative analyses of at-reactor storage versus a variety of waste-management-system configurations, with and without an MRS facility.

The DOE feels that the information developed in this study will be helpful to the MRS Review Commission in discharging its responsibilities. Morever, the Commission has visited facilities where dry-storage

technologies have been implemented. The DOE will also be using the information developed in the Dry Cask Storage Study to support a series of systems-integration analyses for a variety of system configurations, with and without an MRS facility. The results of these analyses will also be provided to the MRS Review Commission.

The DOE would also like to note that the MRS facility described and costed in the 1987 proposal to the Congress\* was to perform functions in addition to temporary storage. At-reactor storage would not, therefore, be a direct alternative to the MRS facility proposed by the DOE, and such a comparison would be complex.

A study published by the DOE in November 1987 under the title Additional Information on Monitored Retrievable Storage (see footnote on page II-7) did compare an MRS facility to various no-MRS system alternatives. This study provides considerable information of the type the commenters feel should be included in the Dry Cask Storage Study.

Both Additional Information on Monitored Retrievable Storage and the environmental assessment for an MRS facility at Oak Ridge, Tennessee (part of the 1987 proposal to the Congress\*), compared the radiation doses estimated for a waste-management system with and without an MRS facility. With an MRS facility, the occupational dose predicted for the waste-management system would increase slightly, whereas the dose received by the public would decrease because of a decrease in the dose received from waste transportation. Additional Information on Monitored Retrievable Storage shows that the radiation exposures received by the public from an MRS facility would be well below the regulatory limits set by the NRC in 10 CFR Part 72: the population doses were consistently estimated to be less than 1 percent of the radiation dose received from natural background radiation.

#### B.3 USE OF THE NUCLEAR WASTE FUND FOR AT-REACTOR STORAGE

#### Synopsis of comments

Many comments were received on the use of the Nuclear Waste Fund (Fund) for at-reactor storage, and all of the comments except comments 12-2 (Middle South Utilities) and 43-8 (National Association of Regulatory Utility Commissioners) agreed with the study's conclusion that, under the current provisions of the NWPA as amended, the DOE does not have authority to use the Nuclear Waste Fund for supporting at-reactor storage. However, the comments expressed a diversity of views on the question of whether the Fund should be used in direct support of at-reactor storage.

<sup>\*</sup>U.S. Department of Energy, Monitored Retrievable Storage Submission to Congress, DOE/RW-0035, three volumes, Washington, D.C., 1987.

The State of Alabama (2-1) and Southern Company Services (13-2) opposed the use of the Fund for at-reactor storage under any circumstances.

Several utilities and utility organizations (New York Power Authority (10-1); Baltimore Gas & Electric (16-29); Duke Power (17-1); Utility Nuclear Waste Management Group (33-1); Arizona Nuclear Power Project (38-2 and 38-12); and Boston Edison (41-2)) felt that the question of whether the Fund should be used for at-reactor storage depends on whether the costs are incurred for the establishment of at-reactor-storage capacity prior to the DOE's start of spent-fuel acceptance in 1998 or for expanding storage capacity beyond 1998 in order to compensate for the DOE's inability to start spent-fuel acceptance in 1998. These commenters felt that, if additional storage is needed because acceptance does not start in 1998, the costs should be the DOE's responsibility.

The Public Service Commission of New York (44-2) recommended that the DOE request authority to use the Nuclear Waste Fund for all costs of at-reactor storage and said that this would reflect "the cost of the back end of the fuel cycle in a more open manner."

The National Association of Regulatory Utility Commissioners (NARUC) suggested (43-8) that the use of the Fund for at-reactor storage in the post-1998 period may not be prohibited by the NWPA. The DOE's contracts with the utilities\* require the DOE to arrange for and provide transportation casks suitable for use at the individual utility's site. In NARUC's view, it is conceivable that a utility that incorporates transportation, packaging, or necessary fuel-handling measures into its at-reactor-storage program may be legally entitled to payments from the Fund.

The Georgia Public Service Commission (9-3, 9-6) felt that the issue of using the Fund requires broader consideration than that provided in the study. It agreed that the issue is complex and that equity and fairness in the use of the Fund are major considerations. However, the Commission stated that the "recently announced 5-year schedule delay," which is beyond the control of the utilities and will result in additional expenditures for at-reactor storage, introduces new considerations deserving additional study.

Middle South Utilities (12-1, 12-2) encouraged research and development on technology to minimize the costs of dry at-reactor storage and said that at-reactor storage represents an allowable and appropriate use of the Fund. Moreover, it suggested that a more detailed evaluation may show that payments from the Fund for at-reactor storage costs due to recent developments (e.g., the DOE's delay in repository startup) may, in fact, yield the lowest overall costs, thereby supporting a request to the Congress for relief from Fund restrictions. Baltimore Gas & Electric

<sup>\*</sup>U.S. Department of Energy, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste," final rule, Federal Register, Vol. 52, September 18, 1987.

has a similar view (16-30), noting that as the cost effectiveness of atreactor storage is increased through standardization, there may be additional incentives for using the Nuclear Waste Fund to support at-reactor storage.

The Environmental Defense Fund (EDF) criticized (24-9) the study for dismissing the use of the Fund on the grounds of inequities among utilities and cost inefficiencies without providing supporting data. The EDF contended that any inequities resulting from the use of the Fund for atreactor storage are no different from the inequities resulting from Fund support for an MRS facility, in that certain utilities will be contributing to the Fund and paying for a facility (MRS) that they do not need before 2003. It is the EDF's contention that the study's evaluation of use of the Fund for these activities is further evidence that the DOE misinterpreted the purpose of the study—namely, an evaluation of the use of at-reactor storage as an alternative to an MRS facility. This type of study, the EDF contended, would have determined the costs, including administrative costs, to the Fund for dispersed storage at reactors as compared with the costs of an MRS facility.

A similar viewpoint is reflected in a comment by Senator Timothy E. Wirth, who said (1-5) that the examination of whether the Nuclear Waste Fund can or should be used for at-reactor storage relates to an evaluation of whether dry at-reactor storage would be cost effective in comparison with an MRS facility.

Ebasco Services said (30-1, 30-44, 30-46) that the question to be addressed is whether the Fund can be used for post-1998 at-reactor storage as a means of fulfilling the DOE's contractual obligation to start accepting spent fuel by January 31, 1998. Moreover, Ebasco suggested that a more direct answer be provided on the issue of "should the Waste Fund be used for at-reactor storage," even if the answer is "it cannot be determined at this time." Duke Power suggested (17-3) that the DOE, in cooperation with the utilities, begin to outline the principles of such a program of support.

The State of Nevada stated (36-8) that the report is unnecessarily vague regarding how the DOE will determine whether and when it might recommend to the Congress that the policy on the use of the Waste Fund be altered. It felt that the DOE should clarify its statement about requesting Congressional authorization to use the Fund for at-reactor storage if such use is demonstrated to be beneficial to the overall system. At least the terms should be defined and criteria be developed for such a determination.

The U.S. Committee on Energy Awareness suggested (34-2) that current NWPA constraints on the use of the Waste Fund should be reconsidered if spent-fuel shipments to a DOE facility are to start after 1998. The DOE's Annual Capacity Report was suggested as an appropriate vehicle for such a reevaluation.

#### DOE\_responses

As noted in Chapter 6 of this report, the NWPA constrains the DOE from using the Nuclear Waste Fund for the direct support of at-reactor storage. The amendments to the NWPA have not altered these constraints. Therefore, the DOE does not intend to use monies from the Fund for the direct support of at-reactor storage or to seek Congressional authorization for such use of the Fund.

With respect to whether the Fund should be used for at-reactor storage, the DOE considers that it should not use monies from the Fund to support activities intended solely to alleviate interim storage needs at reactor sites because of the inequities inherent in such an action. However, if waste-management activities on the part of the owners and generators of spent fuel or high-level radioactive waste lead to significant and clearly identifiable net reductions in the cost of the Federal waste-management system, then the DOE will consider arrangements that would result in the owners and generators sharing in the benefits of such actions. However, a definitive determination as to whether using the Fund to support specific at-reactor storage activities represents a cost benefit to the overall waste-management system is not feasible at this time in view of the current uncertainties about the structure and functions of the system and uncertainties in waste-package design and handling requirements.

Once these issues are clarified by such current initiatives as the evaluations of the Yucca Mountain site, the evaluations being performed by the MRS Review Commission, and the various systems-integration analyses being conducted by the DOE, it will be possible to define with greater confidence the waste-package design, the the waste-acceptance criteria and schedule, and the additional at-reactor-storage requirements. This information, in turn, will permit realistic determinations about specific at-reactor options in terms of economic benefits to the overall waste-management system.

Until such clarifications about the waste-management system are available, it is premature to undertake determinations as to whether specific at-reactor storage options represent net savings to the Fund. These clarifications could also facilitate the development of criteria or guidelines for determining the benefits realized by the Federal waste-management system from specific at-reactor storage options.

The argument that using the Fund for developing the MRS facility represents an inequity for the utilities that do not need additional atreactor storage before the start of repository operations might have some validity if the advantages of the MRS facility were limited to storage. However, even a storage-only MRS facility would provide significant benefits to the combined utility/DOE waste-management system in terms of scheduling and operational flexibility. In addition, the MRS facility may provide preparation functions for the spent fuel received from the reactors.

# B.4 WASTE-ACCEPTANCE SCHEDULE

# synopsis of comments

The State of Maryland said (4-1) that it does not support the premise that the availability of dry-storage technologies allows the DOE to take until 2003 to construct the repository and start accepting spent fuel.

Six utilities (Vermont Yankee Nuclear Power Corp. (11-1), Southern Company Services (13-1), Pennsylvania Power & Light (15-1), Baltimore Gas & Electric (16-12), Duke Power (17-1), and Yankee Atomic Electric (39-1)) noted that the DOE has a contractual obligation to start spent-fuel acceptance in 1998. Duke Power stressed that meeting this obligation is in return for payment of the full costs of the Federal program. To the extent that the DOE does not have an operational facility to start accepting spent fuel in 1998, the utilities and their ratepayers should not have an on-going open-ended obligation to pay for the storage of spent fuel.

Baltimore Gas & Electric felt that the discussion of the trend in additional storage requirements after spent-fuel acceptance is initiated (page 19) should note not only that for several years storage needs will increase at some reactor sites because their rates of spent-fuel discharge will exceed the rate of acceptance by the DOE but also that during the same period other sites will accrue excess storage capacity because the DOE's acceptance rate at these sites will exceed the rates of spent-fuel discharge from their reactors.

The Southwest Research and Information Center stated (25-1) that the DOE erroneously assumed in the study that an MRS facility will enable the DOE to accelerate waste acceptance. It is the Center's view that it will be extremely difficult for the DOE to bring an MRS facility into operation because of difficulties associated with the siting and licensing processes. The DOE should assume that spent fuel will remain at reactor sites until a geologic repository is available.

The Georgia Public Service Commission said (9-2, 9-4, 9-5) that the DOE should establish a reliable schedule for beginning the acceptance of spent fuel for offsite storage, thereby facilitating economic decisions by the utilities about the type of at-reactor storage to use when it is needed. Moreover, the Commission urged the DOE to begin spent-fuel acceptance for offsite storage as soon as feasible.

The State of Nevada faulted (36-2) the report for its failure to analyze a scenario where the DOE is not able to accept waste by 2003 nor the "more realistic" situation involving an indefinite postponement of geologic disposal. For this reason, Nevada suggested that the report analyze two additional scenarios: (1) a no-MRS system in which repository acceptance is delayed 10 or more years and (2) a case where the reactors are required to store spent fuel for up to 30 years beyond the expiration of their operating licenses.

The State of Nevada (36-3) and the National Association of Regulatory Utility Commissioners (43-4) questioned why scenarios of waste acceptance beginning in 1998 and 2008 were selected as opposed to some other milestone dates for starting to accept spent fuel. These dates appeared to Nevada to be "simply arbitrary and convenient."

Virginia Power suggested (23-1) that line 3, paragraph 2 on page vibe revised to include the date assumed for the "start of spent-fuel acceptance by DOE."

The Edison Electric Institute, the Utility Nuclear Waste Management Group, and the Electric Utility Companies' Nuclear Waste Transportation Group recommended (33-1) that the report should not address the issue of the DOE's "statutory commitment to begin taking spent fuel in 1998." These commenters viewed this commitment as an important issue to be addressed in an appropriate forum at an appropriate time.

#### DOE responses

The DOE has entered into contracts with the owners and generators of spent fuel, in accordance with Section 302(a) of the NWPA. The contract provides for the DOE's acquisition of title to the spent fuel, transportation, and subsequent disposal. Under the contract, these services are to be provided "after the commencement of facility operations." As noted in the Draft 1988 Mission Plan Amendment,\* the DOE recognizes that, under current conditions, waste acceptance at a Federal waste-management facility cannot begin in 1998. Moreover, because of the delay in the repository schedule and the linkages between the repository schedule and key milestones in the siting and the construction of an MRS facility, the DOE may not be able to start accepting waste significantly before the year 2003.

In view of these considerations, the reference case used in the Dry Cask Storage Study initiates waste acceptance in 2003. However, consistent with the Draft 1988 Mission Plan Amendment (Section 2.4), this reference waste-acceptance case is viewed as preliminary and is presented for illustrative purposes only. The Dry Cask Storage Study included alternative waste-acceptance schedules in which the removal of spent fuel from reactor sites was assumed to start in 1998 and 2008.

These alternative dates and scenarios were not intended as proposals or commitments by the DOE; their purpose was merely to provide some insight, through sensitivity analyses, into the at-reactor storage requirements and the attendant impacts resulting from changes to the selected reference case (i.e., the starting date and acceptance rates). The results of these sensitivity analyses (Table 3-2) show that the date for the start of spent-fuel acceptance by the DOE significantly affects at-reactor storage requirements. These data will be available to the MRS

<sup>\*</sup>U.S. Department of Energy, <u>Draft 1988 Mission Plan Amendment</u>, DOE/RW-0187, Washington, D.C., 1988.

Review Commission for its evaluation of the need for an MRS facility. The DOE believes that the effects of other alternative acceptance schedules can be readily interpolated or extrapolated by the reader and that an analysis of different acceptance dates and rates is not required of this report.

It is not feasible to establish a "final" waste-acceptance schedule at this time because of the long period of time that will elapse before the start of waste acceptance and the many major program decisions and evolutions that must occur during that period. These major program decisions and evolutions include such items as decisions on an MRS facility, the evaluation of the Yucca Mountain site, the design of the repository waste package, and various systems-integration analyses being performed by the DOE. Once the more significant uncertainties are clarified, it will be possible to establish a waste-acceptance schedule with greater certainty in concert with the affected parties. However, the Standard Contract for the Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste provides the general guidance the DOE will use in developing waste-acceptance priority rankings and delivery schedules. accordance with the provisions of the standard contract, the Annual Capacity Report (most recent update: DOE/RW-0191, June 1988) represents the first step in providing utilities with a preliminary indication as to where specific nuclear power plants rank relative to others in the wasteacceptance schedule.

#### **B.5 STORAGE TECHNOLOGIES**

This section summarizes the major comments and presents the DOE's responses on the status and development of the following technologies for at-reactor spent-fuel storage: metal casks, horizontal concrete modules, concrete modular vaults, concrete casks, and spent-fuel consolidation. Comments and responses on dual-purpose casks are presented in Section B.7.

#### B.5.1 Metal casks

#### Synopsis of comments

Middle South Utilities (12-4), Pacific Gas & Electric (14-3), Virginia Power (23-4), Ebasco Services (30-16), and the Utility Nuclear Waste Management Group (33-9) said that the report should not suggest that boron is the only neutron absorber that can be used in metal casks and other dry-storage systems for the control of nuclear criticality. Related comments were submitted by the State of Vermont (3-10), Baltimore Gas & Electric (16-17), Virginia Power (23-5), and the Utility Nuclear Waste Management Group (33-10), who addressed the issue of receiving credit for spent-fuel burnup in order to minimize or eliminate the use of neutron poisons in dry-storage systems. The State of Vermont sug-

gested (3-4) that similar considerations could be applied to in-pool storage racks.

The Public Service Company of Colorado asked (18-4) whether it is necessary to have the capability at all times for removing spent fuel from metal casks and other dry-storage systems. This concern was associated with the shutdown of a reactor before the DOE accepted all of the spent fuel stored at the reactor site and the need to maintain the storage pool in an operating mode.

#### DOE responses

The DOE agrees that boron is not the only material that can be used as a neutron absorber and acknowledges that configuration design is also a method for eliminating criticality. The text was changed by replacing "boron" with "neutron-absorbing materials," "neutron poisons," or "geometrically safe design control," as appropriate.

In regard to credit for burnup, the DOE, utilities, and vendors are attempting to obtain burnup credit from the NRC. For PWR facilities, the NRC has approved (under 10 CFR Part 50) the use of in-pool spent-fuel storage racks with credit for burnup. The DOE, whose interest in burnup credit is related principally to spent-fuel transportation, is in the process of demonstrating that appropriate administrative controls can be used to ensure that only irradiated fuel is loaded into transportation casks. The results of the current work with transportation casks will also apply to storage casks.

The DOE is unaware of a requirement to have a method for unloading fuel from a cask at all times. This issue is reviewed by the NRC on a case-by-case basis and depends on the design of the cask closure and its redundancy. It is possible to develop redundant closure seals, such as seal welding an outer lid to the body of the cask, that could eliminate the need to be able to unload the spent fuel at any time. However, at the only licensed cask-storage facility in the United States, a means for removing the lid or lids from a cask is required in case a leak occurs in the lid system and repairs are needed. In this specific instance, if the outer lid leaks, it can be removed and repaired on the storage pad, but if the inner lid leaks, the cask must be moved to the pool and both lids removed. Underwater removal is required for the inner lid in order to provide shielding.

# B.5.2 Horizontal concrete modules

#### Synopsis of comments

Several commenters (Baltimore Gas & Electric (16-7, 16-11, 16-16, 16-18), Duke Power (17-4), NUTECH (27-7, 27-15)) stated that more utilities were planning to use horizontal concrete modules than had been suggested in the report. NUTECH requested (27-18) that the report be re-

vised to indicate that utility planning trends are predominantly toward the selection of horizontal concrete storage modules. In addition, NUTECH (27-10) and Ebasco Services (30-21) requested clarification on the loading of a horizontal concrete module.

# DOE responses

The report was revised to say that Duke Power and Baltimore Gas & Electric had submitted or were planning to submit license applications to the NRC for the use of horizontal concrete modules. Moreover, the report was revised to add that Carolina Power & Light (CP&L) has recently announced its intent to establish a dry-storage facility at its Brunswick plant. This facility will use the same storage technology that is used at the CP&L's H. B. Robinson plant—the horizontal concrete module technology (the NUHOMS system). Current plans provide for a capacity to store seven spent-fuel assemblies per module.

Since only five reactor sites have selected a method of dry storage and only two dry-storage facilities are in operation, the DOE considers that it is too early to define trends as to which storage system or method a utility may select.

The NUHOMS module is loaded dry, the spent fuel having been loaded into the storage canister in the pool in a transfer cask. The canister is then sealed, dried, transferred to the storage module, and loaded into the module (in a dry condition) with a hydraulic ram.

#### B.5.3 Concrete modular vaults

#### Synopsis of comments

A number of comments addressed modular vaults (Baltimore Gas & Electric (16-2, 16-8, 16-21), Foster Wheeler (29-4 through 29-9, 29-13, 29-14, 29-15), and Ebasco Services (30-34). Most of these comments were concerned that the discussion of concrete modular vaults in the report was negatively biased because of the lengthy discussion of licensing issues. Moreover, Foster Wheeler (29-3) emphasized the experience outside the United States in using this storage method.

#### DOE responses

The DOE did not mean to imply that concrete modular vaults were inferior to the other dry-storage methods. The report was revised to indicate that similar licensing issues have been raised with metal casks and horizontal concrete modules. In addition, the discussion of international storage practices was revised by adding a section that presented a summary of the more than 17 years of experience with modular concrete vaults in the United Kingdom.

#### B.5.4 Concrete casks

## Synopsis of comments

Most of the comments on metal casks are applicable to concrete casks. Therefore, the section on metal casks should be referenced. However, the B & W Fuel Company (32-1, 32-5) asked for more-detailed information on the designs of concrete casks, whereas Baltimore Gas & Electric (16-2, 16-8, 16-21) asked for information on the status of concrete-cask technology. The B & W Fuel Company (32-6) also challenged the statement that, for dry storage in concrete casks, the spent fuel must be in canisters. Moreover, the B & W Fuel Company (32-1) noted that concrete drystorage casks rely on a metal liner and lid for containment.

# DOE responses

Little value would be added to this report, which has been prepared for the Congress, by including the design details for every metal cask, concrete cask, horizontal concrete module, and concrete modular vault. Therefore, general concepts were presented to give readers a basic understanding of each storage-method design without including details that can be found in technical papers and reports (see the bibliography in Appendix A in Part I).

The status of concrete-cask development and application is that they are being used extensively in Canada. In the United States, one vendor has submitted a topical report to the NRC, another vendor plans to submit a report in 1989, and at least one utility is seriously considering the use of concrete casks at one of its reactor sites. The DOE and Pacific Sierra Nuclear are planning to conduct performance tests (heat transfer and shielding) on one or two concrete casks in 1990.

There are currently no requirements for packaging intact spent-fuel assemblies in canisters for dry storage. The report was revised to say that the use of canisters is an assumption rather than a requirement.

In the initial version of the report, the discussion in Section 4.1.3.1 of the characteristics of concrete casks did state that the casks have a metal liner and a metal lid. However, the text was revised to draw attention to this feature of the concrete casks at an earlier point in the text.

# B.5.5 Spent-fuel consolidation

### Synopsis of comments

The New York Power Authority (10-4, 10-5) said that the development of spent-fuel consolidation is lagging and that the DOE should be funding more research and development (R&D) on consolidation. The same reviewer (10-4) also pointed out that the dry rod-consolidation R&D program at Idaho exceeded cost estimates and is falling short of its goals.

The Environmental Defense Fund (24-7) questioned why rod consolidation was not considered thoroughly in the study since the DOE was certain it could successfully perform dry consolidation at an MRS facility. The same commenter criticized the DOE for focusing on in-pool consolidation notwithstanding the fact that not all the steps of the consolidation process have been satisfactorily demonstrated.

The Southwest Research and Information Center (25-3) said that more information is needed for the DOE to conclude that the technical feasibility and the safety and environmental acceptability of in-pool consolidation have been successfully demonstrated.

The Arizona Nuclear Power Project (38-5) noted that canisters of consolidated fuel should be considered equivalent to standard fuel assemblies. Otherwise, utilities should be informed whether there are technical difficulties associated with the handling of these canisters. Pennsylvania Power & Light (15-2) also noted that the classification of consolidated fuel under the DOE's standard contract with the utilities requires clarification.

The State of Georgia (9-8), the New York Power Authority (10-3), and the B & W Fuel Company (32-9) said that the DOE did not discuss rod consolidation in conjunction with dry storage and that the report should be revised to clarify the impact of consolidation on dry-storage options other than dual-purpose casks.

#### DOE responses

Section 218(a) of the NWPA requires the DOE to "undertake a cooperative program with civilian nuclear power reactors to encourage the development of the technology for spent nuclear fuel rod consolidation in existing power reactor water storage basins." The NWPA goes on to specify that in carrying out "the programs described in subsection (a) "the utility shall select the alternate storage technique to be used...." The DOE has participated in three at-reactor consolidation demonstrations, which were the only activities proposed by the utilities. The consolidation of BWR rods was terminated early in the program when the participating utility, the Tennessee Valley Authority, had to withdraw because of other priorities. The demonstrations by Rochester Gas & Electric and NUSCO were completed and added valuable information to the development of rod consolidation. In addition to the programs that involved DOE participation, there were other demonstrations in which the DOE did not participate. The latter demonstrations were conducted by Maine Yankee Atomic Power, Duke Power, and Northern States Power. The DOE has not been approached to do additional rod-consolidation R&D and thus has no plans for future at-reactor spent-fuel consolidation demonstrations.

In-pool consolidation demonstrations at reactor sites have initially experienced difficulties with the complex equipment that is involved, which is not unusual in the early development of a new technology. In the last two demonstrations, performed by NUSCO and the

Northern States Power Company, the consolidation of the spent-fuel rods was performed without major difficulties. However, difficulties were encountered in the compaction and canistering of the non-fuel-bearing hardware left after consolidation.

Even though the dry-rod-consolidation work at Idaho has cost more than initially estimated, the primary goals are expected to be met at reasonable cost. In this modest dry-rod-consolidation demonstration, 48 PWR assemblies were successfully consolidated into 24 canisters, and it was shown that a consolidation ratio higher than 2:1 could be obtained. The canisters were later loaded into a metal cask, and a performance test (heat transfer and shielding) was performed. In the large prototypical consolidation development program (PCDP), five candidate vendors prepared preliminary designs, and three of these vendors were chosen to develop final designs. One of the final designs has been selected for fabrication and "cold" testing with nonradioactive material. A further demonstration with spent fuel may be performed, depending on the results of the "cold" testing and additional evaluations of the potential advantages of rod consolidation to the Federal wastemanagement system.

The DOE is considering the consolidation of spent fuel before disposal because of the potential cost savings that consolidation may yield for storage at an MRS facility, transport to a repository, packaging for repository disposal, and emplacement in the repository. Consolidation may not be justified alone for benefits to dry storage at the MRS facility but may be justified when the benefits to dry storage are combined with the benefits to additional parts of the system. The definitive estimate of costs and benefits for the centralized-facility consolidation considered by the DOE will not be known until the Idaho demonstration is complete. If consolidation should prove to result in no savings and not be required for the technical performance of the waste package, the DOE will stop its development of central-facility consolidation technology. This would not affect the ability of the waste-management system to accept fuel appropriately consolidated at reactor sites.

The text of the report was revised to better describe the state of technology development and future activities.

Canisters of consolidated fuel are not considered to be standard fuel under the existing standard contract. Any difficulties associated with handling these canisters at the reactor will depend on their designs. Provisions must be made for physically moving them, and their dimensions must be compatible with the utility's in-pool storage racks and with the transportation casks into which they are to be loaded. With respect to the latter consideration, the DOE is supporting efforts to develop canister specifications that will ensure compatibility with transportation casks.

The consolidation of spent fuel offers a potentially attractive method for increasing the capacity of existing reactor pools. However, the relative economic gain from consolidation is lower when performed for

the purpose of dry storage in casks. The dry storage of consolidated fuel has the potential of reducing storage cask or vault costs by approximately 40 percent, provided that (1) a rod-consolidation ratio of 2:1 is achieved, (2) a compaction ratio of 10:1 is achieved for the non-fuel-bearing components, and (3) the storage module has the necessary added capability for heat rejection and radiation attenuation. However, the savings are at least partially offset by the cost of consolidation. pepending on the relative costs of the storage system and consolidation, the net change in total storage costs may be favorable or unfavorable. If a high-cost storage system is involved, consolidation can result in a net cost savings; if a low-cost storage system is involved, there will be little, if any, savings.

#### **B.6 TRANSPORTATION**

#### Synopsis of comments

The New York Power Authority (10-6) commented that the transportation impacts of the various dry-storage options and consolidation were not adequately discussed and that consolidation, dual-purpose casks, and the type of dry storage used are significant to the transportation of spent fuel and the overall operation of the waste-management system.

Baltimore Gas & Electric (16-1) observed that a very narrow definition was applied to the transportation system when looking at the benefits and effects of various at-reactor storage alternatives. For example, it believes that the savings realized in transportation through the use of dual-purpose casks should be shown as being offset by the added expenses incurred by the utilities in connection with the use of such casks.

Baltimore Gas & Electric (16-26), Duke Power (17-2), and NUTECH (27-5) said that the report should mention the transportation advantages of multiple-element sealed canisters, which are used in horizontal concrete storage systems. On the other hand, the B & W Fuel Company (32-10) cited some potential disadvantages of these canisters, such as the complexity and cost of unloading the canisters before loading the spent fuel into transportation casks.

The B & W Fuel Company (32-12) pointed out that, in order to increase the capacity of transportation casks by shipping consolidated fuel, which the report mentions, it is necessary to optimize the design of the cask for consolidated fuel, and considerable savings could be realized in such an event. Ebasco Services (30-43) suggested that the shipment of consolidated fuel in legal-weight truck casks should double the capacity of these casks as compared with the shipment of intact spent fuel.

The Arizona Nuclear Power Project (38-10) commented that canisters of consolidated spent-fuel rods and non-fuel-bearing components should be treated as the equivalent of a standard fuel assembly. It also felt that

negative impacts on storage and the transportation system (difficulty in handling, limitations on the weight of the cask, etc.) that might be caused by such materials should be identified to the utilities at an early date. This commenter was also concerned (38-11) whether the transportation casks developed by the DOE will be able to accommodate its non-standard spent-fuel assemblies. Baltimore Gas & Electric (16-28) questioned the use of spent-fuel casks for shipping non-fuel-bearing components.

The Environmental Defense Fund (24-5) and Senator Timothy E. Wirth (1-4) pointed out that the costs and the risks of transporting spent fuel depend on many factors, including the distance and the age of the fuel, neither of which was considered by the DOE in evaluating transportation impacts. Vermont (3-12) questioned the DOE's assumption that the actual condition of rail lines will not be a factor in the transportation of storage casks.

The Utility Nuclear Waste Management Group (33-4) asked the DOE to clarify the statement in the report that the use of dual-purpose casks would result in minimal overall costs and risks to the transportation system; the Group said that the report does not explain whether the costs and risks would be decreased or increased.

# DOE responses

The observation in the report that the impact of dual-purpose casks on the transportation system is expected to be slight is based on two premises. First, the beneficial impact of dual-purpose casks on the transportation system requires a commitment by the utility to deliver certified casks sufficiently far in advance for the DOE to avoid the purchase of transportation casks for its fleet (see Section B.7 for a discussion of the potential cost benefits). However, studies to date indicate that, if the entire transport fleet were composed of dual-purpose casks, only 28 to 34 such casks would be required. Second, it is doubtful that a utility would want to ship the spent fuel stored in dry storage earlier than the spent fuel stored in the spent-fuel pool.

The use of dual-purpose casks would have the benefit of reduced exposures of workers. The exposure reduction that would result from a reduction in spent-fuel-handling operations at the transportation interface with the reactor would be very low.

There should be no transportation impacts of the other dry-storage options, assuming that the spent fuel delivered to the DOE from dry storage is identical in form with the spent fuel stored in the reactor storage pool. The DOE is studying the potential impacts of receiving the multiple-element sealed canisters that are used in the horizontal concrete storage modules (the NUHOMS system). Preliminary results indicate that multiple-element canisters carrying 21 to 24 PWR assemblies would have little impact on transportation from the reactor, but lower-capacity canisters would have increasingly adverse impacts.

The amount of spent fuel that can be shipped in a single cask loading will be increased by consolidation but is not likely to be doubled. If a 2:1 consolidation ratio for fuel rods is achieved, along with a 10:1 compaction ratio for the non-fuel-bearing hardware, the capacity of a single cask for consolidated fuel would be about 1.67 times higher than its capacity for intact fuel--provided that the cask can reject the additional heat and attenuate the additional radioactivity. These issues are currently under study.

The report attempted to address the impacts of at-reactor storage options on transportation from the reactor to DOE facilities. This included impacts on cask capacity, cask design and cost, freight and associated costs, and the radiation exposure of the general public. The report did not consider similar impacts on the remainder of the Federal waste-management system and on the utility system. These issues are beyond the scope of the dry cask storage study required by the Amendments Act, but they are addressed by other elements of the DOE program, taking into account, as appropriate, the results of this study.

The DOE currently plans to accept "nonstandard" fuel. However, because of the numerous variations that can exist in the characteristics of the fuel, the DOE is first making provisions for the transportation of "standard" fuel and will initiate efforts to develop mechanisms for transporting nonstandard fuel at a later time.

The shipping distance will affect the cost and the shipment-miles involved, and the age of the fuel may also affect these factors. eyer, both the distance and the age of the fuel will have the same relative impact on the costs and risks of shipping any given quantity and form of spent fuel for any specific set of reactor and DOE facility locations. For example, if the costs and risks of shipping 10 MTHM of consolidated fuel over 1000 miles are less than those of shipping the equivalent quantity of intact spent fuel over the same distance, a similar effect will apply to a shipment of 500 miles or 1500 miles. Similarly, if the costs and risk of shipping 10 MTHM of consolidated 10year-old fuel over a distance of 1000 miles are less than those of shipping over the same distance the equivalent quantity of intact spent fuel of the same age, a similar effect will apply to a shipment of fuel that is 5 or 20 years old. The same situation applies to the condition of the rail lines between two points: if the rail line cannot handle the load of a dual-purpose cask, it will probably not be able to handle the load of a rail transport cask.

Whether or not canisters of consolidated fuel rods and non-fuel-bearing components should be treated as the equivalent of standard fuel assemblies is being studied by both the DOE and the utilities. Also under study are the impacts of consolidated fuel and non-fuel-bearing hardware on the Federal waste-management system. This and the subject of whether DOE shipping casks will be compatible with the spent-fuel assemblies from all light-water reactors are not within the scope of this study, but they are being addressed separately by the DOE (see the response to NRC comment 45-1 in Section C).

The statement in the study that the overall costs and risks of using dual-purpose casks are expected to be minimal means that the costs and risks are not expected to vary significantly (either up or down) from those expected for DOE-supplied transport casks.

#### B.7 DUAL-PURPOSE CASKS

#### Synopsis of comments

Vermont (3-11) commented that the study should elaborate on the advantages and disadvantages of dual-purpose casks and pointed out that the costs estimated for loading and unloading shipping casks are very small.

Wisconsin (5-1) said that, while a dual-purpose cask may be desirable for possible cost advantages, flexibility, and reduced radiation exposures, separate casks for storage and transportation may allow design goals to be more readily achieved. However, it believes that the long-term goal should be to use such casks for storage at more than one location (i.e., at reactor sites, the MRS facility, etc.) and for transportation between such activities.

Georgia (9-9) asked the DOE to clarify some of the costs associated with the use of dual-purpose casks. Moreover, it suggested (9-10) the possibility of the DOE's offering a credit to utilities for the transfer of dual-purpose casks to the DOE in view of the prospective cost advantages to the Federal waste-management system and urged that the amount of this credit and the schedule for agreements therefor be established at an early date.

The New York Power Authority (10-7) felt that the report's discussion of dual-purpose casks was incomplete in that there were no recommendations, no commitments for future work, no position taken on the use of such casks in the waste-management system, and no mention of the attractiveness of such casks in achieving the objective of keeping radiation exposures as low as is reasonably achievable (ALARA). This commenter also pointed out (10-8) that some of the cost information provided was inconsistent. Furthermore, it criticized (10-9) the DOE for deferring the development of dual-purpose casks and stated the "strong" belief that it would be prudent to actively pursue the option of using dual-purpose casks.

Middle South Utilities (12-1) believes that the dual-purpose cask minimizes handling costs and reduces personnel exposure and accident risks—and hence should be given priority in research and development.

Baltimore Gas & Electric (16-27) agreed that the use of dual-purpose casks may minimize the number of transportation casks purchased by the DOE, but the DOE is trading its savings for a substantial additional cost to the utilities using dual-purpose casks. Furthermore, if one considers the costs of disposing of the additional hardware associated with a large

 $_{\rm number}$  of dual-purpose casks, there may not be any overall system benefits.

Virginia Power (23-9) felt that the dual-purpose casks could be used for shipments from reactor sites that have barge access, but no direct railroad capability. It also asked for more discussion of the report cited as reference 15.

The Southwest Research and Information Center (25-2) said that safety benefits would result from using dual-purpose casks because spent-fuel-handling operations may be eliminated, reducing the radiation exposures involved in transferring spent fuel from conventional storage casks to transportation or disposal casks. The Center asked for more information on the status of the dual-purpose-cask technology and relevant DOE R&D programs.

Transnuclear Inc. (26-3) and the B & W Fuel Company (32-11) asked the DOE to clarify the cost estimates developed for the use of dual-purpose casks.

NUTECH (27-19) said that the savings associated with the use of dual-purpose casks may be misleading inasmuch as they do not account for the costs incurred by the utilities in purchasing these casks.

The Utility Nuclear Waste Management Group (33-13) asked why the report did not include a range on the additional costs for dual-purpose casks (\$7 per kilogram of heavy metal).

The Arizona Nuclear Power Project (38-4 and 38-9) stated that the costs incurred by the utilities in purchasing DOE-approved dual-purpose casks should be reimbursed in an equitable fashion.

## DOE responses

The report referenced in Section 5.3.1 of the Dry Cask Storage Study, Use of Transportation Storage Casks in the Nuclear Waste Management System,\* provides a detailed discussion of the prospective advantages and disadvantages, both to the utilities and to the Federal wastemanagement system, of using dual-purpose casks. Since the information included in this reference was quite extensive, only a brief summary of its conclusions was included in the report. Further observations on the use of dual-purpose casks can be summarized as follows:

The use of dual-purpose casks by a utility is generally more costly than other methods of dry storage at reactor sites; the Dry Cask Storage Study showed that it was more costly than storage-only metal casks (by about \$7 per kilogram of heavy metal, when all costs were considered).

<sup>\*</sup>Oak Ridge National Laboratory, <u>Use of Transportation Storage Casks in the Nuclear Waste Management System</u>, ORNL/Sub/86-SA094/1, Oak Ridge, Tenn., 1987.

This included a savings of about \$1 per kilogram of heavy metal resulting from the assumption that the dual-purpose cask would not have to be unloaded and the spent fuel it carries would not have to be inspected and then loaded into a shipping cask. However, other methods of storage, such as those involving concrete storage modules (the NUHOMS system) and concrete casks, may be less expensive than metal storage casks, and the costs of using dual-purpose metal casks for storage at reactor sites could be higher, by about \$30 to \$35 per kilogram of heavy metal, than the costs of concrete storage technologies.

On the other hand, dual-purpose casks could be used in the Federal waste-management system with attendant cost savings (avoided costs) provided they are made available by utilities on a timely basis. Three potential scenarios are given below.

- 1. From 28 to 34 dual-purpose casks could be used by the DOE as part of its transportation fleet provided that (a) the casks are certified for routine use for the transportation of spent fuel as of the time of receipt, (b) the casks are received by the DOE at the start of operations in the Federal waste-management system, and (c) a firm utility commitment to deliver the casks is made to the DOE sufficiently early to allow the DOE to avoid the purchase of shipping casks. If these conditions are met, the Federal waste-management system could realize savings of \$90 to \$95 per kilogram of heavy metal for the amount of spent fuel delivered in dual-purpose casks. This would amount to a total savings on the order of \$20 to \$40 million (undiscounted), assuming that the payload is 9 to 12 MTHM per cask and that 28 to 34 casks are delivered.
- 2. Similarly, approximately 50 dual-purpose casks might be used to provide lag storage in the Federal waste-management system if the system does not include an MRS facility. As many as 80 such casks might be so used if an MRS facility is included in the system, provided that the casks are received at the start of MRS operations and a firm commitment to deliver the casks is made sufficiently early to allow the DOE to avoid the installation of the corresponding amount of lag-storage capacity. If these conditions are met, savings of \$50 to \$75 per kilogram of heavy metal could be realized by the Federal waste-management system for the amount of spent fuel that is delivered in dual-purpose casks.
- 3. Furthermore, as many as 240 additional dual-purpose casks might be used in monitored retrievable storage to replace the corresponding capacity of concrete storage casks at the MRS facility, provided that an MRS facility is included in the Federal waste-management system and the casks are delivered on a schedule that would permit the DOE to avoid the procurement of concrete storage casks. If these conditions are met, savings of \$5 to \$30 per kilogram of heavy metal could be realized by the

Federal waste-management system for the amount of spent fuel that is delivered in dual-purpose casks. (The lower level of savings would be applicable for casks equipped with BWR baskets, and the higher level of savings would be applicable for those equipped with PWR baskets).

From the foregoing it can be seen that the use of limited numbers of dual-purpose casks (the maximum realistic total storage capacity is estimated at 1250 MTHM for transport and lag storage in the Federal wastemanagement system) could result in net savings to the combined utility/ DOE wastemanagement system provided the casks are certified for transportation and are delivered at or near the start of Federal wastemanagement operations. It is doubtful that this uncertain usage potential would justify the DOE's expending for the development of dual-purpose casks more funds than those already committed for that purpose. Moreover, because the utilities that might use dual-purpose casks do not necessarily have delivery allocations, accelerating the acceptance of spent fuel in dual-purpose casks in order to obtain these casks when needed could seriously complicate the delivery-allocation procedure set forth in the standard contract with the utilities.

The report intended to say that the designers of casks believe that they can modify the <u>design</u> of the metal storage casks so that the casks can be certified for transportation and that such modifications would increase fabrication costs by \$50,000 to \$300,000. When the costs of design and certification are considered, the additional cost of storage amounts to an average of \$7 per kilogram of heavy metal. In developing this unit cost, the added cost of fabrication was assumed to be \$110,000, which was considered to be reasonable from discussions with cask vendors and is within the range cited above. Moreover, the unit cost accounted for potential economies in the fabrication of casks as experience is gained.

The DOE has been actively involved in attempting to identify any cost savings that might be realized by the Federal waste-management system through the receipt of dual-purpose casks and the conditions under which such savings might be realized. As the design of the waste-management system progresses, any such savings will be quantified to the point where the DOE may be able to take measures to allow utilities to benefit from the use of these casks. Any such benefits to the utilities would correspond to the cost savings realized by the waste-management system.

The Oak Ridge study cited above also concluded that a savings of about \$1 per kilogram of heavy metal (and lower personnel exposures) could be realized because a dual-purpose cask would not have to be unloaded and the spent fuel it carries would not have to be inspected and loaded into a transportation cask before shipment to a DOE facility; however, these advantages did not nearly offset the added cost of the casks to the utility.

#### **B.8 COST ESTIMATES**

#### Synopsis of comments

Several commenters, including the New York Power Authority (10-2), Middle South Utilities (12-3), Baltimore Gas & Electric (16-4, 16-24), NUTECH (27-4), Foster-Wheeler (29-2, 29-11, 29-12), the B&W Fuel Company (32-3, 32-8), Utility Nuclear Waste Management Group (33-11), and the Arizona Nuclear Power Project (38-8), submitted questions or comments about the general cost methodology.

The State of Vermont (3-9), Vermont Yankee (11-2), Baltimore Gas & Electric (16-14), NUTECH (27-4), Foster Wheeler (29-10), and an individual, John Young (40-1) commented on or requested additional information about cost uncertainties. The B&W Fuel Company (32-4) said that the cost estimates for metal casks are low, particularly in view of the assumed contribution from receiving credit for burnup.

The State of Vermont (3-8), the State of Nevada (36-4), and the National Association of Regulatory Utility Commissioners (43-5) suggested that the time value of money should be addressed. The State of New York (44-1) requested estimates of dry-storage costs in terms of mills per kilowatt-hour.

Senator Timothy E. Wirth (1-2) and the Environmental Defense Fund (24-2, 24-4) criticized the report for not including an in-depth comparison of the costs of an MRS facility with those of at-reactor storage.

The State of Vermont (3-7), Baltimore Gas &n Electric (16-14, 16-15, 16-19) and the Utility Nuclear Waste Management Group (33-15) observed that the report's estimates of the cost of licensing were too low since the license fee is \$405,000.

Baltimore Gas & Electric (16-4, 16-23), NUTECH (27-16), Gesellschaft fuer Nuklear-Service mbH (28-1), Foster-Wheeler (29-12, 29-15, 29-16), Ebasco Services (30-19, 30-25, 30-28) the B&W Fuel Company (32-2, 32-8), and the State of Nevada (36-5, 36-6, 36-7) all offered comments on values assumed for specific cost factors.

#### DOE responses

The general cost methodology used for the report was intended to estimate a range of total-system costs that would be likely to bracket the costs of providing additional out-of-pool spent-fuel storage. Since the specific storage technologies will be selected and managed by individual utilities, the DOE will not control the costs, and costs will not be the sole factor in utility decisions of dry-storage technologies. Thus the unit-cost estimates provided were not intended to be used for comparisons among technologies and, because of differences among technologies in the status of technical development and the lack of site-specific costs, should not be interpreted in this fashion. The cost

estimates for each storage technology are based on estimates provided by the utilities and vendors, primarily as presentations at recent conferences on spent-fuel storage, or from other DOE reports.

Basically a three-step cost-estimating method was used. First, ranges of unit-cost estimates for each storage technology were developed as a function of the site storage-requirement capacity. These unit costs were extracted from estimates available in the current literature. The second step involved developing three ranges of system-wide unit costs as a function of individual-site storage-requirement capacities. The third step was the estimation of the ranges of system-wide total at-reactor storage costs, using the system-wide storage costs and various projections of storage requirements at each individual site.

The methods and assumptions used in estimating the individual storage technology unit costs include the following:

- Cost components were selected from existing cost estimates, mainly from utility and vendor estimates presented at fuelmanagement conferences.
- When several estimates were available and all seemed to be reasonable approximations of the costs, the highest and the lowest were used to bound the range of unit costs for the technology.
- When only one estimate was available and it was provided by a vendor, it was assumed that the estimate is likely to be optimistic, so the reported cost was used as the lower cost bound. The upper bound was assumed to be fractionally higher. The value assumed for the fraction was established to represent the degree of uncertainty expected by the DOE. The use of this assumption is supported by the historical cost estimates for new technologies, which almost always tend to be low initially but increase as more design and engineering information is developed.
- When cost estimates were given, they were used as reported. If labor hours were given, they were costed at an average wage of \$16 per hour, with an overhead rate of 70 percent.
- The weights of single spent-fuel assemblies were assumed to be 460 and 185 kilograms of heavy metal for PWR and BWR assemblies, respectively.

After the basic cost-factor estimates were collected, the costs were divided into estimated fixed and variable costs. Then, a high and a low unit-cost estimate was developed for each technology as a function of storage capacity.

Three ranges of system unit costs were developed and used in projections of the individual-site storage requirements to estimate the total-system cost. The three ranges were selected to represent the technologies that currently exist, technologies that are likely to be developed, and a goal, or optimistic, estimate.

Aggregate system-wide costs for at-reactor storage were then developed by using the three ranges of system-wide unit costs and various projections of individual-site storage-requirement capacities. The storage-requirement projections vary with the assumption of nuclear power growth and with the DOE's spent-fuel acceptance schedule.

With respect to cost uncertainties, cost-uncertainty factors were not typically available for the individual estimates that were used. However, cost uncertainties are illustrated by variations in the reported cost estimates. Cost estimates may vary for several reasons, including differences in accounting practices, vendors' enthusiasm for developing a particular storage technology or willingness to absorb losses for a market entry, significant cost reductions due to advances in technology, and improvements in production methods, which may reduce future production costs.

The combination of these factors produces a significant variation between the highest and the lowest unit costs for a given quantity of spent fuel at a site (typically by a factor of 2) as reported in the initial version of the report. When the estimates are applied in the intended context, the DOE has a high degree of confidence in them; that is, the DOE considers that it is highly unlikely that system-wide average unit costs would be outside the ranges developed.

The report of the Dry Cask Storage Study has been revised to elaborate on the uncertainties in cost estimates.

The timing of expenses for the various storage technologies varies considerably. To address the time value of money, it would be necessary to make assumptions about which technologies would be chosen by the specific utilities requiring additional at-reactor storage over the period of interest. The cost of dry storage was not reported in terms of mills per kilowatt-hour inasmuch as this would vary widely, depending on burnup, the type and the size of the reactor, and the plant factor for the relevant period.

The criticism that the study did not include a comparative analysis, including costs, of at-reactor storage and an MRS facility is addressed in Section B.2.

In response to the comment that, in view of the NRC's published licensing fees, the estimated costs of licensing dry at-reactor storage are too low, it should be noted that the \$405,000 license fee is the maximum fee according to a footnote in the fee schedule published in the Federal Register. The upper bound for the licensing cost was increased from \$600,000 to \$1 million in the report, with the system cost estimates being adjusted accordingly. This resulted in a slight change (on the order of 2 percent) in the estimates of system-wide average unit costs and total costs

All comments on values assumed for specific cost factors were reviewed, and none was considered significant enough to justify costestimate revisions at this time. Some of the comments conflict with each

other; for example, one commenter felt that a cost was too low, while another thought it too high. Under the auspices of the Electric Power Research Institute, the DOE asked for better cost information early in the development of the initial version of the report, and the values used in this report reflect the information received from the utility group. Therefore, no change to the reported cost values (other than the adjustment for higher licensing costs) can be justified by the DOE at present.

It should be emphasized that the information included in this report is intended to estimate the system-wide cost of at-reactor storage, not to provide refined cost estimates to influence a utility's choice of storage technology. More accurate cost estimates should be obtained by the utility at the time decisions on storage technologies must be made.

#### B.9 HEALTH-AND-SAFETY IMPACTS

## Synopsis of comments

The Vermont Department of Public Service (3-1) and the Environmental Defense Fund (24-3) said that more evidence should be presented to support the conclusion that at-reactor storage is safe. In addition, the Environmental Defense Fund (24-3) and the National Association of Regulatory Utility Commissioners (43-7) requested that the health-and-safety impacts of at-reactor storage be compared with those of "early" spentfuel acceptance by, and either storage or disposal within, the Federal waste-management system.

Several commenters, including the State of Vermont (3-6) and Pennsylvania Power & Light (15-3), noted the lack of specific health-and-safety data for particular technologies (consolidation, dual-purpose storage-and-transportation casks, and the dry transfer of spent fuel). Pacific Gas & Electric (14-4) suggested that generic issue 82 in reactor safety, "Beyond Design Basis Accidents in Spent Fuel Pools," should be considered in the context of currently reracked pools.

Several comments suggested clarifications of the text describing the health-and-safety implications of various design features.

### DOE responses

The DOE believes that sufficient supporting information and data are available to conclude that the dry storage of spent fuel presents no undue risks to public health and safety and no significant adverse environmental impacts. The bases for these conclusions, as cited in many places in the report, exist in the dry-storage licensing documentation submitted to the NRC and in the NRC's approval of these documents. A discussion of the bases for the NRC's approval of dry-storage technology would be lengthy and detract from the main objectives of the report. No changes to the text were felt to be warranted.

The DOE also considers that comparisons of the health-and-safety impacts of at-reactor storage with either storage at a centralized fa-

cility like the MRS facility or comparisons between surface storage and repository disposal are not appropriate for the report of the Dry Cask Storage Study because such comparisons are outside the scope of the study as specified by the Amendments Act. Furthermore, the licensing record to date demonstrates that at-reactor storage is safe and does not pose undue risks to the health and safety of the public.

The comment regarding the health-and-safety impacts of dual-purpose casks is accurate in that the report assumes that all necessary reviews are adequately performed. This is not to deny that there remain substantive issues in licensing a dual-purpose cask. As acknowledged in the report (page 75), there are few publicly available documents that address the radiation safety of at-reactor spent-fuel consolidation. The reference cited on page 75 indicates that these impacts are expected to be minimal. Several demonstrations, as detailed in the report, have confirmed this expectation. Although the analyses that would permit a detailed discussion of the health-and-safety impacts of consolidation have not yet been published for these demonstrations, the DOE feels that the basic conclusion that at-reactor spent-fuel consolidation is a safe technology is a valid one.

In regard to generic issue 82, the NRC is considering this issue in terms of past and future reracking efforts. To our knowledge, no resolution of this issue has been developed by the NRC. If the NRC so decides, it could issue requirements to utilities to implement improvements to installed spent-fuel storage racks or place administrative controls on the types and ages of fuel placed in them. At this time, the DOE is not aware of any forthcoming requirements in this area.

The purpose of this study, as stated on page 2 of the initial version of the report, was to consider the costs and the health-and-environmental impacts of expanding at-reactor storage capacity through dry-storage technology. The intended audience for the report is the Congress. As such, the report was not intended to provide a sufficient basis for utility decisions on dry storage. It does, however, state that dry loading at reactor sites has not been licensed by the NRC (pages 29, 31) and that it is likely that site-specific analyses would be necessary to obtain NRC approval of such activities.

#### B.10 LICENSING

### Synopsis of comments

Questions and comments on licensing covered a broad range of concerns about the licensing process and several specific technical issues relevant to licensing. Several of the questions and comments on the licensing process were related to the generic nature of licensing. These issues include opportunities for public participation and the streamlining of the site-specific licensing process.

The State of Wisconsin (5-2) and the Arizona Power Project (38-7) expressed support for NRC initiatives designed to streamline the process

for licensing at-reactor storage. However, Wisconsin and the States of Washington (8-1) and Vermont (3-2) cautioned that such undertakings should not reduce opportunities for public participation in the process. They felt that limitations for public participation could undermine the credibility of the dry-storage option and result in possible delays through litigation.

Two commenters, Pacific Gas & Electric (14-2) and Ebasco Services (30-4), indicated that, even after the storage cask (or other technology) had been approved by the NRC, the effort required to obtain a site-specific license could still be significant.

The issue of licensing jurisdiction was raised by one commenter: the Energy Facility Site Evaluation Council of the State of Washington (8-1) criticized the study for implying that only NRC licensing requirements apply to at-reactor dry storage without recognizing the potential for State or local licensing requirements. The Council felt that at-reactor storage is not an integral part of the reactor complex licensed under 10 CFR Part 50; therefore, it assumed that any dry-storage facility will fall under its regulatory responsibilities and require an amendment to the site certification agreement between the State and the utility. The amendment process requires, by law and rule, that the public be in-volved.

Whether the licensing process requires a determination of "feasibility" (in addition to safety) was questioned by Virginia Power (23-3) and the Utility Nuclear Waste Management Group (33-3).

Several commenters questioned the implied assumption that an inoperative reactor with only in-pool storage would require a license under 10 CFR Part 72. Among these were the Public Service Company of Colorado (18-2), Virginia Power (23-8), and the Utility Nuclear Waste Management Group (33-17). The State of Vermont (3-3) suggested that it is necessary to determine the possible effects on spent-fuel storage of extending reactor operating licenses.

A final process-related issue is that of the licensing cost (see also Section B.8). Pacific Gas & Electric (14-2) noted that NRC approval of the use of a precertified cask may still involve a significant licensing effort and potential intervention in the process.

The Environmental Defense Fund (24-8) questioned the range of costs presented in the report for licensing in-pool consolidation (\$200,000 to \$600,000), because to date the licensing proceedings for these activities have not been contested by formal intervention. This commenter also requested the justification for the cost figures provided and an explanation for why cost estimates were not provided for licensing the dry storage of consolidated rods and hardware.

The comments on technical issues commonly mentioned the specificity of an NRC requirement for criticality control with boron and the general issue of burnup credit as part of the licensing process. Several commenters questioned the specificity of the requirement that a cask be loaded under borated water conditions or that cask baskets include boron. In

this context, Middle South Utilities (12-4), Virginia Power (23-4), and the Utility Nuclear Waste Management Group (33-9) stated that it was not aware of an NRC requirement that a cask be loaded under borated conditions (see first full paragraph on page 29 of the initial version of the report). These commenters maintained that the requirement is more general, as represented in 10 CFR Part 50, Appendix A, Criterion 62 (i.e., preferably criticality is to be prevented by the use of geometrically safe configurations). Pacific Gas & Electric (14-3) recommended that the last sentence in the first paragraph of Section 2.1.1 of the initial version of the report be revised to read "...and adding neutron absorber in the racks or imposing fuel burnup requirements to preclude criticality." The issue of burnup credit was mentioned by the State of Vermont (3-10), Virginia Power (23-5), and the Utility Nuclear Waste Management Group (33-10).

In addition to these comments on the licensing process and specific technical issues, several commenters supplied information on licensing developments since the writing of the initial version of the report.

NUTECH (27-1, 27-3) recommended that the licensing status of all technologies be summarized in the Executive Summary.

#### DOE responses

In response to the provisions of Sections 133 and 218(a) of the Nuclear Waste Policy Act, the NRC has undertaken initiatives designed to streamline the process for licensing dry at-reactor storage of spent fuel. A detailed discussion of these regulatory initiatives and their objectives is provided in Section 2.2 of Part I of this report. In summary, the NRC staff is developing a proposed amendment to 10 CFR Part 72 for consideration by the Commission. This amendment would include a process for the issuance, pursuant to a formal regulatory action, of generic certificates of compliance for dry-storage casks. Moreover. the proposed process would enable a utility with a nuclear-plant license issued under 10 CFR Part 50 to register with the NRC for a general license to store spent fuel at the reactor site in NRC-certified casks, pursuant to conditions specified in the general license. These casks could then be used for spent-fuel storage at the reactor site without further licensing actions. The Part 50 license would constitute evidence of compliance with other regulatory requirements for dry storage. Where opportunities for public participation may be reduced, this is a direct consequence of the requirements of the Nuclear Waste Policy Act.

With regard to the time period required to license a dry-storage system, the licensing of the first dry-storage facility required almost 4 years, and the second licensing required less than 2 years. At present, a licensing period of 1 to 2 years is probably a good estimate. The revised report emphasizes that under current regulations the licensing effort is specific to the technology and to the site.

The DOE acknowledges that at-reactor storage may be subject to State regulations. Any State regulation of dry at-reactor storage would have to be done in a manner consistent with 10 CFR 72.8, which provides that "Agreement States" under the Atomic Energy Act "...may not issue licenses covering the storage of spent fuel in an ISFSI...."

The references to a "feasibility demonstration" as a part of the required content of an ISFSI license applications were deleted.

With regard to licensing costs, the \$405,000 NRC license fee is the maximum fee according to a footnote in the fee schedule published in the rederal Register. The upper-bound licensing cost, which includes this fee and other costs, was increased from \$600,000 to \$1 million in the report, and the system-cost estimates were adjusted accordingly. This adjustment resulted in a change of approximately 2 percent in total cost estimates.

The issue of licensing coverage for sites with inoperative reactors is discussed by the NRC in its comment 45-20 (see Section II.C). The extension of a reactor's operating license should not result in any adverse effects on at-reactor spent-fuel storage.

The DOE agrees with the comments on requirements for boron in pool water and cask baskets. In general, references to boron were replaced with the term "neutron absorber or a safe configuration." The reference to boron was left in the text in specific places because boron is actually used in casks and baskets and is the most widely used neutron poison (see also the NRC's comment 45-12 in Section II.C).

The issue of burnup credit is discussed in Section B.5.1. Several commenters called the DOE's attention to recent developments in the licensing of specific storage technologies. These developments are mentioned in the revised report. Moreover, a summary of the current licensing status of the spent-fuel storage technologies has been developed and is presented in Appendix A in Part I.

## B.11 MISCELLANEOUS COMMENTS AND RESPONSES

A number of the comments either required no response or resulted in minor revisions to the text of the initial version of the report, such as changes in sentence structure or substitution of words. Since these appear to be noncontroversial improvements of the text or the transmission of relevant information, the suggestions in the following comments were adopted and the revisions, as appropriate, have been made:

16-3	18-3	27-14	30-18	30-40
16-5	18-5	27-17	30-22	32-7
16-6	23-2	30-3	30-26	33-6
16-10	26-1	30-5	30-27	33-8
16-20	26-2	30-6	30-30	33-14
16-22	27-2	30-8	. 30-33	33-16
16-25	27-11	30-10	30-35	33-18
17-5	27-12	<b>3</b> 0–15	30-37	38-3
17-6	27-13	30-17	30-39	43-1

Other miscellaneous comments, for which a response is deemed appropriate, are addressed in this section because they did not conveniently fit into the generic categories covered in the preceding comment-and-response sections. Since each comment covers a discrete topic, it was necessary to depart from the format of the preceding sections and provide a specific response for each comment.

#### Comment

The State of Vermont (3-5) said that the study should consider what additional support from in-plant systems, such as cooling and cleanup systems, may be required for in-pool spent-fuel consolidation.

#### Response

These considerations have been investigated in some of the joint utility-vendor demonstrations. Cleanup systems have been incorporated into the fuel-consolidation equipment by some of the organizations participating in these projects. (Table A-1 of Appendix A identifies the participating organizations engaged in the field demonstrations to date.) The DOE is not aware of additional cooling being required for these operations.

#### Comment

The Georgia Public Service Commission (9-7) requested a more comprehensive discussion of transshipment, including licensing considerations. The National Association of Regulatory Utility Commissioners (43-6) recommended that transshipment not be dismissed as a viable storage-expansion option since there are no guarantees against future public opposition to any at-reactor-storage option.

#### Response

This study was conducted in accordance with the provisions of Section 5064 of the Amendments Act, which did not include a requirement for the analysis of the costs and other considerations associated with transshipment. Transshipment was mentioned in the background section of the report for completeness. It may be used in some limited instances to achieve more efficient utilization of existing pool storage capacity on an interim basis, but is not generally available for use by all utilities in meeting their storage needs. The use of the transshipment option obviously does not increase the aggregate spent-fuel-storage capacity at reactor sites. However, where the option can be used, it can provide temporary relief for storage-capacity deficiencies.

#### Comment

The Pacific Gas & Electric Company (14-1) suggested that the Executive Summary (page vi, third paragraph) should emphasize the importance of timely spent-fuel acceptance by the DOE and the impact that any delay will have on at-reactor-storage requirements.

# Response

No change was been made to the report to reflect this comment because the referenced paragraph does emphasize the importance of the timing of waste acceptance by the DOE to additional-storage requirements at reactor sites.

# Comment

Baltimore Gas & Electric (16-9 and 16-13) noted the potential conflict for a utility between the DOE's interest in applying the "oldest-fuel-first" principle in spent-fuel acceptance and utility decisions about loading a drystorage facility.

#### Response

The DOE appreciates this concern and is in the process of clarifying this issue in its discussions with the industry's response team for the Annual Capacity Report.

#### Comment

Virginia Power (23-6) requested additional information on the cost estimates for metal storage casks in Section 4.1.1.4.

#### Response

The commenter is referred to Section B.8 for a discussion of the costestimating methodology used in this report. More specifically, cost factors
were developed from cost estimates provided by vendors, utilities, and other
DOE studies. The lower cost ranges for the metal storage casks are consistent
with most of the sources quoted. The consensus in the reported cost estimates
was that casks will cost less than the DOE's purchase price for the four casks
owned by the DOE; therefore, the high cost estimate was assumed to be equal to
the lowest cost of the four casks.

#### Comment

Virginia Power (23-7) requested that "large capacity increases" (Section 4.1.1.4) be defined in terms of metric tons of heavy metal.

#### Response

In Table 4-1 of the initial version of the report, the variable-cost estimates range from \$54 to \$97 per kilogram of heavy metal, and the fixed-cost estimates range from \$800,000 to \$1 million; the latter estimate was revised to \$1.8 million in the final report. Thus, the total unit cost will range from \$55 to \$100 per kilogram of heavy metal whenever the fixed cost divided by the capacity is about \$1 to \$3 per kilogram of heavy metal. Therefore, large capacity increases would be on the order of 700 to 1,000 metric tons of heavy metal.

#### Comment

The Environmental Defense Fund (24-6) felt that the study "ignored the impacts of public opinion regarding transport of spent nuclear fuel shipment." Furthermore, the EDF objected that the DOE ignored the fact that the public is likely to be against an MRS facility for much the same reason.

#### Response

As explained in Section B.2, the scope of this study did not cover a comparative analysis of spent-fuel storage at reactor sites versus an MRS facility; nor was the study intended to conduct an in-depth analysis of the transportation element of the Federal waste-management system; the study addressed only the potential impacts on transportation arising from the possible extended and expanded at-reactor storage of spent fuel. Also outside the scope of the study was an analysis of public acceptance for each at-reactor storage technology. However, public reaction to, and acceptance of, the Federal waste-management program, including the transportation system, are regarded very seriously by the DOE, as can be seen in such program documents as the Transportation Institutional Plan\* and the Draft 1988 Mission Plan Amendment.\*\*

#### Comment

The Southwest Research and Information Center (25-4) noted that the report concludes that existing technologies are technically feasible, safe, and environmentally acceptable options for storing spent fuel at reactor sites until such time as a Federal facility is available to accept the spent fuel. However, no conclusions are offered on at-reactor storage pending the availability of a geologic repository. The Center asked whether the DOE does not believe that existing storage technologies will be safe until a repository becomes available.

### Response

The DOE does believe that existing storage technologies will be safe until a repository becomes available. This belief is based on the data summarized in Chapter 5 of the report and on the safety evaluations performed for all existing technologies, including storage in spent-fuel pools, by the NRC. In addition, the DOE program plans and schedules provide for the geologic repository to be available in 2003. As discussed in Section B.4, present circumstances preclude the availability of the MRS facility for receiving spent fuel significantly in advance of this date. Hence, the conclusion cited about at-reactor storage of spent fuel with existing technologies being an acceptably safe option until a Federal facility is available

<sup>\*</sup>U.S. Department of Energy, <u>Transportation Institutional Plan</u>, DOE/RW-0094, Washington, D.C., 1986.

<sup>\*\*</sup>U.S. Department of Energy, <u>Draft 1988 Mission Plan Amendment</u>, DOE/RW-0187, Washington, D.C., 1988.

 $_{\mbox{\scriptsize app}}$  lies equally to a situation where the Federal facility is the MRS facility or the geologic repository.

# Comment

The Southwest Research and Information Center (25-5) expressed disappointment that the study did not evaluate a variety of configurations for the overall waste-management system, including at-reactor storage, "from the standpoint of how best to assure quality control, minimize transport, and minimize waste handling." The Center would also like the analysis to cover the extent to which the Nuclear Waste Fund can be used to encourage employment of the optimized system configuration.

# Response

The analyses suggested are beyond the scope of this study. The commenter is referred to Sections B.2 and B.3 for a discussion of how these considerations are being addressed in the DOE program.

#### Comment

In regard to the cost uncertainties mentioned in the report, NUTECH (27-4) noted that the costs of dry storage are much more certain to the utilities because much information is developed in the utility procurement process.

#### Response

Cost uncertainties do exist, not necessarily for an individual utility that has already contracted for a storage system, but for dry storage in general. There are, of course, a number of factors that can contribute to the cost uncertainties, such as variations in the costs of construction and manufacturing, site preparation, and licensing. The costs identified in this report are intended to provide a general price range and are not intended for use by utilities in lieu of the normal procurement process.

#### Comment

NUTECH (27-6) commented that the report should identify those dry-storage systems that have been developed beyond the conceptual design stage. More-over, the report should not include system designs that have not been licensed or developed to the point of a "licensing topical report review."

#### Response

The DOE was charged to evaluate the technology for dry at-reactor storage of spent fuel. Therefore, the study included all methods of dry storage on which information was available.

#### Comment

NUTECH (27-9) stated that water is not a typical candidate neutron-absorbing material in metal storage casks.

#### Response

The DOE agrees, and the text of the report has been changed accordingly.

#### Comment

NUTECH (27-17) suggested that Section 4.5.1.5 should reflect the conclusion that can be drawn from the cost-comparison table in the Executive Summary-namely, that at present the horizontal concrete module represents the most economical dry-storage method.

#### Response

It is not the purpose of this report to tell utilities which is the most economical system for their needs, but rather to provide a basis for assessing the overall technical capability and the cost of providing dry at-reactor storage.

## Comment

Ebasco (30-9) suggested that the first paragraph of Section 2.1 be revised to mention that the 1987 Amendments Act imposed the restriction that the construction of the MRS facility may not begin until the NRC issues a construction authorization for the repository.

#### Response

This revision was not made to avoid complicating the text with information that is available elsewhere.

#### Comment

Ebasco (30-11) suggested citing other DOE publications that provide the same or more-detailed information as that contained in the RW-859 forecasts of spent-fuel discharges.

#### Response

This revision was not made. The information and data provided in the report are deemed adequate for the purposes of the study.

#### Comment

Ebasco (30-12) suggested defining the unit of measure "MTHM" for the general public.

#### Response

This unit of measure is defined where it is initially used in the Executive Summary.

# Comment

Ebasco (30-13) said that some "reason should be given for the use of the RW-859 forecast rather than the EIA upper reference case beyond the year 2013."

# Response

The "reason" cited in the comment was not the reason for selecting the RW-859 forecast. The aggregate RW-859 forecast was used consistently throughout for the sake of uniformity since it is the upper bound over most of the time frame of interest.

# Comment

Ebasco (30-14) suggested adding additional remarks in Section 3.1.2 (page 17 in the Initial Version) to emphasize the reference in the second paragraph to the changes over time in at-reactor storage requirements.

#### Response

The suggested revision is not deemed necessary; the initial text sufficiently highlights the point.

#### Comment

Ebasco (30-23) suggested stating that the reason for the change in the NUHOMS system designed for the H. B. Robinson plant, as discussed in Section 4.1.4.2, was to use the CP&L IF-300 cask.

#### Response

As suggested, the text of the report was revised to clarify the reason for the change.

#### Comment

Ebasco (30-29) noted that the words "without any spacer grids" in the first sentence of the first paragraph in Section 4.2.2 makes the sentence inapplicable to the Maine Yankee consolidation license application, which assumed reorienting the spent-fuel rods in a more closely spaced, simple grid array.

#### Response

The text was revised to indicate that the absence of spacer grids does not apply in all cases.

#### Comment

Ebasco (30-31) cited the reference on page 50, Section 4.2.4, to 688 locations in the Millstone Unit 2 pool authorized for the storage of con-

solidated fuel and asked about the source of this number. It also questioned whether the last sentence in the second complete paragraph on this page prejudges the use of dry storage or other methods for any additional storage that may be needed.

#### Response

The number 688 represents the number of in-pool storage locations required to store the spent fuel that is consolidated pursuant to the Part 50 license amendment submitted by the utility and approved by the NRC. There was no intent in the last sentence to prejudge the option selected by the utility to enhance its at-reactor storage capacity in order to maintain a full-core-reserve storage capability, nor does the sentence appear to do so.

#### Comment

Ebasco (30-32) suggested mentioning in Section 4.3 (last paragraph) that significant savings can be expected in the costs of dry-storage facilities if the fuel that is stored is consolidated.

#### Response

The economics of dry storage for consolidated fuel depends on a number of factors that require clarification through additional field demonstrations. A discussion of this subject, including the identification of the aforementioned economic factors, is provided in Section B.5.5 of Part II.

#### Comment

Ebasco (30-41) felt that the discussion on page 73 of the initial version of the report about radiation doses and the regulatory limits in 10 CFR 72.67 should mention the need to compare the doses resulting from dry storage with those from the operation of the colocated nuclear reactors or other radiation exposures from uranium-fuel-cycle operations in the region.

#### Response

The regulatory limits for the annual dose equivalent received by an individual outside the controlled area are specified in 10 CFR 72.104 rather than 72.67. The regulatory limits for radiation exposures of the public (which were cited on page 73 of the initial version of the report) include any contributions from uranium-fuel-cycle operations within the region. Hence, a revision of the report is not required.

#### Comment

Ebasco (30-42) questioned the statement that non-fuel bearing component canisters will constitute a larger source of gamma rays than a spent-fuel assembly.

# Response

The statement in question is based on work performed for the DOE by the pacific Northwest Laboratory. This work is reported in the following PNL documents:

- A. T. Luksic et al., <u>Spent Fuel Disassembly Hardware and other Non-Fuel-Bearing Components: Characterization, Disposal Cost Estimates, and Proposed Repository Acceptance Requirements, PNL-6046, Pacific Northwest Laboratory, 1986.</u>
- A. T. Luksic, "Characterization of Pressurized Waste Reactor Spent Fuel Hardware," paper presented at the 10th Annual DOE Low-Level Waste Management Conference, Denver, Colorado, August 30-September 1, 1988.
- M. A. McFinnan et al., <u>Performance Testing and Analysis of the TN-24P Cask Loaded with Consolidated Fuel</u>, PNL-6631, Pacific Northwest Laboratory (to be published by the Electric Power Research Institute under the report number EPRI NP-6191).

#### Comment

Ebasco (30-44, 30-45) recommended that Section 6.1 of the report mention the DOE's contract with the utilities to start accepting fuel by January 31, 1998; it should also address the question of whether the Nuclear Waste Fund can be used for post-1998 at-reactor storage. Moreover, Ebasco said that the DOE's expression of willingness in Section 6.2 to consider support for at-reactor storage options and the systems-integration studies cited should be referenced.

#### Response

The start of waste acceptance and the use of the Nuclear Waste Fund are discussed in Sections B.4 and B.3, respectively. The systems-integration studies cited are in progress, and therefore no references are yet available. As discussed in the preamble to the standard contract for the disposal of spent fuel, the DOE recognized that certain credits for specific utility actions may become appropriate. At that time, the DOE deferred establishing a policy on issuing credits for any activities. The DOE remains willing to consider possibilities for providing credits when significant savings to the Nuclear Waste Fund are demonstrated.

# Comment

Chem-Nuclear Systems, Inc. (31-1) requested that the next version of this report include a description of a storage concept, the Castor V/12 cask, that it has developed.

### Response

The DOE both recognizes and applauds the efforts of vendors to make new and innovative alternatives available for utilities to meet their future

spent-fuel storage needs. It also recognizes that other such alternatives are likely to be introduced from time to time in the future. However, there is no time to obtain the information necessary for evaluating the cost, licensing considerations, and development status of the Castor V/12 concept and to properly integrate the information into the current study report, which is in the final review stage before issuance. The DOE will continue to monitor progress on the development and application of the Castor V/12 and other storage technologies that may subsequently become available and will include an analysis of such technologies in future reports that are issued by the DOE on atreactor storage, as appropriate at the time.

#### Comment

The B & W Fuel Company (32-10) questioned the conclusion that the use of horizontal concrete systems will have no effect on transportation, pointing out that the utility will have to unload the spent fuel back into the pool for transfer to the transportation cask or have the dry shielded canisters designed for direct loading into the transportation cask.

#### Response

The conclusion in the report was based on in-pool unloading of the dry shielded storage canisters and spent-fuel transfer to a transportation cask. Although this operation requires fuel handling at the reactor site, it has virtually no effect on transportation. The DOE is studying the potential impacts of transporting the dry shielded storage canisters in the Federal waste-management system. Preliminary results indicate that the receipt of spent fuel in canisters containing 21 to 24 PWR assemblies would have little impact on transportation from the reactor. However, the use of lower-capacity canisters would have some impacts, and these impacts would increase with decreasing canister capacity.

#### Comment

The B & W Fuel Company (32-11) noted that the discussion of dual-purpose casks in Section 5.3.1 did not state the assumptions for a life-cycle cost analysis.

#### Response

The total savings in life-cycle cost for transporting spent fuel does not include any added costs that utilities experience in connection with the use of dual-purpose casks. Moreover, transportation casks were assumed to have the same payload capacity as dual-purpose casks.

#### Comment

The Utility Nuclear Waste Management Group (33-2) asked what destination or destinations were assumed, the MRS facility or the repository, in evaluating the potential effects of the various at-reactor-storage options on transportation.

# Response

The study was undertaken, in accordance with the requirements of the Amendments Act, to evaluate the potential effects of at-reactor storage on the costs or risks of transporting spent fuel to a central waste-management facility, such as an MRS facility. The study, therefore, involved an examination of the potential additional impacts of possible expanded and extended dry at-reactor storage on the transportation element of the Federal wastemanagement system. The destination assumed for the shipments—an MRS facility or the repository—has no relevance for the purpose of this study.

# Comment

The Utility Nuclear Waste Management Group (33-5) noted that the practice is generally to store spent fuel in the reactor pool for as many as 5 years before transferring it to dry-storage facilities, not 1 year.

# Response

The text (paragraph 4 on page 10 of the initial version of the report) is not in conflict with this observation. Hence, no change was made to the report.

#### Comment

The Utility Nuclear Waste Management Group (33-7) observed that the issue of land-use requirements for the various dry at-reactor storage optons was not addressed in the report. Estimates of land-use requirements would be useful.

#### Response

The report has been revised to indicate typical land areas needed to accommodate the generic dry-storage technologies covered in the study. It is also noted that, in addition to the land areas actually used for the dry-storage technologies, it may be necessary to take into account the site-specific land-use policies of individual utilities or the land-use regulations of local jurisdictions.

#### Comment

The U.S. Committee for Energy Awareness (34-1) recommended that the study provide additional consideration of the integration of at-reactor storage with the DOE's transportation program for spent fuel, thereby enabling the utilities to plan an at-reactor-storage facility for compatibility with the DOE transportation casks.

### Response

The question of optimizing the compatibility of at-reactor spent-fuel management with the Federal waste-management system is discussed in Section C, in reponse to comment 45-1 from the NRC.

#### Comment

Mr. Frank Clements (35-1) provided 10 reasons why he feels the report's assumption that the geologic repository will be in operation by 2003 is weak.

#### Response

The views expressed on this subject are appreciated; however, an evaluation of the considerations and the probability that the repository will be available by 2003 is not within the scope of this study. As discussed in the Draft 1988 Mission Plan Amendment, the DOE's integrated schedule for the waste-management system shows the repository starting waste acceptance in 2003; hence, it was the logical choice for the reference case used in this study. Other dates were also assumed in the study for the purpose of a sensitivity analysis to reflect the potential impacts of delays in the availability of Federal facilities on requirements for additional at-reactor storage.

#### Comment

Mr. Frank Clements (35-2) noted that the study did not consider alternatives to the current geologic repository program for the disposal of spent fuel, such as reprocessing to remove the plutonium or at-reactor entombment.

#### Response

The objectives of the study did not include comparative evaluations of alternatives to the geologic disposal of spent fuel. However, it should be noted that spent-fuel reprocessing results in high-level-waste streams that must be managed and disposed of by technologies providing permanent isolation for the long-lived radionuclides from the human environment. A portion of the waste destined for disposal in the geologic repository was generated from reprocessing irradiated reactor fuel to remove plutonium and uranium residuals.

#### Comment

The Arizona Nuclear Power Project (38-1, 38-11) stated that it must be assured that the DOE will develop transportation casks that can handle its fuel.

#### Response

The DOE has a major program under way to provide on a timely basis the fleet of transportation casks necessary to discharge its transportation responsibilities under the Nuclear Waste Policy Act. A more extensive discussion of this issue is provided in response to comments in Section B.6.

#### Comment

The Arizona Nuclear Power Project (38-6) encouraged the development of standard methods to verify fuel burnup.

#### Response

In February 1988, the DOE sponsored a two-day workshop on fuel-burnup credit. At this workshop the development efforts of both industry and the DOE were reviewed and discussed. These efforts are ongoing.

#### Comment

The National Association of Regulatory Utility Commissioners (43-3) stated that the Study reflects the fact that an integrated disposal system has not yet been developed. The Association cited the potential cost savings and safety benefits resulting from system integration and standardization and noted that the success of such an approach will depend on close cooperation between the DOE and the utilities in the further development of at-reactor storage facilities.

#### Response

Compatibility between the spent-fuel management systems of the utilities and the Federal waste-management system and the mechanisms for addressing this compatibility are discussed in Section C in response to NRC comment 45-1.

#### Comment

The New York Public Service Commission (44-3) suggested that the DOE investigate the possibility of disposing of a portion of the non-fuel-bearing hardware from rod consolidation as low-level radioactive waste, thereby increasing pool storage capacity for spent fuel.

#### Response

The type of disposal (and the associated degree of isolation from the human environment) that is acceptable for the various categories of radio-active waste is ultimately determined by the NRC in the licensing process. For radioactive wastes to qualify for disposal in near-surface land disposal facilities (the currently licensed commercial facilities for the disposal of low-level waste (LLW)), the concentrations of the radionuclides contained in the waste must fall within the limits set forth in Tables 1 and 2 of 10 CFR Part 61. Thus, in terms of regulatory requirements, any non-fuel-bearing hardware resulting from spent-fuel consolidation would be eligible for disposal in commercial LLW disposal facilities if it complies with the requirements of 10 CFR Part 61 and meets the acceptance criteria (e.g., waste form and packaging) of the disposal facility. However, most non-fuel-bearing components of a fuel assembly with nominal irradiation exceed the limits established in Part 61 and therefore do not qualify for disposal in LLW disposal facilities.

Low-level wastes with radionuclide concentrations exceeding the limits in Part 61 for Class C low-level wastes are referred to as "greater-than-class C waste" and require disposal in a system affording greater confinement (iso-lation) than that provided by the LLW disposal technologies currently in use, but not necessarily the degree of isolation provided by a geologic reposi-

tory. The non-fuel-bearing hardware would normally be classified as greater-than-class C waste unless the spent-fuel assembly from which it came had a below-normal irradiation history, resulting in reduced concentrations of radionuclides (activation products) in the hardware.

There are currently no disposal facilities for commercial greater-than-class-C wastes. The DOE is charged under the Low-Level Radioactive Waste Policy Act to ensure the safe disposal of these wastes. Hence, under the present circumstances, the national strategy for the disposal of greater-than-class C waste will be decided by DOE policy. The DOE can either develop and license a disposal facility with "greater confinement" technologies (sometimes referred to as "alternative technologies"), or it can elect to emplace these wastes in the geologic repository.

The Federal policy is to accept the non-fuel-bearing components removed during consolidation. In other words, if the non-fuel-bearing components were an integral part of the intact fuel assemblies and would be accepted under the standard contract without consolidation, then the DOE will accept such components although they have been removed from the assembly during consolidation. However, a utility is free to dispose of its non-fuel-bearing components as low-level waste if this waste can meet the regulatory qualifications for Class C waste. If it does not qualify as Class C low-level waste, the waste will be classified as greater-than-class-C low-level waste, for which the DOE is responsible for ensuring safe disposal. Under the standard contract, the utility can also deliver the non-fuel-bearing waste resulting from consolidation to the DOE for disposal in the geologic repository.

#### Comment

The New York Public Service Commission (44-4) observed that eventually at-reactor storage casks will have to be decontaminated and decommissioned; therefore, the cost for these activities should be presented.

#### Response

The decontamination of storage casks should be straighforward under normal operations and relatively inexpensive for either metal or concrete metal-lined storage casks. However, when the cask is no longer used for storage and is ready for decommissioning and disposal, it is likely that the storage cask will be used as a disposal package for other wastes, which would save some disposal costs. Moreover, a cost estimate today for the decommissioning and disposal of a storage cask a couple of decades or so in the future is of little utility. The disposal will undoubtedly be in regional or State LLW facilities that are to be established in the future; the disposal-fee schedules for these facilities are unknown at present.

#### Comment

Ebasco (30-7) felt that the third sentence in the second paragraph on page 7 is misleading in that it can be interpreted that the Standard Review Plan imposes a regulatory requirement for reactor storage pools to maintain an ability to receive one full reactor core and the maximum quantity of spent

fuel discharged in one fueling cycle. Ebasco noted that several reactors have already lost the full-core-reserve capacity in their storage pools.

#### Response

After reviewing the cited sentence, the DOE feels that the sentence is appropriate, and hence no revisions were made to the text.

#### Comment

Ebasco (30-36) recommended revising Section 4.5.1.3 on page 56 of the initial version of the report to reflect the following: when comparing the current rates at which spent fuel can be prepared for storage with the rates for in-pool consolidation, the DOE should use the total time required for cask loading and handling plus placing the spent fuel in storage at the dry-storage facility.

#### Response

The cited text was focused on the current time requirements for performing in-pool operations. These operations are normally the most critical from a scheduling standpoint. It is likely that the operations performed after the in-pool work will have greater scheduling flexibility.

The DOE accepted the suggestion to replace the term "fuel-handling cranes" with "cask-handling cranes" in this section of the report.

#### Comment

Ebasco (30-38) felt that the second sentence in Section 4.5.3 on page 58 of the initial version of the report, which seems to imply that large storage requirements may favor consolidation, contradicts the statement in Section 4.2.5 that 350 MTEM is essentially the maximum quantity of additional storage that can be accommodated for a pool.

#### Response

The referenced sentence in the summary section on page 58 of the initial version of the report was not intended to depict dry-storage technologies and rod consolidation as mutually exclusive options. There may be situations that favor, for economic or other reasons, the use of rod consolidation for inpool storage or for dry storage or for combinations of the two. Therefore, the cited statements in Sections 4.5.3 and 4.2.5 are not considered contradictory.

#### Comment

The Public Service Company of Colorado (18-1) noted that it would be helpful if the report provided any available information about the dry cask storage of spent fuel from high-temperature gas-cooled reactors.

#### Response

The generic spent-fuel-storage technologies discussed in the report should be applicable to spent fuel from high-temperature gas-cooled reactors (HTGRs). Because HTGR spent fuel differs from the fuel discharged from light-water reactors, it may be necessary to modify some specifications for the storage facilities. The commercial organizations that have been involved in the development and marketing of the dry-storage technologies should be able to provide useful information about specific applications. Some of the dry-storage experience in other countries, described in Chapter 4 of the report, such as the use of concrete modular vaults in the United Kingdom and metal casks in the Federal Republic of Germany, is related to the storage of spent fuel from gas-cooled reactors.

#### Comment

The Gesellschaft fuer Nuklear Service (28-2) noted that the ventilated concrete casks and the horizontal concrete modules (the NUHOMS concept) apparently do not have inlet or outlet filters for the passive cooling system, and the lack of filters may allow the entrance of insects or animals, which may result in a plugging up of the ducts and potential thermal overloads.

#### Response

Although filters are not provided for the passive cooling system of the horizontal concrete module, wire-mesh screens do cover the inlet and outlet openings of the cooling system to prevent entry by birds or rodents. This consideration did not represent a concern to the NRC in its review and approval of this storage technology. Moreover, the NRC looked at other possible events with the potential for disrupting the performance of the passive cooling system and determined that the thermal overloads that might result from such events do not represent a health-and-safety concern.

#### Comment

The Gesellschaft fuer Nuklear Service (28-3) cited several additional demonstrations that have been conducted outside the United States for the dry storage of different types of spent-fuel assemblies in various versions of the Castor metal casks. These were suggested as additions to the discussion, in Section 4.4.1, of the cask tests and demonstrations in the Federal Republic of Germany.

#### Response

The comment provided no information about the objectives or the results of the tests or demonstrations, and hence the suggested additions were not made. However, for the benefit of those who may have an interest in exploring this matter further, the demonstrations cited in the comment are listed below.

 The Castor-AVR cask has been loaded high-temperature-reactor fuel since 1983.

- Four Castor KRB-MOX casks were loaded with BWR mixed-oxide fuel for one year (1986-1987).
- The Castor WWER 1000 cask was used in 1984 for a storage demonstration at the Voronesh power station in the Soviet Union.

#### Comment

The State of Nebraska (46-1) suggested that the effect of temperature on the concrete needs to be evaluated, especially since there is concern that the structural integrity of the cask cannot be maintained. If so, this could result in a breach of the cask during movement or handling, leading to substantial radiation exposure of personnel. There is also some question as to whether the integrity of the spent would be maintained. This would depend on the extent and the type of cask deterioration from thermal interactions.

#### Response

Normally, concrete casks are designed to maintain temperatures within the limits specified in Standard 359-86 of the American Concrete Institute (ACI). The allowable temperatures specified in this standard are 160°F for bulk concrete with nuclear heating and 250°F for local hot spots during long-term normal operations.

The effects of mildly elevated temperatures on concrete in dry-storage systems are being evaluated in Canada and the United States. In Canada, concrete casks have been used for more than 10 years. Evaluations of concrete performance have been conducted and will continue to be conducted in tests on concrete integrated casks (see Section 4.4.3).

In the United States, spent fuel will soon be loaded in horizontal concrete modules at the dry-storage facility of the H. B. Robinson nuclear power plant. The concrete in the modules will be inspected over time to verify that no degradation is occurring from the mildly elevated temperatures.

The DOE, in cooperation with the private sector, is planning to conduct in 1990 performance tests (heat transfer and shielding) on one or two concrete casks. As part of these tests, temperature instrumentation will be installed in the cask walls to monitor any changes in the thermal properties of the concrete. If there are indications of property changes, samples of the concrete in the walls of the test casks may be taken to determine the condition of the concrete.

Because the steel liners used in concrete casks maintain the structural integrity of the casks, deterioration of the concrete should not lead to a breach of containment. If the concrete deteriorated to the point that its shielding capabilities were reduced, the radiation dose rates at the surface of the cask would increase. Substantial exposure of personnel would not be expected because this process is likely to be a slowly occurring process rather than a breach. However, the concrete is not expected to deteriorate at mildly elevated temperatures meeting ACI Standard 359-86.

Most concrete-cask designs have sealed stainless-steel baskets or canisters in which the spent fuel is stored. Because the sealing of these baskets does not depend on the concrete, the performance of the concrete does not affect the integrity of the spent fuel. The integrity of the spent fuel depends largely on the temperature and the cover gas in which the fuel is stored. Since the steel canister is sealed, the cover gas will remain at its original purity level.

#### Comment

The State of Nebraska (46-2) expressed concern as to whether the integrity of concrete casks can be maintained when the cask is used for transportation after extended storage. This concern stems from possible thermal effects on the concrete and also the potential effects of handling, moving, and shifting the cask. Nebraska questioned whether a concrete cask could withstand a transportation accident "with only minimal, or preferably no, loss of material."

#### Response

Concrete casks are not being considered for dual-purpose storage-andtransportation service. Only metal casks would be used for this application.

#### Comment

The State of Nebraska (46-3) observed that, since there appears to be more than one method for handling and loading the casks with the spent fuel, the possibility of an accident increases significantly in relationship to the number of times the material is handled.

#### Response

The utilities and the DOE have undertaken a dialogue designed to enhance the compatibility of the spent-fuel management systems at reactors and in the Federal sector. One of the objectives of this process is to minimize the cost and the health-and-safety impacts associated with the waste-acceptance interface between at-reactor storage and the Federal waste-management system. An obvious target benefit from these efforts would be to minimize the number of spent-fuel-handling steps associated with cask loading and unloading. This topic is discussed in greater detail in the response to the NRC's comment 45-1 in Section C.

#### . C. NRC COMMENTS AND DOE RESPONSES

This section presents the comments submitted on the Dry Cask Storage Study report by the U.S. Nuclear Regulatory Commission (NRC). All of the NRC comments are presented individually, and each is followed by a DOE response. The complete set of NRC comments can be seen in the NRC's letter, which is reproduced in Part III as comment letter 45.

#### NRC comment 45-1

The Commission is concerned, that inadequate attention is being given to ensure the compatibility of the various steps in the storage, transport, and disposal of spent fuel and thereby enhance the safety and efficiency of fuel handling. With a proliferation of storage options, it appears likely that fuel to be removed from reactor sites in some instances may have to be returned to reactor pools to be unloaded from storage canisters and then loaded into transportation casks for shipment off site. In addition, subsequent operations at the repository, or a monitored retrievable storage site, may be needed to repackage the fuel for ultimate disposal. The Commission believes that radiation exposures and other handling risks should be minimized in the entire process from removing the fuel from the reactor pool the first time to its ultimate disposal. System analysis and action at this early stage could result in minimizing these handling risks, and the Commission suggests that the DOE proceed on this course of analysis and action to achieve cask design compatibility to the greatest extent possible.

#### DOE response

The storage, handling, transport, and disposal of spent nuclear fuel will involve actions by both utilities and the Federal Government. The DOE agrees that these activities should be coordinated to enhance the safety and efficiency of spent-fuel management and plans to increase its efforts to ensure that this coordination takes place. This need has already been recognized by both the DOE and the nuclear utilities, and elements of this general coordination issue have been identified as topics to be addressed through the process for resolving issues concerning the standard contract for the disposal of spent fuel. This contract establishes, among other things, the contractual terms and conditions for the waste-acceptance process. The issue-resolution process associated with the contract is a mechanism for identifying and ultimately overcoming obstacles to the effective and efficient implementation of the contract. The issue-resolution process was described in the June 1988 issue of the Annual Capacity Report\* and is commonly referred to as the "ACR issue-resolution process."

<sup>\*</sup>U.S. Department of Energy, Annual Capacity Report, DOE/RW-0146, Washington, D.C., 1988.

The DOE intends to discuss with the utilities, at the next meeting in the ACR issue-resolution process, the general coordination issue that the NRC has raised, to identify opportunities for, and the timing of, steps to address any coordination elements that are not already being addressed. Any elements of the general coordination issue that are not appropriate for resolution through the ACR issue-resolution process will be taken up separately by the DOE, working with the utilities, under the auspices of the Edison Electric Institute's Utility Nuclear Waste and Transportation Program (successor to the separate Utility Nuclear Waste Management Group and the Nuclear Transportation Group).

In discussing this issue, it should be recognized that the Nuclear Waste Policy Act of 1982 (NWPA) assigns the nuclear utilities the primary responsibility to provide for, and the responsibility to pay the costs of, the interim storage of spent fuel until the fuel is accepted by the DOE. Furthermore, the NWPA does not authorize the DOE to regulate how the utilities meet their spent-fuel storage requirements unless the utilities' activities affect their obligations under the standard contract for the disposal of spent fuel. Furthermore, in certain areas, as explained below, it could be detrimental to the Federal waste-management system to attempt to influence the utility actions prematurely. Accordingly, the DOE believes that the coordination of at-reactor spent-fuel-storage activities with the Federal waste-management system should be pursued through a combination of DOE/utility discussions through the ACR issue-resolution process and DOE-facilitated voluntary efforts of the utilities involved. Furthermore, such activities should be conducted in a deliberate manner whose pace is determined with consideration given to the downstream impacts of the coordination decisions on the entire Federal waste-management system.

In considering the appropriate steps and pace of activities to use in addressing this coordination issue, the following points should be kept in mind:

- 1. As of the year 2003, approximately 80 percent of all spent fuel that has been discharged will still be in storage in the utilities' storage pools. Only the 20 percent that will have been moved into other storage mechanisms might be affected by efforts to increase coordination.
- 2. Over the next 5 years (1989-1993), only about 930 MTHM of spent fuel in excess of the projected pool capacity will be discharged. If this fuel is handled in a less than optimum fashion with respect to integration with the Federal waste-management system, it will still constitute less than 2 percent of the approximately 50,000 MTHM of fuel projected to be discharged through 2003 and an even smaller percentage of the total fuel destined for disposal. Thus, the DOE and the utilities have several years in which to develop the mechanisms to be used for coordinating at-reactor spent-fuel storage with the Federal waste-management system and still have these mechanisms in place in time to be used for the great majority of the spent fuel to be discharged and stored outside the reactor spent-fuel storage pools.

This point is illustrated graphically in Figures C-1 and C-2, including data on the cumulative amount of spent fuel projected to be discharged from 1985 to 2020, for the projected cumulative out-of-pool spent-fuel-storage requirements assuming that the repository opens in 2003, and for the projected cumulative out-of-pool spent-fuel-storage requirements assuming no repository operations through 2020.

- 3. Since the DOE has only begun to characterize a proposed repository site in detail, it is still several years away from being able to specify the characteristics of the repository waste package. The waste-package requirements and designs will determine items such as materials selections and quantities, physical configurations, and disposal-package heat and radiation limits. Hasty action taken by the DOE at this time could easily result in the selection of standard requirements that, while they might result in more nearly optimum front-end handling of the relatively small amounts of spent fuel to be moved into dry storage in the near term, might be incompatible with the final waste-package requirements or might be decidedly nonoptimum for the much larger amount of spent fuel to be discharged over the long run.
- 4. All of the mechanisms now being pursued by the utilities ensure that the minimum required level of compatibility is maintained. This is accomplished by retaining the capability to return the spent-fuel assemblies to the spent-fuel storage pool, thus allowing them to be transferred to the Federal waste-management system as if they had never been placed in dry at-reactor storage to begin with.

In recognition of these facts, the DOE considers that, although the coordination issue in general should be pursued as expeditiously as possible, certain of the coordination efforts may have to be paced to incorporate the requirements stemming from the final waste-package design or other design specifications. Clearly, the better defined the Federal waste-management system, the more productive these coordination efforts will be. In addition, all of the coordination activities must weigh the cost and impact of the restraints implicit in the coordination versus the benefits that can be obtained.

As described in the body of the Dry Cask Storage Study, several different types of technologies for expanding at-reactor storage are in various stages of development. No single technology is likely to meet the requirements of all of the utilities. Furthermore, the utilities believe that they need to retain the flexibility to choose the option that best suits their requirements while choosing systems that incorporate compatibility elements that are jointly developed on the basis of system requirements.

As more information is obtained concerning which of the spent-fuelstorage technologies will be needed to fulfill utilities needs, it will be appropriate and natural to consider certain features or interfaces within each of the technology categories for compatibility with the Federal waste-

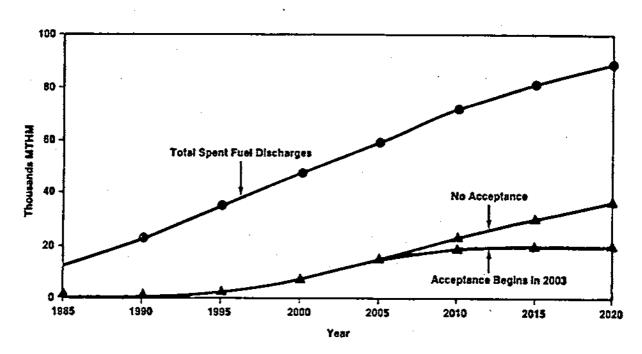


Figure C-1. Cumulative spent fuel discharges and cumulative storage requirements (Aggregate RW-859 forecast).

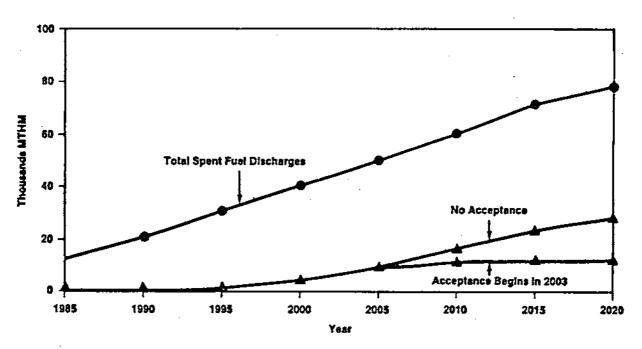


Figure C-2. Cumulative spent fuel discharges and cumulative storage requirements (EIA no-new-orders case).

management system. These features or interfaces could include items such as dimensions, weights, payloads, materials, heat and radiation limits, and handling features.

The compatible elements of each of the major types of technology can then serve as focal points for combined Federal and utility efforts to ensure that the various technologies interface satisfactorily with the Federal wastemanagement system. Such a process will allow those items of the spent-fuelmanagement system that can be designed to be compatible in the near term to be so handled. However, it will also provide time prior to the design of the storage mechanisms to be used for the majority of the spent fuel, and that could affect the downstream elements of the Federal waste-management system, to allow the MRS issues to be resolved, more experience to be obtained with the various at-reactor storage technologies, and the waste-package requirements to become better defined.

In the meantime, prior to any coordination activities, the DOE's near-term shipping-cask designs will be oriented toward the development of the basic designs needed to ship the bulk of the spent fuel (i.e., the 80 percent of the spent fuel that consists of intact spent-fuel assemblies stored in water-filled pools). The DOE's longer term shipping-cask design efforts will consider modifications of these basic designs to maximize the efficiency of handling as much of the remaining 20 percent of the spent fuel as possible, primarily the portion whose storage incorporates the compatibility features discussed above.

Finally, the DOE will separately consider how to handle any spent fuel whose storage mechanisms do not comply with the compatible techniques established in cooperation with the utility industry, recognizing that such fuel may be subject to delayed acceptance under the terms of the standard disposal contract.

#### NRC comment 45-2

With reference to the paragraph beginning at the bottom of page vii and continuing on page viii, the NRC notes that while topical reports have been referenced in dry storage licensing, there is no requirement to do so. A license applicant could simply submit a new design detailed in the Safety Analysis Report that is submitted as part of the site-specific license application.

#### DOE response

The text in question has been revised in accordance with the comment.

#### NRC comment 45-3

Concerning the first full paragraph and sixth full paragraph of pages viii and 13, respectively, a utility would not apply for a general license to store spent fuel in NRC-certified casks under the proposed amendment to 10 CFR Part 72. The utility would, instead, register with the NRC to use a certified cask, thus committing to the specific conditions of the general license.

#### DOE response

The two paragraphs in question have been revised in accordance with the comment.

#### NRC comment 45-4

Insert the following underlined wording at the end of the first sentence, fourth full paragraph, page viii: "...for dry storage in that dry storage involves a new license under 10 CFR Part 72, while consolidation where it increases the number of assemblies permitted to be stored in the pool involves an amendment to the 10 CFR Part 50 license. To the extent that utilities have consolidated spent fuel rods as a demonstration, they have performed these limited consolidations under 10 CFR 50.59. First of all...."

#### DOE response

The text has been revised as recommended.

#### NRC comment 45-5

In the third sentence of the first full paragraph on page x, the words "for at least 30 years beyond the expiration of the operating license" refer also to reactor-pool storage.

#### DOE response

The text has been revised as recommended.

#### NRC comment 45-6

Delete the last sentence from the partial paragraph at the top of page 9. Also, revise the second sentence in the first full paragraph on page 9 by incorporating the underlined words as follows: "...all spent fuel storage pools where an evaluation shows that the pool can support the additional weight...."

#### DOE response

These proposed revisions to page 9 of the report have been made.

#### NRC comment 45-7

Note that 10 CFR Part 72 has been recently amended (<u>Federal Register</u>, Vol. 53, p. 31651, August 19, 1988), and this Part is now entitled "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste." This change in title should be reflected in the fourth paragraph of page 11.

#### DOE response

The text has been revised as recommended.

# NRC comment 45-8

Delete the last paragraph on page 11 and top of page 12 and replace it with the following paragraph:

Consolidation where it increases the number of assemblies permitted to be stored in the spent fuel pool involves an amendment to the 10 CFR Part 50 license. To the extent that utilities have consolidated limited numbers of spent fuel rods as a demonstration, they have performed these consolidation programs under 10 CFR 50.59.

#### DOE response

This proposed revision has been made.

#### NRC comment 45-9

In connection with the second full paragraph of the page 12, NRC points out, as was done earlier in comment 45-2, that a topical report on a specific dry storage technology is not required by regulation to be submitted for NRC review and approval prior to applying for a license under Part 72 for a storage facility employing that technology.

#### DOE response

The cited paragraph has been revised to clarify this point about the regulatory requirements.

#### NRC comment 45-10

The first sentence in the third full paragraph on page 13 should be revised to read "Consistent with this objective, the NRC staff is currently developing a proposed rule for consideration by the Commission which would amend 10 CFR Part 72 to provide a process for the issuance of..." (A similar revision has been made to the first sentence in the first full paragraph on page viii.)

#### DOE response

The proposed revision has been made.

#### NRC comment 45-11

The first sentence of the fourth full paragraph on page 13 should be revised to read "The proposal under development envisions an amendment to 10 CFR Part 72 to specify the following process..."

#### DOE response

The proposed revision has been made.

#### NRC comment 45-12

The first sentence of the first full paragraph on page 29 concerning cask loading in the storage pool and boron is incorrect. Nuclear criticality analyses to date have not taken credit for the presence of boron in the water.

#### DOE response

This observation has also been made by others (see, for example, comment 12-40) and responded to in Section B.10. The response is consistent with the correction recommended by the NRC.

#### NRC comment 45-13

Gesellschaft fuer Nuklear Service mbH is improperly identified in Section 4.1.1.2, paragraph 3 on page 30, and in Section 4.1.2.3, paragraph 1 on page 34. This should read General Nuclear Systems, Inc. (the U.S. partnership).

#### DOE response

The proposed changes in the text of the report have been made.

#### NRC comment 45-14

The first paragraph in Section 4.1.2.3 (page 35) should note that the technical review panel set up by the NRC to investigate the acceptability of nodular cast iron for transportation casks has been completed. It was concluded that nodular cast iron should not be used as the primary structural material in spent fuel shipping casks based on the material properties and available information at this time.

#### DOE response

The text of the report has been revised and updated to reflect the new developments cited in the comments.

#### NRC comment 45-15

The first sentence, paragraph 2 of Section 4.1.4.2 on page 41 should cite the topical report rather than the topical safety analysis report.

#### DOE response

This change has been made throughout the text of the report.

#### NRC comment 45-16

The first sentence in the second paragraph on page 47 should be revised to read "...with rod consolidation are primarily economic in nature. They include the difficulties...."

#### DOE response

This sentence has been revised to reflect the comment.

#### NRC comment 45-17

The first two sentences in the second full paragraph on page 49 should be deleted and replaced with the following sentences:

As explained in chapter 2, consolidation where it increases the number of assemblies permitted to be stored in the spent fuel pool involves an amendment to the 10 CFR Part 50 license. To the extent that utilities have consolidated rods as a demonstration, they have performed these limited consolidation under 10 CFR 50.59.

#### DOE response

The proposed revision has been made to the report text.

#### NRC comment 45-18

Delete the words "local or" in the third sentence of the third full paragraph on page 49.

#### DOE response

This deletion has been made.

#### NRC comment 45-19

Delete "1993-1994" in the fourth sentence of the second full paragraph on page 50 and insert in its place "1997."

#### DOE response

This revision has been made in the report.

#### NRC comment 45-20

With respect to the first paragraph on page 72, the reactor operating license may be amended at the end of the plant operating life. Thus, spent fuel may be stored in the reactor pool under a "possession only" license pursuant to 10 CFR Part 50. The reactor license cannot be terminated until the reactor is decommissioned. To fully decommission the reactor, all spent fuel must be removed from the site.

#### DOE response

The referenced paragraph in the initial version of the study report has been deleted. It is replaced by a paragraph reflecting the substance of NRC comment 45-20.

#### D. INDEX OF COMMENTS AND RESPONSES

This section presents the index of comments and responses. The index gives the identifying number assigned to each comment letter, the identifying number assigned to each comment, and the subsection in Section B where the comment is addressed. The comment letters are reproduced in full in Part III.

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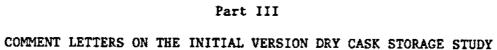
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# United States Senate

WASHINGTON, DC 20510

October 27, 1988

The Honorable John S. Herrington secretary Department of Energy 1000 Independence Ave., NW Washington, D.C. 20585

Dear Mr. Secretary:

I am writing to comment on the initial version of the Department of Energy's (DOE) Dry Cask Storage Study, which was requested by Congress as part of the Nuclear Waste.Policy Act (NWPA) Amendments of 1987 (Public Law 100-203). This study could play an important role in the development of a national strategy for nuclear waste disposal in the United States.

By including the Dry Cask-Storage Study in the 1987 NWPA Amendments, I believe Congress recognized the need for the nation to examine alternative options for the our nuclear waste disposal management program in the context of persistent concerns about the costs, safety and impacts of the federal government's program to manage the disposal of nuclear waste. The Dry Cask Storage Study was requested to help provide Congress and others with information about at-reactor dry cask storage as one of those options.

In addition, this information could be essential to the Monitored Retrievable Storage Commission's mandate to evaluate the need for a monitored retrievable storage (MRS) facility. In particular, this study could provide the commission with information about the cost-effectiveness and safety of dry cask storage of spent nuclear fuel as an alternative to a MRS facility. Unfortunately, due to certain assumptions made in the initial version of the report, I fear that the report may not provide the commission, the Congress and the public with a complete picture of dry cask storage as an option.

First, I am concerned that the initial study does not provide an accurate comparison of the costs of at-reactor dry cask storage in relation to several scenarios explored in the study that involve the siting of an MRS facility. In the reference case for at-reactor dry cask storage, all of the costs of a pre-repository storage system are considered. However, the study's examination of the costs of at-reactor storage under alternative spent-fuel-acceptance schedules at a MRS facility do not include the total pre-repository costs. The costs associated with the siting, development, licensing and transportation to and operation of a MRS facility are simply excluded from analysis. In order for the MRS review commission and Congress to evaluate the need for and alternatives to an MRS, the full costs of an at-reactor dry cask storage system must be weighed against a system that requires additional at-reactor storage and a MRS facility. A more thorough examination of costs of the alternatives must be included in the final study.

Page Two October 27, 1988

The same deficiencies in the study can be applied to consideration of the comparison of impacts of dry cask storage. Again, the impacts of at-reactor dry cask storage should be compared against the total impacts associated with additional in-pool/at-reactor storage and the establishment of an MRS.

Similarly, I am very concerned about the study's limited examination of the transportation costs and impacts. States and municipalities across the country are extremely sensitive to the transportation of spent nuclear fuel. At-reactor dry cask storage may be a promising alternative to a MRS facility precisely because it could minimize the number and distance of shipments required before spent nuclear fuel is permanently disposed of. The study fails to fulfill the request in the legislation for an examination of the affects of at-reactor storage on the cost and risk of transportation directly to a repository versus and safety considerations involved in the transportation of nuclear wastes must be compared more completely in order for Congress to evaluate the alternative waste management systems.

Finally, the study inadequately examines P.L. 100-203's provision related to an examination of whether the Nuclear Waste Fund can or should be used for at-reactor dry cask storage. I believe the intent of this provision was to provide Congress with an evaluation of whether at-reactor dry cask storage would be cost-effective in relation to the full costs (as described above) of a MRS facility. Chapter Six of the initial study correctly points out that whether dry at-reactor storage costs are paid for by utilities or the Nuclear Waste Fund, they will be paid by the utilities ratepayers. Congress would benefit from an analysis of whether or not ratepayers will pay more or less from at-reactor dry cask storage versus the alternative of MRS facility storage. The study mentions that DOZ is "examining the potential for at-reactor storage to contribute to the the goals of the waste-management system." DOE should work to ensure that these studies are completed expeditiously and included in the final Dry Cask Storage Study report.

In conclusion, I believe the study can and should be expanded to give all interested parties a more thorough examination of the overall picture of alternative nuclear waste management systems. The study contains a thorough and thoughtful analysis of the various dry storage cask technologies. Unfortunately, I believe it fails to apply the same thorough analysis in other areas. As I have described above, I believe the data on costs is limited. Furthermore, the study provides no data on the effect of the at-reactor dry cask storage alternative in terms of transportation or impacts.

Page Three

October 27, 1988

The nation needs to develop the safest most cost-effective system possible. I am confident that DOE will help further this effort by expanding its study to analyze at-reactor dry cask storage as an alternative to an MRS by considering the full costs and impacts of these options in relation to one another. I look forward to working with you in this process.

With best wishes,

Sincerely yours,

Timothy E. Wirth

III-3



### STATE OF ALABAMA

GOVERNOR'S OFFICE

MONTGOMERY 36130

GUY HUNT GOYERNOR

October 11, 1988

Mr. Charles Head
U. S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322 Forrestal Building
1000 Independence Avenue SW
Washington, DC 20585

Dear Mr. Head:

On behalf of the State of Alabama, I would like to thank you for giving us an opportunity to review your report on at-reactor nuclear waste storage using dry cask technology.

Alabamians are greatly concerned about the problem of nuclear waste disposal. Although your report seems to indicate that several safe methods exist to increase storage capacity at the reactor site until the permanent Department of Energy (DOE) disposal facility is available, at-reactor storage capacity is expensive and adds to the cost of providing electric power to our citizens. This at-reactor storage expense is in addition to the millions of dollars Alabama electric power consumers are paying into the DOE Nuclear Waste Fund.

Nuclear utilities have long been concerned about their capability for long term storage of spent fuel on-site. Most nuclear plants were designed assuming spent fuel would be shipped off-site for reprocessing. Spent fuel pools were typically designed to hold two or three years worth of discharged fuel as well as the entire reactor core if a core unload was planned. The unavailability of commercial reprocessing and lack of a national repository forced utilities to evaluate and implement various methods of increasing their on-site storage capacity. Such methods include re-racking of spent fuel pools with closer-spaced storage racks, fuel assembly disassembly and fuel rod consolidation, transshipment to other reactor sites, and on-site dry storage casks.

Alabama Power Company, at its expense, has re-racked its two spent fuel storage pools to hold 1407 fuel assemblies each. Based on a discharge of 72 fuel assemblies at each refueling,

- 2 -

storage is available at Farley Units 1 and 2 to maintain full core discharge capability until the year 2004 and 2007 respectively. Current fuel management schemes are expected to result in refueling discharges below the assumed values. In addition, the storage racks were designed to accommodate the possibility of further increasing capacity through rod consolidation. These measures minimize the chance that Alabama Power will have to utilize on-site dry cask storage. Nevertheless, failure of DOE to begin receiving spent fuel reasonably close to the 1998 schedule could force the use of on-site dry cask storage.

Other utilities are physically unable to expand their spent fuel capacity and could require alternative storage means such as dry cask storage even if DOE could provide storage beginning in 1998. We concur with DOE's conclusion that the various dry storage technologies addressed in the study are technically feasible, safe, and environmentally acceptable for on-site fuel storage until a federal facility is available to accept the fuel.

Of particular concern to us is the issue raised in the study of using the Nuclear Waste Fund for at-reactor storage. DOE acknowledges that the Act does not authorize use of the Fund to provide direct financial support for fuel storage at reactor sites, and properly concludes that Congress intended that utilities be responsible for interim storage until permanent facilities are available in 1998. DOE also correctly states that the primary issue to be considered in using the Nuclear Waste Fund for on-site storage activities is the matter of equity among utilities; i.e. why should funds provided by one utility's ratepayers subsidize storage at another utility's facility? DOE also concludes the Nuclear Waste Fund should be used for on-site storage when such storage provides overall benefits to the waste-management system and would so recommend to Congress if appropriate.

We strongly oppose this concept and see no reason why one utility's ratepayers should subsidize storage at another utility's facility.

The need for such storage could be substantially reduced if DOE would concentrate its efforts on providing off-site disposal and/or storage by 1998 in accordance with legislative and contractual obligations, not increasing on-site storage capabilities.

Sincerely

Guy Hupt



STATE OF VERMONT
DEPARTMENT OF PUBLIC SERVICE
120 STATE STREET
STATE OFFICE BUILDING
MONTPELIER 93602
TEL 802 323-3211

October 28, 1988

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Head:

Governor Kunin has asked me to respond to your requests for comments on the DOE study of dry cask storage on behalf of the State of Vermont.

I strongly support the need to develop acceptable approaches to solving the problem of high level radioactive waste disposal. At the current rate of generation, much existing on-site storage capacity will be used before any off-site option is ready. Solutions must be identified and developed. This is essential in order to protect the public from the potential hazards presented by these wastes and to allow existing nuclear power facilities to remain a viable option for electric generation. The use of dry casks for storing spent fuel could provide the storage necessary to allow sufficient time to solve finally the disposal problem. In order to fill this role, the use of dry casks will have to be accepted not only by utility and government officials, but by the public. This will not be easy under the present environment. There is a great deal of distrust of official assurances from either the nuclear industry or the federal government. This makes it extremely important that conclusions and decisions on the options for spent fuel storage have substantial supporting data. The support should include designs, testing, demonstrations, and licensing. Simple assertions and poorly supported conclusions by federal or industrial officials will be be sufficient.

The conclusions presented in the study on health and safety effects need more detailed and specific support. A general conclusion by the NRC in its waste confidence proceeding that there is "reasonable assurance that spent fuel--can be stored safely" and the conclusions from two site and design specific evaluations are not adequate bases of support for the broad conclusion that health, safety and environmental affects of dry cask storage are negligible. Additional studies need to be either presented or performed in order to support the conclusion. The conclusions on the risks of transportation of dual purpose casks (pg. 76) do not appear to be conclusions, but assumptions of what the result would be if all the necessary actions and appropriate reviews are adequately performed.

Another area of extreme importance to the success of the development and use of dry cask storage is public participation. If the cask option is to maintain credibility, the public, including state governments, must be included in the process as much as possible. This should include the right to request and participate in formal licensing proceedings. Attempts to expedite the process by eliminating the requirement for a formal licensing action when a power plant proposes to use dry cask at its site, as the study states the NRC plans to attempt, just frustrates the public's attempts to be involved and is questionable public policy.

In addition to the general areas which I have just discussed, I have a number of specific comments regarding the study.

- The study needs to identify and quantify to the extent possible the effects on fuel storage that would result from the widespread use of operating license extensions.
- 2. The assumption that there is no additional expansion of storage possible within existing pools needs to be supported. There are a number of different designs for in-pool storage racks. For dry casks, the study includes the effects of potential changes in licensing criteria, such as being able to take credit of burn up. The same consideration should be given to in-pool storage racks.

- 3. The study needs to consider and discuss what additional support may be required by plant systems, such as cooling and clean up systems, due to in-pool spent fuel consolidation.
- 4. An expanded discussion including support is needed with respect to the health and safety affects of spent fuel consolidation. The existing study does not present any significant information on this subject.
- 5. The basis for the licensing cost estimates needs to be discussed. The discussion should include an explanation of the type of proceedings assumed (i.e., were they formal contested or another type) and the support for that assumption.
- 6. The cost estimates need to be adjusted for the affect of the time value of money. Estimates where that is not considered necessary or possible need to be identified, along with an explanation of why and a discussion of the uncertainties that result from not making the adjustment.
- 7. The study needs to quantify to the extent possible what the uncertainty is in the cost estimates. The study does attempt to use bounding cases to account for some of the uncertainty. However, the broad range of the numbers and the unspecified high degree of uncertainty make it difficult to know how much confidence should be attached to the estimates. They study needs to identify what degree of confidence the authors have in the estimates and why.
- 8. Purther discussion and support is needed of the assumption made in the study that the NRC will relax its requirements on dry cask storage with respect to burn up considerations.

- 9. The study needs to elaborate on how significant the advantages and disadvantages are of using dual casks.

  During the discussions on dual casks, it is inferred that their use would be a significant advantage. However, the cost estimated for loading and unloading shipping casks show those costs as very small.
- 10. The study needs to support the questionable assumption that the actual condition of rail lines will not be a factor in the transportation of storage casks.

Thank you for the opportunity to comment on the study, I hope that my comments are useful in revising the study and furthering the development of the dry cask storage option.

Sincerely,

eorge Sterringer

pl



## DEPARTMENT OF THE ENVIRONMENT

201 WEST PRESTON STREET . BALTIMORE, MARYLAND 21201 AREA CODE 301 . 225-5385

William Donald Schaefer Governor

October 26, 1988

Martin W. Waish, Jr. Secretary

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

Your letter to Governor William Donald Schaefer regarding our views on the use of dry cask storage methods at nuclear reactor sites has been referred to me for response.

The idea of long term dry cask storage at one or both of the nuclear power plants within Maryland's area of immediate concern (Calvert Cliffs in Maryland and Peach Bottom in Pennsylvania) for a period of up to eleven years is unacceptable. (Note: Calvert Cliffs will reach pool storage capacity in 1992). The expeditious construction of a permanent geologic repository should be the top priority of the U.S. Department of Energy's (DOE) Office of Civilian Radioactive Waste Management, and no slippage of the 1985 Mission Plan Schedule should be permitted. (Start of phase I operations for the repository is scheduled for the first quarter of 1998). As it now stands Maryland has no choice but to accept some form of dry cask storage, but does not support the premise that this method of storage allows DOE to take five years longer to develop this much needed permanent repository.

Regarding the methods of storage, staff at the Center for Radiological Health (CRH) have reviewed the August 1988 document entitled, "Initial Version Dry Cask Storage Study." As indicated in this study, we note that there is no immediate, simple solution to the problem of storing spent nuclear fuel once the capacity of on-site reactor pools has been reached. Further, indepth studies of the various types of dry storage (metal, concrete or dual purpose cast and/or modular vault systems) have not yet been completed, thus complicating comparisons of various storage methods almost as much as individual reactor site conditions and available equipment.

III-10

Hr. Charles Head page Two

Acknowledging these limitations, it is our position that both the metal casks and the horizontal concrete modules represent the most acceptable methods of on-site dry cask storage and are the only ones currently licensed by the Nuclear Regulatory Commission (NRC).

Although the total costs for the dry cask storage methods are estimated and may vary from site to site, the horizontal concrete module concept appears to offer lower costs in the study's range of 100-1000 metric tons of heavy metal (MTHM). This method also provides greater flexibility for future storage expansion in the event that the proposed permanent Federal repository is not available as planned. These factors may make horizontal concrete module storage the preferred dry cask storage methods at reactor sites.

If you have any questions concerning these comments, please contact me at (301) 225-5385 or have a member of your staff contact Mr. Roland Fletcher, Administrator, Center for Radiological Health, at (301) 333-3130.

Sincerely,

Martin W. Walsh, Jr. Secretary

MWW:1j

Tommy G. Thompson Governor James R. Kiauser Secretary



Mailing Address: Post Office Box 7864 Madison, WI 53707-7864

# State of Wisconsin Department of Administration

101 South Webster Street • Madison, Wisconsin

October 5, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independance Avenue, S.W. Washington, DC 20585

Dear Mr. Head:

At the request of Governor Thompson, we have rewed the initial version of the Dry Cask Storage Study which was ent for our comments by Acting Directory Charles E. Kay.

The Dry Cask Storage Study offers an excellent review of the present status of our knowledge of dry cask storage of spent nuclear fuel. Dry cask storage is designed for use at existing electric utility industry reactor sites. As in-pool storage space at existing reactor sites becomes full, dry cask storage will become an important part of our mix of options for storage of spent nuclear fuel.

We note that the EIA no-new-orders case was used as the reference case for projections of spent-fuel discharges. This seems to be the more realistic case since recent years have not demonstrated the likelihood of additional orders for new nuclear power plants.

The study references a survey Page 58 of 118 nuclear reactor operators. A large portion of those responding have not extensively studied their options for increased at-reactor storage of spend-fuel. This lack of preparedness is a matter of concern and makes the present study even more timely.

The need for dry cask storage is further demonstrated by the recognition of the limitations of the concept of rod-consolidation. In the last full paragraph of page vii there is an acknowledgement that the maximum rod-consolidation ratio is never achieved because of the non-fuel-bearing hardware that is left after consolidation but which still takes up in-pool storage space.

Mr. Charles Head October 5, 1988 page 2

The study provides an excellent review of existing technology and discusses several options for the use and future development of dry cask storage. Wisconsin has concerns with some of the proposals.

The concept of a dual-purpose cask for use in both storage and transportation is desirable in terms of potential reduced cost, increased flexibility and possible reduction in radiation exposure. However, it may be difficult to design and fabricate a cask which fulfills both functions. Separate function casks may allow for the design goals to be more easily achieved. We feel the long term goal should, however, be a cask which can be used for Monitored Retrievable Storage. After a long storage period the cask should have enough integrity to allow it to be transported and then be usable for continued long term storage at another site.

Another issue of concern is the reference on page viii to a proposed rule to streamline licensing procedures after a drystorage cask has been issued a generic certificate of compliance. We strongly support the proposed rule to reduce "licensing related activities" and to streamline the licensing procedure. However, streamlining procedures could also reduce the opportunities for public information and input at individual reactors with the possible result of litigation delays. These opportunities for public participation are critical in developing public confidence and acceptance by local communities because of the perceived hazards associated with the storage of radioactive materials.

We appreciate the opportunity to review the August 1988 Initial Version Dry Cask Storage Study and we are pleased to send you our comments on this important issue.

Sincerely,

James R. Klauser

Sècretary



#### STATE OF NEW JERSEY BOARD OF PUBLIC UTILITIES

CHRISTINE T. WHITMAN PRESIDENT

Two Gateway Center Newark, N.J. 07:02 20: 646-2027

October 17, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactiva Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Re: Dry Cask Storage of Nuclear Fuel CTW 804-88

Dear Mr. Head:

This is to acknowledge receipt of Mr. Charles E. Kay's letter of September 1, 1988 to Governor Thomas H. Kean on the above matter which the Governor has referred to me for reply.

Please be advised that I received a copy of Mr. Kay's September 1, 1988 letter addressed to me directly and I replied to it on September 11, 1988. Attached is a copy of that response for your information.

Please do not hesitate to call upon me if I may be of further assistance in this matter.

Sincerely,

Christine Todd Whitman

President

CTW/MVE



#### STATE OF NEW JERSEY BOARD OF PUBLIC UTILITIES

CHRISTINE T. WHITMAN

September 14, 1988

Two Gateway Center Newark, N.J. 07:02 20:648-2027

Wr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestalo Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Re: Dry Cask Storage of Nuclear Fuel CTW: #721-88

Dear Mr. Head:

We have received a letter from Mr. Charles Kay, Acting pirector, Office of Civilian Radioactive Waste Management requesting that the New Jersey Board of Public Utilities furnish our views on the use of dry cask storage to meet the utility industries spent nuclear fuel storage needs through the start of operation of a permanent geologic repertory. Mr. Kay requested that we respond directly to you with our reply.

The ultimate decision regarding the disposal of spent nuclear fuel waste resides with congress and the DOE. Since the New Jersey Board of Public Utilities has no legal jurisdiction regarding the disposal or reprossessing of spent nuclear fuel, or other radioactive waste, nor any technical staff experts in that field, we are unable to offer meaningful comments on the options evaluated in the dry cask storage study report submitted with Mr. Kay's letter.

Thank you for contacting the New Jersey Board of Public Utilities regarding our views on this matter. Please do not hesitate to call upon us again whenever we may be of assistance to you.

Sincerely,

Christine Todd Whitman

President

CTW/MVE/peb



## COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES Post Office Box 2063

Harrisburg, Pennsylvania 17120 October 1, 1988

**Bureau of Radistion Protection** 

(717) 787-2163

Charles E. Kay, Acting Director Office of Civilian Radioactive Waste Management Department of Energy Washington, DC 20585

Dear Mr. Kay:

We appreciate the opportunity to provide comments on your draft report pertaining to dry cask storage of nuclear spent fuel at nuclear reactor sites. We have reviewed the report and have no substantive comments at this time. We do believe that the concept has merit to alleviate the spent fuel storage problem. We would be interested in reviewing specific designs and NRC implementation at specific reactor sites.

Sincerely,

Thomas M. Gerusky

Director

CURTO ESCHELS



#### STATE OF WASHINGTON

## ENERGY FACILITY SITE EVALUATION COUNCIL

Mail Stop PY-11 • Olympia, Washington 98504 • (206) 459-6490 • (5CAN) 585-6490

October 24, 1988

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322, Forrestal Building
1000 Independence Avenue S.W.
Washington, D.C. 20585

Dear Mr. Head:

The Washington State Energy Facility Site Evaluation Council (Council) is pleased to provide you with its comments to the August 1988 Initial Version Dry Cask Storage Study.

Background: In Washington State the Council has statutory authority for licensing thermal power facilities over 250 megawatts. The Council's goal is "to assure Washington State citizens that, where applicable, operational safeguards are at least as stringent as the criteria established by the federal government and are technically sufficient for their welfare and protection." The state has authority to license nuclear power plants in Washington.

The state currently has issued licenses for the construction and operation of three commercial nuclear power plants, of which one has been completed and has been operating for three years. The license is a contractual agreement between the state and the utility termed a Site Certification Agreement (SCA). The SCA has been developed through a public process as required by statute.

Issues: The Council's concern with issues presented in the Initial Study are limited to licensing. The study implied that all licensing will be by the NRC, and does not address possible state or local licensing requirements or any public involvement on siting, or the licensing of the site. Because the proposed dry cask storage will not be an integral part of the reactor and will not fall under 10 CFR 50, the Council assumes that a dry cask storage facility would fall under its regulatory responsibilities and its SCA with the utility. The Council's position is that its regulations require an amendment to the SCA for construction and operation of a dry cask facility. Amendments to the SCA are, by law and rule, public processes.

Mr. Charles Head October 24, 1988 Page 2

Washington State also shares a common border with Oregon along the Columbia River. The Trojan nuclear power plant sits on the Oregon side of the river but the prevailing winds are toward Washington. Although Washington does not regulate this site, this state feels it should be involved through a public process with the ability to participate in a decision by the Trojan plant to develop a dry cask storage facility. Without the ability or right to participate regarding such a facility that may have an impact on the citizens of Washington, we feel the study fails to provide the necessary measures for special concerns to be addressed.

The scenario described in the USDOE Initial Study does not address regulatory concerns other than those of the NRC. Public involvement is at the root of the state process. A public process is the policy of the state involving its statutory responsibility to protect the health and safety of its citizens.

Sincerely

Chairman

CE:AJF:ab

cc: Tom Walt, Portland General Electric G. C. Sorensen, WPPSS Bill Dixon, Oregon DOE Max Power, Office of Nuclear Waste Management, Ecology SPORTS ONERS. CHAIRMAN
SPORTS STINKS. WICE CHAIRMAN
SPORTS GOOST! PAFFORD
SPORTS GOOST! PAFFORD
SPORTSON



WILLIAM J. BUCKNER

EXECUTIVE DIRECTOR/SECRETARY

## Georgia Bublic Service Commission

244 WASHINGTON STREET, S.W. ATLANTA, GEORGIA 30334

October 24, 1988

Mr. Charles Head U. S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, DC 20585

Dear Mr. Head:

On September 1, 1988, a copy of the initial version of the Dry Cask Storage Study was transmitted to the Georgia Public Service Commission soliciting review and comments. We have completed our review of the initial version of the Dry Cask Storage Study and our comments are attached for your consideration.

There are considerable uncertainties in the DOE schedule for beginning to accept spent fuel and in the costs associated with various storage options. This is of special concern for minimizing costs to ratepayers in Georgia because depending on the timing of DOE acceptance of spent fuel within the limits covered by the study, at-reactor storage costs could vary between nothing and over \$100 million. These costs would ultimately be passed on to ratepayers.

The major points contained in the attached comments are summarized below:

- (1) DOE should begin to accept spent fuel for off-site storage as soon as feasible (and should accelerate the current schedule if possible) which will minimize costs associated with atreactor storage;
- (2) DOE should provide a reliable schedule for beginning to accept spent fuel for off-site storage which will allow economic decisions to be made for what type of at-reactor storage to use when it is needed;

Mr. Charles Head October 24, 1988 Page 2

(3) The possibility of using the Nuclear Waste Fund to assist in defraying at-reactor storage costs for spent fuel should be given a broader consideration than the narrow view taken in the study that such funding was not originally authorized.

Additional comments are also provided on other areas for your consideration.

If you have questions on these comments, please call us.

Sincerely

Ford B/ Spinks Vice-#hairman

FBS/rpb

Attachment

C: Gary B. Andrews, Chairman Billy Lovett Robert C. Pafford Cas Robinson B. B. Knowles, Director of Utilities

# COMMENTS ON THE INITIAL VERSION OF THE DRY CASK STORAGE STUDY

### GENERAL COMMENTS

9-5

- (1) DOE should begin to accept spent fuel for off-site storage as soon as feasible (and should accelerate the current schedule if possible) which will minimize costs associated with atreactor storage. According to Table 3-3 in the study, 10 states which would previously have required little if any additional at-reactor site storage with a 1998 start (the original schedule) will likely go above the threshold and require additional storage with a 2003 start (the current schedule). The study states that a five year acceleration or delay in schedule affects costs downward or upward by 50%. When the nominal nationwide costs are between \$470 million and \$2 billion for additional at-reactor site storage, the 50% cost savings or increase clearly deserve top management priority and an aggressive program to stay on or ahead of schedule.
- (2) <u>DOE should provide a reliable schedule for beginning to accept spent fuel for off-site storage which will allow economic decisions to be made for what type of at-reactor storage to use when it is needed.</u>

A utility which believed it would need only small amounts of at-reactor storage could choose a particular option for that storage believing that was all it would need before DOE storage would be available. If the off-site storage was then not available when needed, the utility could be forced to make further investments which taken in total with the earlier decisions could be uneconomical.

Likewise, a utility could choose the most economical option for a large amount of storage not realizing that DOE storage would be available prior to the time that all of the larger extra capacity was needed. This could easily result in a net investment in storage capacity which is uneconomical.

(3) The possibility of using the Nuclear Waste Fund to assist in defraying at-reactor site storage costs for spent fuel should be given a broader consideration than the narrow view taken in the study.

The report's basic conclusion of the Congressionally mandated question of whether the Nuclear Waste Fund should be used to fund at-reactor site storage of spent fuel is given an inadequate treatment by the study. It basically states that the fund was originally set up to prohibit its use for funding

at-reactor site storage and that equity and fairness provisions preclude further consideration of use for that purpose unless it is in the national interest as part of an overall policy on waste management.

We agree that the issue is complex and that equity and fairness are a major consideration. Nevertheless, utilities (and ultimately ratepayers) are already paying 1 mill/kw-hr for ultimate storage of spent fuel. In many cases (as noted above, in 10 states including Georgia), the recently announced 5 year schedule delay which is beyond the direct control of utilities will cause expenditures to be required for atreactor site storage where previously none would have been required. This fact should also be considered in determining how equity and the public interest should be served.

In addition, if, as stated in the study, the legislative record is indeed clear that the narrow interpretation taken by DOE is correct, it is not clear why the question was mandated for consideration at all in the Nuclear Waste Policy Amendments Act of 1987.

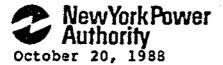
#### DETAILED COMMENTS

- (4) A more comprehensive discussion of transshipment should be provided. In Section 2.1 of the study, a single paragraph discusses (and dismisses) the possibility of transshipment of fuel between sites as an option. Although such transshipment is not a long term solution, a more comprehensive discussion should be provided. According to the Section 6.1 of the study, this is an option which must be considered before a utility can meet the legislatively dictated qualifications for contracting with DOE for interim spent fuel storage at existing DOE facilities. The reasons given for not discussing transshipment further is that there has been opposition. Although this is certainly correct, it fails to ment on other significant considerations. Transshipment of fuel is not authorized by power reactor operating licenses and requires license amendments with associated costs as well as transportation and handling costs. Also, if fuel from different types of reactors is being stored in a common Also, if fuel from facility, possible spent fuel pool rack or supporting system modifications would be required. In some cases, this may nevertheless represent a viable option for a utility, particularly in states which are on the threshold for not needing additional storage and where there are reactors of different ages.
- (5) Section 4.2 of the study generally provides a good discussion of fuel rod consolidation. The discussion of costs associated with fuel consolidation in Section 4.2.5 is clear. Clarification is needed however with regard to how the use of consolidation would affect the ultimate costs of other storage

options. This is mentioned briefly for duel purpose casks, but not for the other dry storage options.

- (6) Section 4.1.2.4 should clarify the costs associated with duel purpose casks. It is not clear what fixed and variable costs are or whether it is anticipated that the fixed costs would be handled entirely by the vendor so that the end user would see only variable costs.
- (7) Sections 4.1.2 and 5.3.1 discuss the possibility that the use of duel purpose casks could reduce aggregate costs if the utility owner of such casks would agree to transfer ownership to DOE early enough to enable DOE to procure that many fewer casks. Presumably if this is the case, DOE will offer that utility a credit of some kind for the transfer of ownership. Both the amount of this credit and the schedule for entering such agreements should be specified clearly so that the benefit is not lost due to a failure to communicate.

123 Main Street White Plants, New York 10601 914 681,6800



J. Phillip Bayne President and Chief Operating Office

Mr. Charles Head U. S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S. W. Washington, D. C. 20585

Dear Mr. Head:

Under the terms of the Nuclear Waste Policy Act of 1987, the U. S. Department of Energy is to provide a report to Congress on the use of dry cask storage at reactor sites to meet the utility industry's needs for spent nuclear fuel storage through the start of operations at a permanent geological repository. The report was to consider costs, effects on human health and the environment, and the degree to which the Nuclear Waste Fund could be used to provide funds for at-reactor storage.

Authority staff have reviewed the Initial Version of the 'Dry Cask Storage Study' sent to us for review. The Attachment to this letter provides the Authority's comments.

I also want to express the misgiving I feel regarding the progress of the Department of Energy's repository program. The National Waste Policy Act (NWPA) of 1983 required start of repository operations in 1998. That legislative intent was incorporated in a contract between the Authority and the Department of Energy. It now appears, law and contract notwithstanding, that the 1998 date will not be met and significant storage will be required until a permanent repository becomes operational. This additional interim storage is different from that envisioned and discussed in the NWPA. Therefore, the pr hibition contained in that act against funding interim: prage from the Nuclear Waste Fund does not appear applicable under a revised repository schedule.

j.p. Bayne page Two

The Authority is continually evaluating its storage requirements. We are into 2nd generation modifications of both of our nuclear units. If the 1998 date is not achieved, significant additional engineering effort and funds will be required.

If you have any further questions or comments, please contact Mr. William Yario (914-681-6493).

very truly yours,

J. Phillip Bayne

President and

Chief Operating Officer

JPB:elb

#### ATTACHMENT

NEW YORK POWER AUTHORITY

COMMENTS ON

INITIAL VERSION OF THE

'DRY CASK STORAGE STUDY'

The significant cost increase to the utilities caused by the announced 5 year delay in the repository program is understated. In fact this delay contributes about 1/2 of the estimated cost to utilities for reactor storage. In addition, the significant utility in-house engineering cost of managing an ever increasing amount of spent fuel is not even mentioned.

The report tends to understate the difficulty in increasing spent fuel storage in technically acceptable and cost effective ways. For example, it states in a number of places that fuel consolidation is developed, when in fact it is far from a reliable cost-effective reality. Similarly, it states that dry storage in casks is readily available neglecting the fact that many plants, because of low capacity cranes and site restrictions, will find it difficult to use the more efficient heavy (\$\frac{1}{2}\$ ll0 ton) storage casks. The use of transfer systems is discussed but this cannot be considered a developed technology except for a specific storage system.

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The development of consolidation continues to lag behind predictions. The program at Idaho has exceeded estimates while achieving less than the stated goals. The DOE staff have recently stated there are no short term plans for a significant poolside consolidation R&D effort. If fuel per shipment can be almost doubled with consolidation, DOE should be funding consolidation R&D with the objective of decreasing shipping cost and perhaps decreasing storage cask cost. Statements in the report that there will not be significant savings are not substantiated.

If consolidation is not given significant R&D support, it may never become a feasible option. While the DOE report points to the Northern States Power-Westinghouse demonstration at Prairie Island as a success, the program was characterized by low-throughput. In another case, the EPRI/NUSCO program was marked by high cost and unresolved problems. These consolidation programs were with PWR fuel. No similar programs have been carried out on BWR fuel. A current ESEERCO report summarized the accomplishments of the consolidation demonstrations and identified the need for further development. There are few consolidation successes to report on.

options and fuel consolidation in general are not adequately discussed. The report treats all systems and storage issues as being not important or of having little impact. Actually, fuel consolidation, dual purpose casks and the type of dry storage employed, are important and significant in the transportation of spent fuel and the overall waste system operation.

10-4

The discussion in the report on dual purpose casks (DPC)is not thorough. No technical recommendations, no commitments for future work, and no position on the use of DPC in the waste

The attractiveness of the DPC in achieving ALARA objectives is not mentioned. Utilities consider the one time handling feature of a DPC as one of its chief advantages.

The discussion on the cost of DPC's is inconsistent in that it states that metal "storage casks" can be modified at a cost of from \$50K to \$300K in order to utilize them for transportation.

It gives the additional cost per Kg of heavy metal as about \$7 (with no range given). This calculates to be about \$75K per cask, nowhere near \$300K.

DOE states that the licensing of DPC depends on demand but it has the responsibility for repository schedule and spent fuel shipments and, therefore, will directly determine this same demand.

DOE in recent months has deferred the development of this option while continuing to support the truck and rail shipping cask program. The Authority strongly believes that it would be more prudent to actively pursue the dual purpose cask option.

## VERMONT YANKEE NUCLEAR POWER CORPORATION



RD 5, Box 169, Ferry Road, Brattleboro, VT 05301

J. GARY WEIGAND

PRESIDENT AND CHIEF EXECUTIVE OFFICER

@321 257-\$271

October 25, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building. 1000 Independence Ave., S.W. Washington, D.C. 20585

Dear Mr. Head:

Subject: August 1988 DOE Bry Cask Storage Study

We have reviewed the subject draft DOE study and have no technical comments on this draft. An earlier version of the study was reviewed and commented on by the Utility Nuclear Waste Management Group (UNWMG) and the Utility Nuclear Transportation Group (NTG) with the aid of their respective consultants. We believe that these reviews identified most of the problems with the initial draft; and, for the most part, the Department of Energy (DOE) took these comments into account during preparation of the subject draft.

We would like to reiterate, however, that DOE is required by the standard contract to begin accepting spent fuel in 1998. Vermont Yankee continues to believe that DOE should make every effort to accept fuel by that time. The study shows that any delay beyond 1998 could cost the utility industry up to \$2.7 billion to augment on-site storage capacity if acceptance of spent fuel is delayed to 2008. The longer the delay, the greater the cost.

Vermont Yankee also feels that more emphasis should be placed on the cost of uncertainties associated with the utilization of the dry cask storage option, especially in light of today's regulatory and legal environment.

Thank you for the opportunity to comment on your study.

Very truly yours,

Gang Weigen

MIDDLE SOUTH UTILITIES, INC/BOX 23070/JACKSON, MS 39225-3070/(601) 950-9696

WILLIAM CAVANAUGH, TE SENIGR VICE PRESIDENT SYSTEM EXECUTIVE-NUCLEAR

October 25, 1988

Mr. Charles Head
U. S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, Southwest
Washington, D. C. 20585

Dear Mr. Head:

12-1

Your memo of September 1, 1988, requested comments on the initial version of the Dry Cask Storage Study (DOE/RW-0196). I am pleased to respond on behalf of the Middle South Utilities System. Middle South Utilities operates four nuclear generating units in three states: Louisiana Power & Light's Waterford Unit 3; Arkansas Power & Light's Arkansas Nuclear One (ANO) Units 1 and 2; and System Energy Resources' Grand Gulf Nuclear Station Unit 1.

We agree with the report's conclusion that dry cask/modular storage is a technically feasible, safe, environmentally acceptable option for interim storage of spent fuel pending final storage at a federal repository.

We offer the following comments for your consideration:

1. Using DOE's midpoint estimates for the cost of dry stor ge (approximately \$75 per kilogram of discharged heavy metal), we estimat annual expenditures (in excess of the current 1 mill/kwh) of \$2-\$3 million per unit at Arkansas Nuclear One beginning in 1995. At Waterford Unit 3, costs are estimated at \$2 million annually beginning in 2001. Grand Gulf would pay an estimated additional \$2 million per year beginning in 2003.

Given the magnitude of these additional expenses for on-site dry storage, we are keenly interested in selecting and using the most cost effective technology available. We encourage research and development in technology that will minimize costs and brileve such R&D programs are an appropriate and allowable use of Nuclear W te Fund monies. One particularly attractive design concept that ould be given priority is the dual purpose shipment and storage care. Use of such a cask minimizes handling costs, reduces personnel exposure, and reduces accident risks.

Mr. Charles Head Page 2 October 25, 1988

12-2

2. DOE has argued that the Nuclear Waste Fund has provisions that prevent its use to support utility on-site storage of nuclear fuel. DOE, however, has not adequately addressed the question of what actions should be recommended to Congress to address the changes that have occurred which will impact utilities' storage costs, e.g., DOE's delay of repository operation until 2003 and the consequential costs to be paid by the utilities for on-site storage in addition to the 1 mill/kwh waste disposal fee. The report presents a general rather than a detailed cost-effectiveness argument on this point. A more detailed evaluation may show payments to utilities from the Nuclear Waste Fund do, in fact, yield the lowest overall cost, supporting a request to Congress for relief from the above-referenced restrictions.

3. Chapter 4 of the report estimates storage costs for dry casks and other methods. So that future cost estimates can be independently performed using DOE's methodology, we request that DOE add more detail concerning their estimates of future costs of storage. This detail could be an appendix to the report presenting assumptions, cost data, and calculations.

4. At Page 29, the report states: "If the cask contains spent fuel and water -- as it would, for example, during loading in the storage pool -- the NRC requires that boron be used to prevent a nuclear chain reaction (nuclear criticality)." We are not aware of any specific NRC requirement to load a cask under borated conditions. The requirement as we understand it is more general and is found in 10CFR50 Appendix A, Criterion 62, which states:

"Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by the use of geometrically safe configurations."

We suggest the report be revised to address the more generic requirement.

Middle South Utilities appreciates the opportunity to comment on this report.

W. Cavanaugh, III

System Executive-Nuclear

WCIII/sep

cc: Mr. T. H. Cloninger

Mr. W. T. Cottle

Mr. T. G. Campbell

Hr. J. G. Dewease

Mr. F. B. Rives

III-31

Southern Company Services, Inc. Post Office Box 2625 Birmingham, Alabama 35202 Telephone 205 870-6011



Certified Mail

October 26, 1988

U. S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building ... 1000 Independence Avenue, SW Washington, D.C. 20585

Attn: Mr. Charles Head

Re: Comments on the use of dry cask storage at nuclear reactor sites through the start of operation of a permanent geologic repository and its impact on Contract No. DE-CROI-83NE44361 with Alabama Power Company and Contract Nos. DE-CROI-83NE44478, 83NE44479 and 83NE44386 with Georgia Power Company.

In August, 1988, the Department of Energy ("DOE") through the Office of Civilian Radioactive Waste Management, published its Initial Yersion -Dry Cask Storage Study. This letter is submitted to the DOE by Southern Company Services, Inc. ("SCS"), the service company subsidiary of The Southern Company, on behalf of Alabama Power Company ("APC") and Georgia Power Company ("GPC"), the operating company subsidiaries of The Southern Company which operate nuclear electric generating facilities. APC and GPC are owners and generators of spent nuclear fuel ("SNF"), and, as such, are purchasers from the DOE of SNF disposal services under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste ("disposal contracts"), 10 CFR Part 961. Specifically, APC is the holder of DDE Contract No. DE-CRO1-83NE44351 covering the disposal of SNF from the Joseph M. Farley Nuclear Plant and GPC is the holder of DDE Contract Nos. DE-CROI-83NE44478, 83NE44479 and 83NE44386, covering the disposal of SNF from the Edwin I. Hatch Electric Generating Plant and the Alvin W. Yogtle Electric Generating Plant. Under the disposal contracts in exchange for payment to the DOE by the purchasers of the cost of disposing of SNF generated by the nuclear facilities, the DOE is responsible for accepting title to, transporting, and disposing of such SNF commencing not later than January 31, 1998. This letter is being submitted because of continued concern over what appears to be an indication by DDE that it may not comply with its obligations under APC and GPC disposal contracts and the possible use of the Nuclear Waste Fund for at-reactor storage.

The Nuclear Waste Policy Act of 1982 (the Act) requires the Department of Energy (DOE), with funds provided by nuclear utilities and other generators of high-level radioactive waste, to develop, design, license, construct and operate a national repository for spent nuclear fuel and other high-level waste by 1998. Each nuclear utility has been required to contract with DOE for spent final disposal services which currently requires a payment into a Nuclear muste Fund of one mill per kilowatt-hour for actual nuclear generated net electricity.

Mr. Charles Head October 26, 1988 Page 2

The Nuclear Waste Policy Amendments Act of 1987, in addition to designating Yucca Mountain, Nevada, as the only potential repository site to be examined, also required DOE to prepare the subject report on the use of dry cask storage at nuclear reactor sites which are expected to exhaust their spent fuel pool storage capacity prior to DOE's ability to begin acceptance of their spent fuel at the national repository or the possible monitored retrievable storage facility. Despite the statutory schedule contained in the Act and the express will of Congress which enacted the legislation, DDE continues to assert in its Annual Capacity Report (ACR) and Draft Hission Plan Amendment (DMPA) that it does not expect to be able to receive any spent fuel until 2003 and then only on a limited basis. Please refer to Attachment 1 for APC and GPC comments on the 1988 ACR and 1988 DMPA regarding the acceptance of title to. transportation and disposing of SNF commencing no later than January 31. 1998. Further, the current allocation schedule in the latest ACR indicates that no spent fuel will be accepted from GPC and APC until the third and fourth year of repository operation.

Nuclear utilities have long been concerned about their capability for long term storage of spent fuel on-site. Most nuclear plants were designed assuming spent fuel would be shipped off-site for reprocessing. Spent fuel pools were typically designed to hold two or three years worth of discharged fuel as well as the entire reactor core if a core unload was planned. The unavailability of commercial reprocessing and lack of a national repository forced utilities to evaluate and implement various methods of increasing their on-site storage capacity. Such methods include re-racking of spent fuel pools with closer-spaced storage racks, fuel assembly disassembly and fuel rod consolidation, trans-shipment to other reactor sites, and on-site dry storage casks.

Both APC and GPC have re-racket their spent fuel pools with high density fuel racks at Plants Farley and Hatch, respectively. It should be further noted that GPC's Plant Vogtle also plans to install high density spent fuel racks in its spent fuel storage pool. Based on current fuel management schemes, storage will be available at Farley Units 1 and 2 to maintain full core discharge capability until the year 2004 and 2007. With its combined spent fuel storage pool, Plant Hatch is expected to lose full core discharge capability in 1999. Once all racks have been installed, Plant Vogtle will lose full core reserve in 2008. In some cases, the storage racks were designed to accommodate the possibility of further increasing capacity through rod consolidation. These measures were taken at each utility's own expense in order to minimize the use of on-site dry cask storage. Nevertheless, failure of DOE to begin receiving spent fuel by January 31, 1998 could force the use of on-site dry cask storage. Both APC and GPC realize that other utilities may be physically unable to expand their spent fuel capacity and could require alternative storage means such as dry cask storage even if DOE could provide storage beginning in 1998. APC and GPC also concur with DOE's conclusion that the various dry storage technologies addressed in the study are technically feasible, sate, and environmentally acceptable for

Mr. Charles Head October 26, 1988 Page 3

on-site fuel storage until a federal facility is available to accept the fuel. As noted in the Dry Cask Storage Study, the need for such storage could be substantially reduced, as much as 50%, if DOE would concentrate its efforts on providing off-site disposal and/or storage by 1998 in accordance with legislative and contractual obligations.

In addition there is concern over the issue raised in the study of using the Nuclear Waste Fund for at-reactor storage. DOE acknowledges that the Act does not authorize use of the Fund to provide direct financial support for fuel storage at reactor sites, and properly concludes that Congress intended that utilities be responsible for interim storage until permanent facilities are available in 1998. DOE also correctly states that the primary issue to be considered in using the Nuclear Waste Fund for on-site storage activities is the matter of equity among utilities; i.e. why should funds provided by one utility's ratepayers subsidize storage at another utility's facility. However, DOE concludes the Nuclear Waste Fund could be used for on-site storage when such storage provides overall benefits to the waste-management system and would so consider and recommend to Congress if appropriate. DOE should take all necessary actions to meet its contractual obligations to commence fuel receipt in 1998 and not use the waste fund for on site storage.

Alabama Power and Georgia Power, as individual utilities and through their membership in the Edison Electric Institute and the Utility Nuclear Waste Management Group, will continue to monitor the intended use of the Nuclear Waste Fund to ensure fair treatment of their ratepayers. Further, they encourage DOE to adjust its Waste Management Program to meet the original 1998 schedule. In conclusion, both APC and GPC:

- (1) support the concept of on-site dry cask storage as technically feasible, safe and environmentally acceptable, pending completion of federal facilities.
- encourage DOE to minimize the need for such storage by expediting completion of federal facilities in accordance with statutory and contractual obligations, and
- (3) oppose use of the Nuclear Waste Fund for on-site storage.

Sincerely,

B. E. Hunt Manager, Nuclear Fuel

SOUTHERN COMPANY SERVICES, INC. (Agent for Alabama Power Company and Georgia Power Company)

Matteur Las

III-34

Mr. Charles Head October 26, 1988 Page 4

BEH: DCH/16

### Attachment

R. P. McDonald
R. G. Hairston, III
R. D. Rickels
R. P. McDonald
R. D. Hairston, III
L. T. Gucwa
R. D. Baker

SZ-0010 SZ-0100 SZ-0200 SZ-0300

3043H

Pacific Gas and Electric Company

77 Beale Street San Francisco, CA 94106 415/972-7000 TWX 910 372-6587 James D. Snifter 120898 Vice President Nuclear Power Generation

October 20, 1988



Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management, RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

Reference: DOE letter from Charles E. Kay to Richard A. Clark dated September 1, 1988

The attachment to this letter provides our comments on the Initial Version Dry Cask Storage Study dated August 1988, which we received via the referenced letter. We appreciate the opportunity to review and comment on this report.

. Sincerely.

"ttachments: Comments on DDE/RW-0195, August 1988

#### ATTACHMENT

COMMENTS ON DOE/RW-0198, August 1988 "Initial Version Dry Cask Storage Study"

- 1. The last sentence of the third paragraph on page vi of the Executive Summary should emphasize how important the timely acceptance of spent fuel by the DOE is, and the significant impact that any delay would have on the required onsite storage capacity at plants.
- The second paragraph on page viii in The Executive Summary describes how a proposed rule would allow a utility with a nuclear plant licensed under 10 CR50 to apply to the NRC for a general license to store spent fuel in a NRC certified cask and to use their casks without further licensing activities. This implies that the "general license" to store fuel would involve a very small licensing effort since a certified cask is used. It should be acknowledged that NRC approval for use of even a precertified cask may still involve a significant licensing effort and potential intervention.

14-2

- 3. We recommend changing the wording at the end of the last sentence in the first paragraph under 2.1.1 on page 8 from "--and adding neutron-absorbing material to minimize the potential for nuclear critically" to "--adding neutron absorber in the racks or imposing fuel burn up requirements to preclude criticality".
- 4. The first paragraph on page 9 refers to Generic Safety Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools". If this issue is mentioned, it should be in the context of the potential affect on not only reracking, but also on existing storage capacities at plants that have already reracked.



## Pennsylvania Power & Light Company

Two North Ninth Street • Atlentown, PA 18101-1179 • 215/770-5151

October 25, 1988

Robert K. Campbell Chairman/President Chief Executive Officer 215/770-5947

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mr. Head:

Your letter dated September 1. 1988 requested comments from Pennsylvania Power & Light Co. on the Initial Version - Dry Cask Storage Study prepared by the OCRWM. Thank you for the opportunity to participate in the review process of this important study.

The Dry Cask Storage Study provides a comprehensive assessment of at-reactor storage options currently being researched and tested. Our review of the report resulted in the following comments:

 Section 6.1 of the study states "It is the DOE's position that the utilities are responsible for storing spent fuel at reactor sites until an operating Federal facility is available to accept the fuel."

Section 6.2 goes on to state "the DOE has determined that the Nuclear Waste Fund should be used to support at-reactor storage only when such storage provides overall benefits to the waste-management system and not as a means of providing direct assistance to utilities in their at-reactor storage facilities."

The report fails to address the appropriateness of financial assistance to utilities in the event that DOE does not comply with its contractual obligation to accept spent fuel by the year 1998. The year 2003 has been identified both in the Dry Cask Storage Study and the Draft 1988 Mission Plan Amendment as the reference date for spent fuel acceptance to begin under the DOE Waste Management System. This date has not yet been established as meeting DOE's contractual obligation and clearly will have a significant economic effect on utilities. The DOE report confirms the economic impact by noting that the five year delay will result in cumulative additional storage requirements estimated to cost \$200 million to \$900 million.

PP&L recommends that DOE address its obligation to assist utilities with the costs of additional at-reactor storage when those costs are imposed as a result of DOE's failure to begin accepting fuel by 1998. If, as DOE has inferred, it is inappropriate to users Nuclear Waste Fund for this category of

15-1

financial assistance, then DOE should consider financial assistance from its general revenues.

 The report depicts in-pool consolidation as a promising technology in terms of making more efficient use of spent fuel storage space and, more importantly, in terms of much lower storage costs as compared to other alternatives.

However, the cost estimates of consolidated fuel summarized in Table 5-1 of the report do not consider the fact that consolidated fuel is presently classified as non-standard fuel by the DOE. As non-standard fuel, its position in the acceptance quere could be jeopardized per Article VI, paragraph A.2(b) of the LOE Contract for Disposal of Spent Fuel And/or High-Level Radioactive Waste. If the shipment of consolidated fuel were delayed because of the non-standard classification. the economic benefits of this technology could be more than offset by the necessity of additional storage, especially if pool space is exceeded. The costs associated with in-pool rod consolidation cannot be properly estimated by utilities until the issue of classification is resolved. While PP&L recognizes that this is one of the thirty-four ACR issues being evaluated by DOE, PP&L also believes that the Dry Cask Storage Study should note that the feasibility of in-pool consolidation may be dependent upon the schedule for acceptance of such fuel.

15-2

3. The study does not provide sufficient detail regarding the logistics or health physics aspects associated with dry transfer of spent fuel, such as from a dry storage cask to a shipping cask. The potential hardware requirements and ALARA considerations are not clear. A better understanding of these issues may help utilities to decide on their own best alternatives, e.g., the use of a dual-purpose cask.

The Dry Cask Storage Study represents a significant step toward assessment of the options available to nuclear utilities for increasing at-reactor storage of spent fuel. PP&L appreciates the efforts of DOE in research projects of this nature as well as the work DOE has put into this informative study. PP&L believes that the continued viability of nuclear power generation is greatly dependent upon industry and government working together successfully toward the common goal: A promise of safe, economical, and reliable electric service to meet our nation's needs into the next century.

Sincerely,



#### CHARLES CENTER · P. O. BOX 1475 · BALTIMORE, MARYLAND 21203

JOSEPH A. TIERNAN VICE PRESIDENT NUCLEAR ENERSY

October 27, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S. W. Washington, DC 20585

Dear Mr. Head:

After reviewing the initial version of the OCRVM Dry Cask Storage Study, Baltimore Gas & Electric offers the following comments for consideration.

#### CENERAL COMMENTS

The report is a useful reference with respect to the status of storage technologies and the industry-wide capacity expansion that is occurring and will be needed in the future. In many instances, however, it appears to present a microcultural perspective of the overall spent fuel storage/transportation/ disposal system, focusing on potential benefits to DOE alone. Some specific instances are mentioned under our specific comments. Generally, there was a .very narrow definition applied to the "transportation system" when looking at benefits and effects of various At-reactor storage systems. The savings to DOE when dual purpose casks are used is not countered by the added expense to the utility. The many beneficial effects of a transportation system that is compatible with the shipment of multi-element sealed canisters are not mentioned - in fact, horizontal modular storage is said to have "no effect" on the transportation system. Baltimore Gas & Electric, having committed to a horizontal modular storage system for capacity expansion, is keenly awars of the potential effects that can exist, and urges DOE to strongly consider the at-reactor interface issues when designing the from-reactor transportation system.

#### SPECIFIC COMMENTS

p. vii - Under "Hodular vault dry-storage systems", it is stated, "To date, this concept has not been implemented in the United States." Dual purpose casks and concrete casks have not been implemented in the US either. Singling out of the vault system to make this statement unnecessarily implies a negative bias.

p. vii - Under "Evaluation of in-pool storage concepts", the statement, "These demonstrations achieved a rod consolidation ratio of up to 2:1, the maximum possible, but none achieved effective compaction and packaging of the non fuel bearing hardware ..." should be modified to read, " a consolidation ratio of up to 2:1, but none have yet achieved effective ...". Two to one is not the maximum possible consolidation ratio, and some vendors are proposing to exceed 2:1. The demonstrations of compaction are ongoing, so the insertion of the words "have yet" avoids the implication that they are not.

p. ix - The estimated unit costs for storage expansion presented in the table are, in many cases, not reflective of the market. DOE should note that, in compiling this study, they have had limited access to the type of cost information that a utility would obtain during a competitive procurement process. System unit costs will vary widely because of such things as vendors trying to break into the market or different assembly weights (MTHM). The study seemed to imply that any uncertainties in cost were due only to varying levels of maturity and uncertainty as to which systems will be chosen by utilities.

- p. x Under "Health and Safety Impacts", HB Robinson is located in South Carolina, not North Carolina as is stated.
- 2.1 The statement, "utilities are using fueling cycles of 12 to 18 months, ..." should be changed to read " ... of 12 to 24 months, ...". Both Calvert Cliffs Units are currently on 24 month fueling cycles, and other utilities are moving in this direction as well.
- 2.1.2 (paragraph 3) Under the discussion on horizontal concrete modules, the statement, "At least one additional reactor site has firm plans to implement this technology, and is preparing a license submittal." should be added after "The use of this .... for another site has been submitted". Calvert Cliffs plans to submit an application in 1989. DOE should contact CP&L about their plans for Brunswick, as well.
- 2.1.2 (paragraph 4) Under the discussion on the dry vault, the statement, "this concept has not been implemented in the United States" should not be made unless it is also made with respect to all other technologies which have not been implemented in the United States, such as dual purpose casks and concrete casks.
- 2.1.2 (paragraph 6) When discussing which fuel will be taken to a dry storage facility first, DOE should note the difficulty a utility faces in placing its oldest fuel in the dry store in light of the fact that no specific guidance from

DOE exists on the Oldest Fuel First issue. If the utility were forced to ship its oldest fuel to the repository first, it could have to download its dry store for shipment and then reload it to maintain adequate pool capacity. A reasonable approach involves imposition of a heat load limit, or minimum cooling time, with utilities allowed to ship any fuel assemblies falling within that limit.

- 18-10 2.2 (paragraph 5) The phrase "are considered to be not an integral part" should be reworded to read, "are not considered to be an integral part".
- 2.2 (paragraph 13) The statement, "The latter technology is also proposed for use in a dry storage license application by a third utility" should be modified to read, "... by a third utility, and has been selected for implementation at two additional sites". Both Calvert Cliffs and Brunswick plan to implement the NUHOMS, system.
- 3.2.1 (paragraph 1) The discussion on removal from reactor sites ignores the fact that DOE is under contract to commence fuel acceptance in 1998, not 2003. The discussion in paragraph 2 relative to the mismatch between acceptance rate and discharge should point out that while some sites need more space than they are allocated, some are allocated more than they need to keep up with discharge.
- 3.2.3 The discussion on oldest-fuel-first should point out the impact that the issue can have on selection of fuel for on-site dry storage, since utilities wish to minimize the amount of fuel handling that is performed, and avoid unnecessary fuel handling.
- 4.1.1.4 (paragraphs 354 and table 4-1) Costs quoted for metal casks do not reflect the market. The licensing costs quoted seem low as well, since the NRC application fee alone is \$400,000.
- 4.1.3.4 Licensing costs are underestimated since NRC application fee alone is \$400,000. Cask costs presented in Table 4-2 vary depending on whether the cask is ventilated or not.
- 4.1.4 The statement, "...has been licensed and constructed, and another installation is being designed Both systems use .... and are designated NUHOMS-07 and NUHOMS-24." should be modified to read, "...has been licensed and constructed, and three additional installations are being designed. All of the systems use .... The currently existing facility and one being designed are designated NUHOMS-07, and two racilities being designed are designated NUHOMS-24, storing 7 and 24 assemblies in each module, respectively." Both Brunswick and Calvert Cliffs are presently designing such facilities.

- 4.1.4.1 (paragraph 2) The statement, "does not contain neutron absorbing materials" should read, "may or may not contain neutron absorbing materials"
- 4.1.4.2 The following paragraph should be added after the description of Duke Power's facility plan. \*Baltimore Gas and Electric has selected the NUHOMS-24 system for its Calvert Cliffs facility. Fuel loading is scheduled to begin in 1991, with 24 modules being loaded during the first phase of activity, and 8 modules being loaded every other year after that.
- 4.1.4.4 Licensing costs are underestimated, as NRC application fees alone are \$400,000
- 4.1.5.1 (paragraph 1) The module size of 83 PWR assemblies is not a hard number. While 83 was the number used in the topical report, individual modules storing up to 200 or more fuel assemblies can be built.
- 4.1.5.2 The statement "At present, no utility has indicated that it plans to implement this dry storage option." should be deleted. The status of MVDS is not different in this regard than that of concrete casks or dual purpose casks.
- 4.2.3 (paragraph 7) DOE should contact Northern States Power to verify their current thinking with regard to consolidation.
- 15-23 4.2.5 Costs assumed for equipment do not reflect the market.
- 5.1 Same comment on Table 5-1 that applied to Executive Summary, page ix., regarding the limited applicability of the presented cost information relative to that which a utility will see in a competitive procurement process.
- 5.2.1.3 (paragraph 9) HB Robinson is located in South Carolina, not North Carolina.
- 5.3 (paragraph 3) It is stated that horizontal concrete systems would have no effect on transportation. While it may be true that the number of shipments may not be affected, that should only be considered as one aspect of "transportation". It should be noted that the transportation system (i.e., shipping casks) can be designed to be compatible with multi-element sealed canisters, and that this can have beneficial effects on the overall system. At the reactor site, the reopening of canisters and rehandling of individual assemblies can be avoided, as well as the subsequent disposal of the canisters. If the canisters are transferred to the shipping cask dry, there is no need to place the cask in the spent fuel pool, making the entire operation more efficient, and obvisting the need for decontamination activities and liquid

waste processing. At the federal site, handling of individual assemblies can be avoided as well.

- 5.3.1 While it is true that the use of dual purpose casks has the potential to minimize the number of transportation casks purchased by DOE, that by no means implies an overall benefit to the system. DOE is trading its savings for a substantial additional cost to the utility using dual purpose casks. Coupled with the additional hardware to be disposed of with the introduction of a large number of dual purpose casks, it is not clear that the overall system benefits,
- 5.3.2 (paragraphs 2 & 4) Why should it be assumed that fuel casks would be needed/used to ship NFBC? A separate canister/cask system could be used that was designed just for that purpose.

6.1/6.2 We agree on the interpretation that the Waste Fund is not to be used to provide interim storage to utilities, where interim is defined as the period prior to 1998, when the contract calls for DOE to begin accepting fuel. When the period of time called "interim" is stretched out due to slippage in the operation of a federal facility (and subsequent acceptance of fuel), the use of the Waste Fund to provide on-site storage after 1998 seems a reasonable alternative for DOE to consider as DOE attempts to meet its contractual obligations to the utilities.

As DOE discovers that standardization in the at reactor program would lead to a more cost-effective program overall, additional incentive may exist to use the Waste Fund to encourage such standardization by participating in at-reactor storage capacity expansion.

Baltimore Gas & Electric appreciates the opportunity to provide comments on the Dry Cask Storage Study. If there are any questions concerning any of our comments, we would be pleased to discuss them with you.

Hallery sours.

JAT/PAF/lat

Duke Pourr Company Electric Center P.O. Box 33189 Charlotte, N.C. 28242 T C Menteria Vice President Design Engineering (704)373-4400



**DUKE POWER** 

October 27, 1988

Mr. Charles Head U. S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D. C. 20585

Subject: Comments of DOE/RW-0196, Initial Version Dry Cask Storage Study (August 1988)

Duke Power Company appreciates the opportunity to comment on the subject dry cask storage study. As you are no doubt aware, we have had to expand the . spent fuel storage capacity on our system on a number of occasions, beginning in the mid-1970's. To date such expansion has been accomplished primarily through spent fuel pool rerackings. In the case of one of our plants, it was possible to physically expand the size of the spent fuel pool early in plant construction. In addition, Duke has employed transshipment between plants on a limited basis to balance inventories, effectively delaying loss of storage capacity, and Duke conducted the first demonstration of the rod consolidation technology at our Oconee Nuclear Station in 1982. On March 31, 1988, Duke submitted an application to the NRC for authorization to construct and operate an Independent Spent Fuel Storage Installation at Oconee. This facility will utilize dry storage in horizontal concrete modules. In light of our extensive experience in on-site spent fuel storage, Duke feels particularly qualified to comment on the content of DOE's Initial Version Dry Cask Storage Study.

The Nuclear Waste Policy Amendments Act of 1987 contains the legislative requirements for this study. In it, Congress required DOE to study and evaluate the use of dry cask technology for storage of spent fuel on the sites of civilian power reactors until a geologic repository is available. In particular, Congress required DOE to examine two primary issues: 1) the costs, as well as the health and environmental impacts of such storage, and 2) the extent to which amounts in the Nuclear Waste Fund can and should be used to provide for such on-site storage.

In general, the report reflects an accurate representation of the current status of dry storage and other technologies available for on-site use. Also, the range of spent fuel generation rates and pool capacities used for projection of storage expansion needs appears reasonable. However, DOE's treatment of the second issue above — us. of the Nuclear Waste Fund to provide on-site storage — gives us concern. Specifically, we agree with DOE's primary conclusion regarding the use of the Waste Fund, i.e., that the

Act does not appear to authorize such use, but we disagree as to DOE's reasoning and the impact of that reasoning on the cost of spent fuel storage expansion needs beyond 1998.

Duke Power believes Congress ordered the dry cask study in recognition of, on the one hand, the likelihood that no MRS or repository will be in operation by 1998, and on the other, the obligation of the Federal government to accept spent fuel from civilian power reactors at such a rate as to eliminate the need for further on-site storage expansion by that date. In our view, this basic principle underlies the Act and the DOE/utility waste disposal contracts. To the contrary, DOE apparently takes the position that it has no responsibility for storage of spent fuel until it is accepted by DOE for transport to Federal facilities, whatever that date might be.

DOE relies on Section 111(a)(5) of the Nuclear Waste Policy Act (NWPA), which states "the generators and owners of high-level radioactive waste and spent nuclear fuel have the responsibility to provide for, and the responsibility to pay the costs of, the interim storage of such waste and spent fuel until such waste and spent fuel is accepted by the Secretary of Energy in accordance with the provisions of this Act." In short, Duke believes that the "interim storage" that is referred to in the Act is pre-1998 storage, and that acceptance of spent fuel "in accordance with the provisions of this Act" means acceptance beginning not later than 1998. In fact, the "Interim Storage Fund" and the associated "interim" storage program established by the NWPA, by the very nature of its limited capacity (1900 MTU) and limited availability (contract deadline January 1, 1990) appears to have been designed by Congress to bridge what was intended to be a short gap between what the utilities could confidently provide in the way of storage expansion and acceptance by DOE beginning in 1998.

In crafting the language of the Amendments, Congress had the opportunity to use the term "interim storage" in referring to the function it ordered DOE to evaluate, as well as the opportunity to change the 1998 date. It did neither. In fact, despite the many times the term "interim" was used in the original Act, the term "temporary" was used in the Amendments when referring to the type of storage to be covered by the dry cask storage study. Duke therefore continues to believe that the bargain struck between U. S. nuclear utilities and their customers and the Federal government calls for performance of the government's obligations beginning on a date certain, 1998, in return for payment of the full costs of the Federal program. To the extent that the DOE does not have an operational facility to accept spent fuel in 1998, the utilities and their customers should not have an ongoing openended obligation to continue to pay for spent fuel storage. That would be a one-sided bargain indeed.

The above discussion represents Duke Power's primary comment on the Initial Version Cask Storage Study. Attached please find specific comments focussing on two other issues: 1) the need for better treatment of the integration of on-site dry storage into the overall waste management system, and 2) the need to establish guidelines for reimbursement from the Waste

Fund for certain specific utility on-site activities which provide net benefits to the waste management system. We would be pleased to discuss these comments and the issues raised in this letter should you so desire,

Very truly yours,

T. C. HcKeekin, Vice President Design Engineering

RGS:dyh

#### Attachment

cc: W. E. Owen

R. B. Priory

T. F. Wyke

K. S. Canady

F. G. Hudson

R. W. Rasmussen

A. V. Carr, Jr.

W. J. Bowman, Jr.

S. P. Kraft (EEI)

#### Attachment .

Comments on Initial Version Dry Cask Storage Study (DOE/RW-0196 August 1988)

#### Integration of Dry Storage into Overall System

Section 5.3 discusses the impact of at-reactor storage options on transportation. In it, DOE concludes that no transport system benefits would accrue from any form of dry storage except dual-purpose metal casks. Duke would point out that benefits to the transport system may also result from the transfer of multielement sealed canisters such those which which we, and we firmly believe other utilities, will be utilizing in the future. In general, we believe Section 5 would be improved by a more thorough treatment of the opportunities for optimization of the entire system with on-site dry storage.

Section 6.2 raises the issue of the impact on overall system efficiency resulting from specific utility actions. It would improve the usefulness of this report if DOE would describe actions it could undertake to ensure that the DOE transport cask fleet is as compatible as possible with utility atorage systems. Obviously, we must be willing to engage in give and take with DOE as both the Federal system and the utility systems develop. As an example, DOE could outline a program of phased transport cask design and procurement which recognizes the need of utilities to be able to implement a limited number of different storage systems based on different fuel types, site constraints, etc., while providing utilities with guidelines based on reasonable weight and size limitations of the yet-to-be designed Federal facilities and transport systems.

#### Reimbursement for Utility On-site Activities

Section 6.2 indicates DOE's willingness to consider support from the Nuclear Waste fund for activities undertaken by utilities which have overall demonstrable savings for the system \*\* a whole. While we realize it is premature to try to identify every activity eligible for reimbursement and the amount of such reimbursement, we believe DOE, in cooperation with the utilities, should begin to outline the principles of such a program of support. In addition, we believe it is possible at this time to identify a limited number of eligible activities and the a-sociated level of reimbursement, particularly if eligibility criteria and payments are made subject to periodic prospective adjustment as the system develops.

#### Editorial Comments

- Section 4.1.4 We understand an additional utility has formally announced its intent to utilize the NUHOMS-24 system. DOE should confirm and so reflect.
- 17-5 Section 4.1.4.2 Dake Power currently intends to load seven modules in 1990.
- Section 4.1.4.3 Duke license submittal for the Oconee ISFSI was dated March 31, 1988.



2420 W. 26th Avenue - 100-D Denver, Colorado 80211

Public Service Company of Colorado P.O. Box 840 Denver, CO 80201- 0840

October 26, 1988 Fort St. Yrain Unit No. 1 NDG-88-0890

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

We have received a copy of the "Initial Version Dry Cask Storage Study" which was sent to Mr. Richard F. Walker and Public Service Company of Colorado (PSC) for review and comment. Overall, the report was very informative and thorough. The main comment which PSC has is that the report addresses storage of spent fuel from PWR and BWR plants only. PSC operates and maintains the Fort St. Vrain (FSV) nuclear power plant which is a high temperature gas cooled (HTGR) power plant. We currently ship our spent fuel to the DOE facility in Idaho, but due to contract limitations, we are investigating dry cask storage for use with HTGR fuel.

We realize that it is difficult to include all aspects of dry cask storage as it pertains to HTGR fuel since FSV is the only plant with this type of fuel. However, it would be helpful if any available information could be included in the report. A few additional comments are also attached to this letter for your consideration.

Again, the report was very well put tigether and we appreciate the chance to comment on it. If you have any questions, please call me at (303) 480-6910.

Sincerely,

D. W. Warembourg
Hanager, Nuclear Engineering

DWW/KD:dh Attachment

III-49

CC: K. Dvorak
M. Fisher
P Sargent

## COMMENTS ON THE INITIAL VERSION DRY CASK STORAGE STUDY

Page 13, Section 2.2:

The report states that the license issued by the NRC under 10 CFR Part 50 would constitute evidence of compliance with other regulatory requirements for dry storage, such as safeguards and security. What if the dry storage is required for a plant which is intending on shutting down and reducing the Part 50 requirements since the plant is no longer in operation? At this point, what would the level of requirements be and under which license would they be contained?

Page 24, Table 3-3 and Page 25, Figure 3-6:

The table and the figure do not reflect Colorado as requiring additional storage requirements for spent fuel. As stated in the cover letter, PSC is currently investigating dry cask storage options for the FSV nuclear power plant for the storage of spent HTGR fuel which is not under contract for

storage at the Idaho facility.

Page 28, Section 4.1.1.1:

The report specifies a typical metal dry storage cask for BWR and PWR fuel. PSC has had preliminary analysis performed which indicates that the metal dry storage cask may also be suitable for the storage of HTGR fuel. The cask is very similar to the cask described in the report (somewhat smaller due to the proposed dry loading method directly from FSV's refueling machine) with the main difference being the basket design to accommodate the hexagonal shaped HTGR fuel.

Page 29, Section 4.1.1.1:

Pertaining to the discussion on dry loading, the preliminary plan is to dry load the HTGR fuel into the metal storage cask directly from FSV's refueling machine. Normal spent fuel loading into shipping casks is currently performed dry for HTGR fuel.

Page 76, Section 5.3:

The report states that if these storage options are used, the stored fuel will be transferred to a transportation cask for shipment, and the transportation system will be virtually identical with the reference system. What is the current plan for the transfer mechanism or process and will it be standard to mate with all types of dry storage casks? If a plant is planning on shutting down, will it have to recain the original loading system functional until the time when the fuel will be transferred to the DOE shipping casks?

General Comment:

Is a means for removing the fuel from the dry storage casks required at all times? Normal reactor plant equipment will be used to load the fuel but this equipment may be unavailable if the reactor is shut down or decommissioned prior to DOE transferring the fuel to the repository.



### LONG ISLAND LIGHTING COMPANY

1

EXECUTIVE OFFICES 175 EAST OLD COUNTRY ROAD . HICKSVILLE, NEW YORK 11801

WILLIAM J CATACOSINOS

October 6, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, DC 20585

Dear Mr. Head:

The Long Island Lighting Company appreciates the opportunity to comment on the initial version of the dry cask storage study prepared by the U.S. Department of Energy. In general, we find the report informative and descriptive of the present situation on dry cask storage of spent fuel at civilian nuclear reactors.

By virtue of its existence as well as its description of spent fuel storage requirements in the near future, the report highlights the need for prompt federal action on a repository for spent fuel and other high-level radioactive by-products of reactor operation. Although the Long Island Lighting Company agrees in principle with the necessity and viability of dry cask on-site fuel storage, we can only continue to urge the federal government to move promptly in finding a permanent resolution to the spent fuel and high-level waste storage problem.

Very truly yours,

WJC:MF



SACRAMENTO MUNICIPAL UTILITY DISTRICT [] P. O. Box 15830, Sacramento CA 95852-1830, (916) 452-3211

AN ELECTRIC SYSTEM SERVING THE HEART OF CALIFORNIA

GM 88-628

October 3, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Ave., S.W. Washington, DC 20585

Dear Mr. Head:

INITIAL VERSION DRY CASK STORAGE STUDY

The District appreciates the opportunity to review and comment on the Department of Energy Report DOE/RH-0196. "Initial Version Dry Cask Storage Study." As a result of our review we have no technical comments; however, we do wish to indicate our support for efforts to streamline the licensing process. Since the need for dry cask storage facilities will increase during the next several decades, a streamlined licensing process will offer a significant advantage from a resource planning and cost standpoint for both the NRC and nuclear utilities.

Members of your staff with questions requiring additional information or clarification may contact Steve Crunk at (209) 333-2935, extension 4913.

Sincerely.

David A. Boggs General Manager



HIAGARA MOHAWK POWER CORPORATION/300 ERIE BLVD. W\_SYRACUSE. NY 13202/TELEPHONE (315) 428-6192/TELECOPY (315) 428-3406

Prezident

September 23, 1988

Mr. Charles E. Ray Acting Director Office of Civilian Radioactive Waste Management Department of Energy Washington, D.C. 20585

Dear Mr. Kay:

In response to your letter of September 1, 1988 to Mr. John G. Haehl, Jr. requesting comments on the "Initial Version Dry Cask Storage Study", please be advised that our comments on this study are being incorporated into the comments to be provided by Edison Electric Institute's Utility Nuclear Waste Management Group (UNWMG) of which we are a member. It is not our intention at this time to submit separate comments on this report.

We thank you for the opportunity that you have provided for direct comments, however, we believe working through the UNMWG is the most effective means of providing our input.

Sincerely,

AM Educi

JME:dam

cc: W. J. Donlon

C. V. Mangan

The Light company

COMPANY
Houston Lighting & Power South Texas Project Electric Generating Station P. O. Box 308 Bay City, Texas 77414

October 7, 1988 ST-HS-FD-4 R6

Charles E. Kay, Acting Director Office of Civilian Radioactive Waste Management US DOE Washington, DC 20585

Reference: 9/1/88 Letter C. E. Kay, USDOE to D. D. Jordan, HL&P

Dear Mr. Kay:

Due to the magnitude of the South Texas Project Electric Generating Station on-site spent fuel storage capacity (approximately 33 years of discharges), we have no immediate need for dry cask storage of spent fuel. Accordingly, we will not be submitting comments on the initial version of the Dry Cask Storage Study attached to the referenced letter.

Through the Utility Nuclear Waste Management Group (UNWMG), we will continue monitoring your organization's dry cask storage activities and, when necessary, will submit comments through the UNWMG.

Best regards,

J. Robert Worden

Manager,

Nuclear Fuel Division

BAH/ssf

cc: S. L. Rosen
D. J. Denver
UNWMG - S. Kraft
STP RMS



Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-222, Forrestal Building 1000 Independence Avenue, SW Washington, DC 20585

Dear Mr. Head:

#### COMMENTS ON INITIAL VERSION OF DRY CASK STORAGE STUDY

Virginia Electric and Power Company (Virginia Power) is pleased to provide the attached minor comments on the Initial Version of the Dry Cask Storage Study. In addition to our specific comments, Virginia Power wishes to also endorse the comments submitted by the Utility Nuclear Waste Management Group. We find the report to be a thorough review of the subject and would like to commend you for your overall effort.

If you have any questions on these comments, please contact Mr. M. L. Smith at (804) 273-2244.

Very truly yours,

W. L. Stewart

Senior Vice President, Power

Attachment |

cc: Mr. S. P. Kraft, UNWMG

#### ATTACHMENT

#### COMMENTS ON INITIAL VERSION OF DRY CASK STORAGE STUDY

- 1. Page vi, paragraph 2, line 3. Provide the date assumed for "start of spent-fuel acceptance by the DOE." While the reference date of 2003 is used in the next paragraph, it should also be included in paragraph 2.
- 2. Page vii, Metal Storage Casks and page 28. Section 4.1.1. Metal Dry-Storage Casks. The first reference uses 1983 for the start of metal storage cask demonstration while the second reference uses the correct date of 1984.
- 3. Page viii, paragraph 1. This paragraph indicates in two places that "feasibility" must be demonstrated as part of either technology or facility licensing under 10 CFR Part 72. Demonstrating feasibility is not required under 10 CFR Part 72, but as a practical matter feasibility is established as part of demonstrating safety.
- 4. Page 29, paragraph 2. This paragraph indicates that "the NRC requires that boron be used to prevent a nuclear chain reaction..." We do not know of any such requirement. The use of boron in storage cask design is left entirely to the discretion of the designer.
- 5. Page 31, Section 4.1.1.3, paragraph 2. Licensing storage casks and facilities for burnup credit now appears to be mainly the responsibility of the facility licensee. Our experience with the U.S. NRC indicates that completing cask criticality analyses and establishing loading controls will be our responsibility with minimal design support from the cask vendor.
- 6. Page 32, Section 4.1.1.4, paragraph 4. Not enough detail is provided to duplicate the calculation of the range of cask costs of \$50 to \$90 per kilogram from the original \$90 to \$105 per kilogram. What assumptions are used for capacity increases from burnup credit?
- 7. Page 33, Section 4.1.1.4, paragraph 1. Please define "large capacity increases" in terms of MTHM.
- 8. Page 72, Section 5.2.1.2, paragraph 1 We are not aware of any NRC requirement that spent fuel pools be licensed under 10 CFR Part 72 after expiration of a reactor's operating license. At such time, reactor operators could obtain a license under 10 CFR Part 50 allowing only possession and storage of spent fuel.
- 9. Page 76, Section 5.3.1, paragraph 2. Dual purpose casks could also be used from reactor sites that have barge access, but no direct railroad capability. Also, please discuss in more detail the report cited as Reference 15.

# ENVIRONMENTAL DEFENSE FUND

1405 Arapahoe Avenue Boulder, CO 80302 (303) 440-4901

October 27, 1988

Mr. Charles Head
Department of Energy, Office of Civilian Radioactive Waste
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

RE: Initial Version, Dry Cask Storage Study

Dear Mr. Head,

The Environmental Defense Fund (EDF) is a non-profit national organization with over 60,000 members. EDF, whose members include attorneys, scientists, economists, teachers, other professionals and citizens concerned about the management of hazardous materials, including radioactive wastes, holds a long term interest in the subject of nuclear waste management. Our goal is to encourage decision-makers, through advocacy in administrative, legislative and judicial fora, to choose environmentally and economically sound solutions to the problems which plague the nation's nuclear waste management system. To that end, EDF has filed comments on the Environmental Assessments for the first repository candidate sites; EDF was a plaintiff in several sets of litigation over the Department of Energy's (DOE) repository selection; an EDF representative participated in the Nuclear Regulatory Commission's (NRC's) negotiated rulemaking

for repository licensing reform; and an EDF representative serves today on the League of Women Voters Nuclear Waste Education Steering Committee. EDF has focused much of its attention on the risks and costs associated with the transportation component of the waste management system; in that capacity, EDF has been asked to testify before several Congressional subcommittees.

EDF supported the amendment to the Nuclear Waste Pelicy Act, initially proposed by Senator Wirth, which directed DOE to produce a study for Congress by October 1, 1988 considering the technology, costs, health effects, transportation risks and other factors associated with dry cask storage of spent nuclear fuel. The following comments on the Initial Version of the Dry Cask Storage Study reflect our deep disappointment in the facile analysis contained in this report. DOE should not release a final study until it corrects the problems catalogued below. The Department is missing an opportunity to describe a more cost effective and safer interim storage system than that system (with reliance on an MRS) which was authorized by Congress in 1987.



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Due to the significant failings of the Initial Version, or draft, Dry Cask Storage (DCS) Study, EDF urges DOE to rethink the entire composition of the final DCS Study. Rather than repeat the limitations and inadequacies of the initial version, DOE should use the opportunity of a final DCS Study to consider a scenario that meminizes the benefits of using at-reactor dry cask storage. Such a reference case would start with the premise that each reactor or reactor group stores al. spent fuel on site, either in pools with reracked. but nonconsolidated fuel rods or in dry casks. The waste management system would entail mostly single bulk shipping campaigns from each reactor to a repository, preferably immeddately after reactor decommissioning. All spent fuel and high level waste, consolidated or compacted to the extent that the technology exists, would be transported to the repository after decommissioning in this one campaign unless the reactor or group of reactors 24-1 did not have sufficient on-site capacity to hold the fuel for its entire service life. Under those circumstances, interim shipping campaigns would be allowed. If necessary to comply with the ill-conceived "contracts" that DOE has already signed with most utilities to accept title to spent fuel in 1998, DOE would honor those contracts by accepting title but not relocating the wastes, just as the Department will have to do if neither the repository nor MRS is opened by that date.

Using this system as the reference case, DOE can then compare its costs, risks and impacts to a system wherein DOE builds an MRS for dry cask storage and rod consolidation. The costs, risks and impacts of that system (the "authorized" system) include those associated with (a) the additional at-reactor storage that will be necessary, (b) the MRS, and (c) transportation from reactor to MRS and from MRS to repository. Only through the tool of this kind of whole system comparison can DOE assess the potential for reliance on at-reactor dry cask storage, including buch positive or negative factors.

Listed below, EDF identifies the major failings of the draft DCS study. They involve either unwarranted assumptions, false comparisons, or unsubstantiated conclusions.

1. Apples & Oranges: The False Comparison of Costs and Impacts

The draft DCS Study has created a meaningless comparison, in terms both of costs and of impacts. The "reference" case includes at-reactor storage and a repository, but no central interim storage facility such as the Monitored Retrievable Storage facility (MRS). Draft CCS Study, pp. 17-18. 1/ Thus, the reference case considers the total pre-repository storage system. By contrast, the systems with which it is compared, which are variations on the "authorized" system that includes an MRS, analyse the costs, risks and impacts of at-reactor storage but exclude the other pre-repository storage costs and

1/ All further page references are to the draft DCS Study.

3 5 3

Charles Head, OCRWM October 27, 1988 Page 3

impacts, i.e., those associated with storage at an MRS. (pp. 20-21.) The DCS Study is supposed to have presented an analysis of an alternative to the authorized system. For a true comparison, DOE must compare the pre-repository costs, risks and impacts of the reference case to those of the authorized case. DOE did not do so; this is a fatal flaw of the study, rendering it virtually useless as a tool for informed decision-making either by Congress or by DOE policy officials.

In Chapter 5 of the draft DCS Study, DOE announces that it will not consider human health or environmental impacts of reliance on at-reactor storage, because the NRC determined in its Waste Confidence Proceeding that the impacts were negligible. (pp. 63 & 70.) DOE has missed the very point of doing the DCS study. What are the health and environmental impacts of relying on dry-cask at-reactor storage as compared to the impacts associated with (a) in-pool rod storage, (b) in-pool rod consolidation storage, or (c) storage at an MRS. NRC simply did not address these issues. The instant study is the forum in which Congress has directed DOE to evaluate this question: DOE has failed entirely to do so.

Chapter 5 of the draft DCS Study also contains DOE's cost estimates for the alternatives considered therein. As explained above, the total costs for the reference case, given the definition thereof, include all pre-repository storage costs. (p. 68.) However, in defiance of the very purpose of the DCS Study, this cost estimate assumes the use of in-pool rod consolidation for facilities needing between 70 and 350 metric tons of spent fuel storage. (pp. 65-66.) Moreover, in keeping with the limited scope of DOE's alternate scenarios, their cost figures do not include the costs of storage at an MRS (p. 69); thus, the costs of the alternative scenarios are understated.

#### 2. Conclusions without Data: Transportation

The costs and risks of transporting spent nuclear fuel depend on many factors, the most important of which are (a) number of miles traveled and (b) how hot the fuel is (i.e., how long it has been out of the reactor core). The cursory treatment of transportation costs impacts and risks in the draft DCS Study considers three alternatives and occupies all of two pages. (pp. 76-77.) The draft DCS Study concludes that at-reactor dry cask storage will have no impacts on transportation. (p. 76.) Yet, the draft DCS Study contains no comparative mileage data, no comparative data regarding spent fuel age and, in fact, no data at all. On what hasis could DOE have reached any conclusion for this section given that it would appear from the draft DCS Study that DOE did no analysis?

As a corrolary, it is puzzling that DOE has ignored the impacts of public opinion regarding transport of spent nuclear fuel shipments. While excluding transshipments as an option (p. 7) because of concerted adverse public pressure, DOE ignores the fact that the public is likely to be against an MRS for much the same reason: its existence substantially increases the number of shipments, especially in the corridor states around such a facility. If DOE

is willing to consider adverse public opinion regarding unnecessary shipments of waste when rejecting one storage option, the Department should extend this consideration in evaluating all system facets, i.e., throughout the draft DCS Study.

#### 3. Missing the Point In Pool Rod Consolidation

In sec. 5604 of the Budget Reconciliation Act of 1987, DOE was directed to evaluate the technology, impacts, risks and costs of dry cask storage. Nonetheless, the centerpiece of DOE's draft DCS Study is a lengthy discussion of spent fuel rod consolidation which focuses on in-pool rod consolidation. (pp. 46-52.) DOE almost dismisses rod consolidation in conjunction with dry cask storage; the draft DCS Study devotes a mere seven sentences to the topic. (pp. 52-53.) Moreover, DOE appears to indicate a belief that utilities will ultimately favor in-pool rod consolidation (p. 55), notwithstanding that proponents have yet to demonstrate the technology's capacity to perform the whole task -- consolidation of both rods and hardware -- in a way which would make reliance on rod consolidation efficient. DOE not only acknowledges that consolidation has thus far failed to complete the critical second half of the task -- hardware consolidation -- (pp. 48-49), but also admits that licensing of rod consolidation as a method for increasing pool storage capacity has been controversial (and therefore expensive). (pp. 49-50.) Not only do these discussions ignore the European and Canadian successes with dry cask storage, and not only do these discussions ignore that DOE itself intends to use dry cask storage at its preferred interim storage option (the MRS), but this discussion is antithetical to the Congressional mandate for a dry cask storage study. Why is DOE so reluctant to do what Congress asked? And, why if DOE is certain that it can accomplish rod consolidation successfully at the MRS -- which will be a dry cask storage facility -- is this option not considered thoroughly in this study?

#### 4. Failing to Understand the Lessbus of the Past: Licensing

After acknowledging that licensing for in-pool rod consolidation had been controversial in at least one of the two cases where the issue arose, DOE proclaims that license-amendment costs for in-pool consolidation would range from \$200,000 to \$500,000. (p. 50.) DOE giver no figures for rod consolidation done in conjunction with dry cask storage, despite the fact that the study was request d to provide Congress with an evaluation of dry cask technology. DOE does however, estimate the costs of licensing dry casks for at-reactor storage of unconsolidated spent fuel rods: \$300,000 to \$600,000 (p. 32.) This range is higher despite the fact that neither of the existing 244 licensed dry cask technologies were done in contested proceedings, and despite the fact that DOE admits that dry cask straage is a more "mature" technology than rod consolidation. (p. 55.) What is the justification for the cost figures given, and what is the justification for not giving a cost estimate for dry cask stora; of consolidated rods and hardware? III-60

Not only should the final DCS Study address these questions and adjust the ranges as appropriate, but DOE should also consult with NRC and those organizations which DOE fondly refers to as "antinuclear groups" (p. 50) in reassessing the cost figures. EDF would suggest that DOE has failed to appreciate an important distinction. One reason that there has been no opposition to dry cask storage may derive from the technical information available to industry critics which has led to their perception that dry cask storage is safer than pool storage and is therefore preferred. The result of this perception would be that dry casks could continue to be licensed without opposition, in stark contrast to utility attempts to increase reliance on pool storage.

#### 5. Flawed Data, Flawed Result: Use of the Nuclear Waste Fund

DOE correctly analyzes the Nuclear Waste Policy Act and Congressional intent that as originally drafted, the Nuclear Waste Fund provisions were not expected to be used or designed for use to provide funding for at-reactor storage generally, or dry cask storage as a specific subset thereof. (pp. 81-84.) At the time, of course, at-reactor dry cask storage was not considered to be an integral part of the water management system. (Id.) However, DOE then fails to analyze correctly the second, and more important question posed in the amendments to the original act that direct DOE to do the DCS Study. Although DOE conceeds that if would be appropriate to use Nuclear Waste Fund monies for system components, presumably including at-reactor dry cask storage, which result in "significant demonstrable savings," DOE proceeds to dismiss at-reactor dry cask storage as such a system enhancement component on the grounds that reliance on dry cask storage would result in inequities between utilities and would result in cost inefficiency. (p. 85.) DOE includes no data to support these alleged deficiencies.

With regard to cost efficiency concerns, DOE has once again missed the point of what it was supposed to be studying. Assuming that at-reactor storage would be used as a substitute for the MRS, how do the costs of dispersed storage compare to the costs of an MRS? What are the administrative costs of each? Is it in fact less efficient to have flexible, modular dry cask units at individual reactors instead of a single mammoth facility which, once built, cannot respond in a flexible cost effective manner to a decrease in projected storage? Put another way, does the MRS truly allow for an economy of scale that is different from that which would obtain if all reactors were to rely on at-reactor dry ca-k storage until the repository became available, thereby significantly increasing economies of scale in the dry cask manufacturing industry? Would reliance on rod consolidation vendors who could move from reactor to reactor increase cost efficiencies?

EDF is surprised to see DOE arging that using the Waste Fund to subsidize at-reactor storage would lead to inequities between utilities. Would the resulting inequities be any less than those associated with the MRS? In that case, certain utilities' contribution to the Waste Fund would be paying for

facility which they do not need for pre-2003 storage. Why is it inequitable to require collective financial responsibility for dispersed storage (and rod consolidation) but not for centralized storage (and consolidation)? DOE has assumed that each utility will pay for its own dry cask at-reactor storage and that the Nuclear Waste Fund will pay for HRS storage. As EDF suggested above, if dry cask at-reactor storage is framed as an alternative to an MRS, then DOE would be taking title to the spent fuel and dry cask storage costs would be for DOE to pay from the Waste Fund. If examined in that light, then the inequities problem disappears.

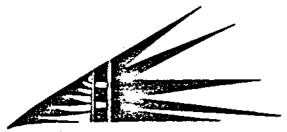
EDF hopes that these comments are helpful and that DOE makes the effort to engage in a significant reworking of the draft DCS Study so that it presents useful information to Congress along the lines of what Congress requested. The draft DCS Study does not meet this criterium.

Sincerely,

Melinda Kassen Senior Attorney

Velender Casser

cc: Senator Tim Wirth
Nuclear Regulatory Commission
Office of Management & Budget



SOUTHWEST RESEARCH AND INFORMATION CENTER Albuquerque office: P.O. Box 4524, Albuquerque, New Mexico 87106 (505) 262-1862 Washington office: 2001 O Street, N.W., Washington, D.C. 20036 (202) 457-0545

October 28, 1988

Mr. Charles Bead U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Bead:

The Department of Energy's (DOE) Office of Civilian Radioactive Waste Management has circulated for comment the Initial Version Dry Cask Storage Study, DOE/RW-0196. What follows are the comments of the Southwest Research and Information Center. Southwest Research is a non-profit, environmental organization based in Albuquerque, New Mexico with offices in Washington, D.C. Southwest Research has a long-standing interest in federal nuclear waste programs and works closely on nuclear waste-related issues with citizen and environmental groups throughout the United States.

Our specific comments are as follows:

#### Estimates of additional at-reactor storage requirements

The factor that has the most significant effect on at-reactor storage requirements is the timing of waste acceptance by the DOE. DOE erroneously assumes that a Monitored Retrievable Storage (MRS) facility will enable the Department to accelerate waste acceptance.

It will be extremely difficult for DOE to bring a MRS into operation. MRS siting has engendered widespread opposition in states under consideration for the facility. MRS siting and licensing processes are likely to experience substantial delays.

In anticipating storage requirements, DOE should assume waste will remain at reactors until a geologic repository is available and not place false hope in an early MRS.

#### Dual Purpose and Universal Casks

It appears that safety benefits could potentially derive from the the use of dual-purpose and universal casks. Dual-purpose casks

Mr. Charles Head, OCRWM October 28, 1988 Page Two

would be used for storage and transportation; universal casks would be used for storage, transportation and disposal. The use of these casks would potentially eliminate the handling operations and attendant radiation exposures involved in transferring spent fuel from conventional storage casks to transportation and/or disposal casks.

While the discussion of dual-purpose storage is fairly thorough, there is almost no mention of universal cask technology. More information is needed on the status of the universal cask technology and any relevant DOE research/demonstration programs.

#### Safety of Rod Consolidation

Rod consolidation is a means of reducing the volume of waste and increasing storage capacity. Spent fuel rods are removed from the assemblies that hold them together and loaded into canisters in a closer array. The assembly-hardware components are then compacted and loaded into similar storage canisters. Southwest Research is concerned that there may be significant safety risks associated with rod consolidation operations.

The report refers to problems encountered during the compaction of the non-fuel-bearing hardware, the potential for releasing gaseous radionuclides, the limited number of actual rod consolidation demonstrations and the lack of "publicly available" documents on the occupational doses (and other radiological impacts).

Clearly more information is needed for DOE to legitimately conclude that: "The feasibility of ir-pool consolidation has....been successfully demonstrated...." and "The safety and environmental acceptability of consolidating and storing canisters of fuel rods in storage pools have been demonstrated in safety analyses, NRC safety evaluation reports, and experience."

#### Evaluation of dry-storage concepts

Section 5604 of the Nuclear Waste Policy Amendments Act of 1987 requires DOE to conduct \*a study and evaluation of the use of dry cask storage technology at the sites or civilian nuclear power reactors for the temporary storage of spent nuclear fuel until such time as a permanent geologic repository has been constructed and licensed by the Nuclear Regulatory Commission....and is capable of receiving spent nuclear fuel.

(Emphasis added.)

While the report concludes \*h\*r-o\*xisting technologies are technically feasible, safe, and environmentally acceptable

Mr. Charles Head, OCRWM October 28, 1988 page Three

options for storing spent fuel at the sites of civilian nuclear reactors until such time as a <u>Federal facility</u> is available to accept the spent fuel, it offers no conclusions on at-reactor storage pending the availability of a <u>geologic repository</u>.

could it be that the Department does <u>not</u> believe existing technologies will be safe until a repository becomes available? If so, please explain.

\*\*\*

In general, we appreciate the information the Dry Cask storage Study (DCSS) provides on the status of nuclear waste storage technologies. It offers, perhaps, the most straightforward assessment yet that, indeed, technically feasible at-reactor storage technologies are readily available to nuclear utilities.

We are disappointed, however, that DOE chose a piecemeal approach to evaluating at-reactor storage technologies and did not take the opportunity in the DCSS, to evaluate the use of at-reactor dry storage casks in a broader context. The DCSS would do a greater service to decisionmakers both in and outside the DOE had it included a more comprehensive analysis and comparison of a variety of waste storage/tranport/disposal configurations.

For instance, Southwest Research would like to see an evaluation of a repository system that puts waste acceptance "enhancement" last on the list of objectives and safe storage, transport and disposal first. DOE would examine a variety of waste management configurations from the standpoint of how best to assure quality control, minimize transport, and minimize waste handling. For instance, Southwest Remearch would like to see an analysis of a configuration wherein nuclear utilities store unconsolidated fuel on-site in dual-purpose or universal casks pending shipment via dedicated train to a geologic repository. We'd also like to see an analysis of the extent to which the Nuclear Waste Fund Could be used to encourage such a configuration.

DOE does a disservice in not using the DCSS as an opportunity to examine the potential for dry cask storage and other at-reactor activities to contribute to the goals of the overall waste management system.

Sincerely,

Canchine Petti
Furnime Petti
Nuclear Waste Safety Project

# -X TRANSNUCLEAR, INC.

September 28, 1988

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, DC 20585

Subject: Comments on DOE/RW-0196

Initial Version - Dry Cask Storage Study

Dear Mr. Head:

The description of dual-purpose casks in Section 4.1.2.1 of the study contains a reference on page 34 to a paper which discusses Transnuclear's experiences with the NRC relative to the certification of metal storage casks for transport.

The authors of the study have reached the wrong conclusion from the paper, a copy of which is attached for your information. There was not meant to be any implication that only "minor modifications" would be required to a storage cask to meet NRC's requirements for transportation. On the contrary, the intent of the paper was to show how difficult it is to get a Part 71 license for any cask with innovative design features.

As recognized in the last two paragraphs in this section, NRC requirements for certification of a transport cask are very different from those for a storage cask. These paragraphs list storage cask components which might require change in order for the cask to meet transportation requirements: lid, sealing system, basket, and body. Since every major component might require modification, it is clear that more than "minor modifications" will be necessary to meet transport certification requirements.

We appreciate DOE's recognition of Transnuclear's contributions to storage and transport cask technology. However, we would also appreciate a correct rejecence to our paper. The following paragraph would be an apprecriate replacement for the first paragraph on page 34:

"It is reported that several vendors of metal storage casks plan to apply to the NRC for transportation certificates. Some of the designers of these casks have incorporated features and used





materials which may make the casks easier to license for transport under 10CFR Part 71. However, the difficulties of licensing a cask for transport should not be underestimated. 12".

The next two paragraphs may need to be rewritten slightly and we suggest that the last paragraph in Section 4.1.2.3 be moved to the end of Section 4.1.2.1.

In Section 4.1.2.2, the reference to the Transnuclear Company should be changed to Transnuclear, Inc.

In Section 4.1.2.4, it is not clear what is included in the estimated additional costs of \$50,000 to \$300,000. Is this only an adder per cask for the upgraded components or does it include amortization of the additional engineering, design, and testing work which will be required? In Reference 11, the \$7/KgU cost is said to be the additional cost of acquisition and handling for a dual-purpose cask. This reference estimated the cost of a dual-purpose cask to be \$990,000 and the cost of a storage-only cask to be \$880,000, a difference of \$110,000, excluding the costs of design and licensing.

We will be pleased to discuss our views on dual purpose casks with OCRWM. Please call if clarification or more information is needed.

Very truly yours,

Bill R. Teer

Senior Vice President

BRT:nb 1618N

Enclosure

#### OPPORTUNITIES IN THE CERTIFICATION

OF

METAL STORAGE CASKS FOR

SPENT FUEL TRANSPORT

by

Bill R. Teer Transnuclear, Inc. January 1988

The current regulatory climate in the Transportation Certification Branch of the Nuclear Regulatory Commission is such that the applicant for a Certificate of Compliance must submit a well prepared, comprehensive Safety Analysis Report which meets all requirements of Regulatory Guide 7.9. All methods and procedures for structural, nuclear and thermal analyses must be qualified and benchmarked. The materials used for the containment boundary, impact limiters, neutron and gamma shields and internal structures must have documented and reproducible properties and, ideally, be referenced in a recognized national standard. And, finally, in most cases, the analyses must be supplemented by model or full scale test results.

Where, then, do the opportunities arise if the requirements are so rigid? All cask designers believe their design is new and improved when compared with others. As the improvements frequently are made by using new materials which were analyzed with new tools and put together in new ways, the cask designer has the opportunity to prove the design to the NRC.

The paper will discuss some recent Transnuclear experiences with the NRC Transportation Certification Branch in attempting to get the TN-BRP and TN-REG casks certified for the transport of spent fuel. We have utilized non-standard materials for the baskets and a modified material for the containment. The impact limiters are not of a conventional design. Some of our analytical procedures are proprietary codes which are not used by others in the industry.

These characteristics have combined to make the certification process for these casks interesting and lengthy. Compromises have been necessary to reach the present status. More analyses, tests and compromises will be required before a Certificate of Compliance is issued.

#### INTRODUCTION

The metal storage casks referred to in the title of this paper are the TN-BRP and the TN-REG which are large transport/storage casks designed by Transnuclear for Nuclear Fuel

services, Inc. (NFS). The basic program and the details of the casks have been described at previous INMM meetings (1,2) and elsewhere, so only a brief summary for background will be presented today.

As a result of special terms in two reprocessing contracts in the early seventies, NFS acquired ownership of 85 assemblies from consumers Power Company's Big Rock Point (BRP) nuclear power station and 40 assemblies from Rochester Gas and Electric Company's R.E. Ginna (REG) station. These assemblies were not reprocessed and were still in the pool at the West Valley facility when the Nuclear Waste policy Act was signed in January 1983. In order to empty the pool at West Valley, NFS and the Department of Energy entered into a cost sharing contract in early 1984 to develop and demonstrate dual purpose Shipping and storage casks which would be used for transporting the NFS owned fuel from West Valley to DOE's Test Area worth facility at the Idaho National Engineering Laboratory and for demonstrating extended storage at that facility. The broader objectives of this program are to:

- Demonstrate the feasibility of a large transportable storage cask for aged spent fuel;
- Provide a design and develop the manufacturing techniques for such a cask;
- Provide data and information useful in demonstrating dry cask storage technology;
- Provide verification of spent fuel integrity in long-term dry storage.

NFS selected Transnuclear, Inc. to provide two casks for this purpose, one for the transport and storage of the BRP fuel and the other for the REG fuel. The casks were designed by Transnuclear, fabricated by Kobe Steel, Ltd (KSL) and delivered to the West Valley site in the summer of 1985; both casks were two weeks ahead of schedule. The total elapsed time between start of design and delivery of the first cask to West Valley was less than 19 months.

The characteristics of the fuel and design constraints on the casks are given in the references. Figure 1 shows a longitudinal section and a cross section of the TN-BRP cask. The TN-REG is the same basic design. Principal dimensions of both casks are given in Table 1.

The focus of this paper will be on the certification activities with both DOE and NRC. Although the TN-BRP and TN-REG casks were originally intended for DOE certification, they were the first casks designed to comply with both the U.S. Nuclear Regulatory Commission's (NRC's' transport regulations in 10CFR71 and the storage regulations in 10CFR72. They are also designed to comply with the U.S. Department of Transportation (DOT) regulations in 49CFR173. In addition, the

NRC's Regulatory Guides, Series 7, served as a basis for the designs and for preparation of the Safety Analysis Reports (SAR's).

#### DOE CERTIFICATION

It was intended originally to perform the transports of the BRP and REG fuel under certificates issued by DOE. Oak Ridge National Laboratory (ORNL) was designated by DOE to review and approve the SAR's prepared by Transnuclear.

The simultaneous development of two different cask designs required an innovative approach to certification. It was clear from the beginning that time did not permit adhering to the normal procedure of first developing a complete cask design, followed by preparation of a complete SAR prior to the first submittal for certification review. All parties agreed that sections of the SAR could be submitted and reviewed as they were completed. This approach saved schedule time, especially in the few instances in which ORNL's review demonstrated a need for design changes which could be made prior to finalizing other aspects of the design.

In all other respects, ORNL's review utilized the same approaches as used by the NRC. The adequacy of the designs was judged by full compliance with federal regulations and the requirements of NRC's Regulatory Guides. Questions and comments were formally documented by Oak Ridge and led to controlled revisions of the SAR's by Transnuclear. The final revisions served as a basis for ORNL's technical review report (3) and recommendation to DOE to issue certificates for the transports.

#### NRC CERTIFICATION

In August 1985, a decision was made by DOE to perform the transports under NRC Certificates of Compliance (COC's), rather than under DOE certificates and Transnuclear was instructed to apply for COC's at NRC. We made relatively minor changes to the SAR's in format to facilitate the NRC's review and submitted the TN-BAP SAR to NRC in mid-September 1985 and the TN-REG SAR one month later. At that point we began to realize that we would have many opportunities for discussions with the NRC. The chapter by chapter submitted of the SAR's described earlier did not result in the tightly knit volume desired by NRC. One of our opportunities then was to reformat the SAR's to meet exactly the requirements of Reg. Guide 7.9 and incorporate all information developed in discussions with the ORNL reviewers.

Additional opportunities arose as NRC reviewed the details of the designs and in particular the properties of the materials used for the cask body, basket and impact limiters.

One common opportunity which we did not have was to make design changes in response to NRC concerns. Both casks, as mentioned earlier, had been fabricated and delivered to the customer. We have to prove that the as-built casks meet NRC requirements.

Several meetings have been held with NRC on questions and comments related to the TN-BRP cask and basket designs. The questions and comments were formally documented by NRC in a letter dated February 12, 1986.

Acceptable approaches to answering the questions and comments have been identified except for those relating to the design of the impact limiters and to the use of boron stainless steel as a structural material for the baskets.

#### SPECIFIC ISSUES

#### Containment Material:

The quick and easy way to meet fracture toughness requirements for thick walled monolithic vessels at low operating temperatures is to use an austentetic stainless steel for the cask body. Transnuclear elected to use a standard carbon steel modified by the addition of small amounts of alloying elements to achieve specified low temperature properties. This material, SA-350LF3, has been found acceptable by both ORNL and NRC.

Although the ORNL reviewer accepted the material on the basis of Charpy tests on impact samples which showed 100% shear fracture, we had an opportunity to use a different criteria to prove the material to the NRC. The reviewers at NRC required us to prove that the nil ductility temperature of the material was satisfactory. We were able to meet both criteria and convince both sets of reviewers that the material was acceptable. This illustrates that there are plenty of opportunities for the applicant to prove versatility.

#### Basket Material:

Constraints on the allowable size and weight of the BRP and REG casks dictated a high capacity in a minimum space envelope. One of the design features developed by Transnuclear to meet this requirement was use of a combined structural neutron poison material for the barket. Interlocking foron stainless steel plates assembled in an egg-crate design provided the minimum size and weight basket which would control criticality and meet structural requirements.

Once again, we encountered a difference of opinion between the ORNL and the NRC reviewers. After much discussion and detailed analyses Oak Ridge decided that the baskets were acceptable even though some yielding in a few of the outer plates was expected. Analyses showed that the fuel assemblies would not shift into a more critical configuration after the 30 foot drop accident. Material properties used by Transnuclear in the basket analysis were determined by tests on the samples from the actual plates used in the casks.

However, as the boron stainless steel is not an accepted material with properties which can be referenced in a code manual, NRC has refused to accept it. Transnuclear and other DOE subcontractors have taken the opportunity to do dynamic analyses of the baskets to prove acceptability. Tests of scale models and full size mockups of the basket have been proposed. The NRC reviewers have continued to insist on a standard material.

Design and operational changes have been proposed to alleviate concerns about the post accident condition of the basket and fuel. Aluminum inserts around the periphery of the basket at the inner surface of the cask will be used to stiffen and add support to the edges of the basket plates. Current plans are to ship only one-half the total number of assemblies at one time with stainless steel inserts in alternate basket compartments. This allows a sub-critical configuration to be maintained without any dependence on the basket for structural support or to maintain neutron poisons between the fuel assemblies.

Certainly a tremendous opportunity has arisen for materials development and standardization program on boron steel, stainless borated aluminum and other combined structural/poison materials. Ιf sufficient time were available. Transnuclear would recommend to DOE that such a program be undertaken for the BRP/REG basket material.

#### Impact Limiters:

Many spent fuel casks designed in recent years have used polyurethane foam in impact the limiters for absorbtion. Transnuclear's TN-8 and TN-9 truck casks, use a combination of redwood and balsa and we have elected to stay with wood for our impact limiters. A major advantage is the ability to get adequate energy absorbtion in a smaller envelope as compared to foam. In addition, the use of different woods and grain orientations gives the designer flexibility not present with the use of foam. The anisotropic wood proterties and the different grain orientations require a complex analysis to predict the performance of the wood filled limiters. This analysis, which is performed with a Transnuclear developed computer code, must be verified by obtaining force-deflection. curves from scale model tests.

Dynamic drop tests will not be conducted in contrast to earlier plans; static tests will demonstrate the capability of the impact limiters, i.e., provide the force-deflection curves and prove the adequacy of the attachments.

other Cask Components: -

Trunnions

Bolted on trunnions provide the cask lifting and tie-down attachments. The design basis was to take loads by friction between the trunnion flange and the cask body. This design approach and subsequent design and analysis was accepted by the ORNL reviewers. During fabrication, a 500 ton load test was applied to the tie-down shoulder of the rear trunnions. Only the two highest stressed bolts were removed for inspection and after replacement all bolts were sealed to prevent untorquing. The NRC, however, will not accept reliance on friction and it was necessary to change the trunnion design to utilize the engagement area between the trunnions and cask in addition to the bolts in shear to balance the lifting and tie-down loads. Modifications to the trunnion flanges and some of the trunnion bolts will be required.

Lid Bolts

Fine mesh finite element analysis was performed in the lid and bolt area to assure maintenance of the seal during the drop accidents. This analysis led to an extremely tight tolerance between the lid and the cask to limit lateral movement and longer lid bolts to minimize stresses. Final analysis showed no loss of seal during the maximum bolt stretch. Several of the highest stressed bolts showed yield in approximately 10t of this cross section. The design and analysis was acceptable to the ORNL reviewers but the NRC reviewers do not accept yielding of the lid bolts. This will require replacing the lid bolts with bolts of a higher strength material so that it can be shown that there is margin to yield.

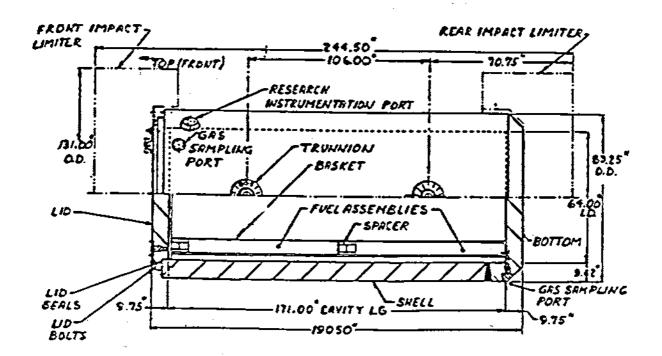
#### SUMMARY

The certification of an advanced design spent fuel cask presents many opportunities for the applicant to present a case to the NRC. We hope our experiences will help others plan their strategies to eliminate many of the opportunities with which we were presented.

We believe our current strategy will result in a Certificate of Compliance for both the TN-BRP and TN-REG casks being received at some point in the not too distant future.

#### REFERENCES

- Bill R. Teer, "Demonstration of Cask Transportation and Dry Storage of Spent Fuel." Proceedings of the 25th Annual Meeting of the Institute of Nuclear Materials Management (1984).
- 2. Bill R. Teer, Kurt Goldmann, Michael Mason, "Transportable Storage Casks for NFS Spent Puel." Institute of Nuclear Materials Management Seminar on Spent Fuel Storage Technology, Washington, D.C., January 21, 1987.
- 3. L.D. Bates, et.al., "Summary of the Technical Review of the Safety Analysis Reports for Packaging (SARP) for the Transnuclear Transport/Storage Casks: TN-BRP and TN-REG." ORNL/TM-9889, July 1986.



LONGITUDINAL SECTION

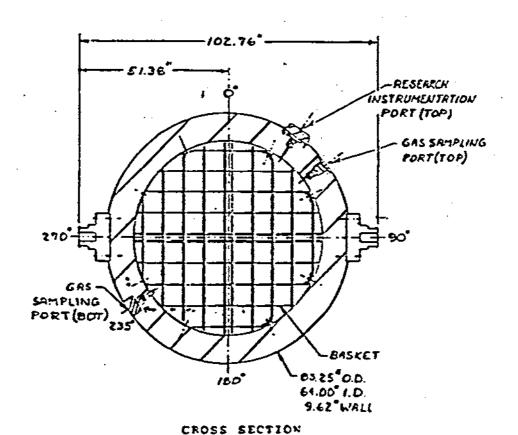


FIG. 1 - TH-BRP TRANSPORT/STORAGE CASK

III-75

TABLE 1

CASK PARAMETERS

	TN-BRP	TN-REG
CAVITY I.D., INC.	64.00	** **
	64.00	71.75
CAVITY LENGTH, INC.	171.00	163.00
WALL THICKNESS, INC.	9.62	9.25
CASK O.D., INC.	83.25	90.25
BOTTOM THICKNESS, IN.	9.75	8.25
LID THICKNESS, IN.	9.75	8.50
OVERALL LENGTH, IN.		
- W/O IMPACT LIMITERS	190.50	180.00
- WITH IMPACT LIMITERS	244.50	234.00
SPACING BETWEEN TRUNNIONS, IN.	106.00	106.00
NUMBER OF FUEL ASSEMBLIES	85 BWR	40 PWR
DECAY HEAT LOAD, KW	6	5.5

#### CONFIRMATION OF TELECOPY



145 MARTINVALE LANE \* SAN JOSE, CALIFORNIA 85119 \* PHONE: (408) 629-9800 TELEX: (RCA) 278971 \* TELECOPY: (408) 281-6106

> October 26, 1988 WJM-88-217

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Subject: NUTECH Comments on Initial Version Dry Cask Storage Study

Dear Mr. Head:

NUTECH appreciates the opportunity to provide comments on the subject report. We hope that our comments are helpful to the Department of Energy (DOE) in the preparation of the final report and they contribute to the successful implementation of DOE activities associated with the Nuclear Waste Policy Amendments Act of 1987.

#### General Comments

As stated in the executive summary, one of the elements studied to evaluate costs and impacts of dry storage was the potential effects on the transportation system. However, limited detail is presented in the report. It is concluded in Section 5.3 that most dry storage options "would have no effect on transportation."

The subject of interfaces between the various dry storage systems and the transportation system is complex and a function of the specific storage systems selected by the utilities. The systems chosen are influenced by economics as well as plant handling considerations (crane capacities, transportation access, etc.). These interfaces cannot be fully addressed in the near term since the DOE transportation system development is still in its early design stages while many dry storage system designs have been developed to the point of field implementation.

Mr. Charles Head U.S. Department of Energy

Notwithstanding the above described plant unique considerations and the differences in timing between utility dry storage decisions and DOE transportation system development activities, there can be a substantial benefit to the overall transportation system (e.g. required fleet size cask turnaround time, if transfer activities at the plant site are optimized at an early date. Direct transfer of multi-element shielded canisters to the DOE system without returning them to the fuel pool provides an opportunity to facilitate these interfaces and to realize these savings. Additional benefits accrue to plant workers in terms of reduced occupational exposure and lessened impact on overall plant operations, especially in the fuel pool area.

These benefits of direct transfer of canistered fuel to the transportation system, and the associated interfaces should be more fully explored in the report, similar to the evaluation of dual purpose casks. The combined goal of the DOE and the utilities is to provide for the safe, reliable, and economical dry storage as well as transportation of spent fuel. Further study of the interfaces between the concrete modular storage system and the transportation system can result in optimization of the combined systems prior to the time that the transportation program is completed and DOE acceptance of fuel commences.

#### Specific Comments

- Two of the most important considerations for the various dry storage concepts are their economics and licensing status. Accordingly, these considerations should both be summarized in the Executive Summary section of the report. Although the economics aspect of the concepts is adequately covered in the table on page ix, summary of the licensing status is totally absent. It is recommended that an appropriate table be included and referenced in paragraph 3 (page viii) under the subsection entitled "Licensing of Storage-increase Options". The table should identify submittal dates and licensing status of both Topical Reports and site license applications.
- The second paragraph under the aforementioned subsection (page viii) should be expanded to indicate that such proposed rule making is also applicable to horizontal concrete modular storage so as not to bias opinion toward metal cask storage per se.
- The Executive Summary should also clearly identify which utilities have chosen which storage system. This could be provided under a separate subsection entitled "Utility Selection of Storage-increase Options" or also be included in

27-4

4.

the subsection entitled "Estimated Costs" (page viii) to eliminate the uncertainty indicated as to storage method selection by the utilities.

- The report states that the costs of dry storage are uncertain. It should be noted that these costs may be more certain to utilities than to the report authors since much cost information is developed as a result of the utility procurement process. In the cases where utilities have made dry storage decisions detailed cost estimates are provided by vendors based upon thorough knowledge of component costs and past experience with dry storage system development. For example, concrete modular storage system dry shielded canisters have been designed and fabricated. Detailed costs are prepared by fabricators based upon the experience of fabricating these components.
- 5) The first objective of the study is to consider "..,the extent to which the storage on the sites of civilian nuclear power reactors affects the costs and risk of transporting spent fuel..." Interfaces between the concrete modular storage system and the transportation system can provide economic benefits as well as enhanced safety through the transport of welded canisters which have an additional sealed barrier between the fuel and the environment. These benefits should be more fully evaluated in the report.
- 6) Page 2 "..Various design concepts..." Some dry storage systems are developed beyond the conceptual stage and should be so noted. Designs which have not been licensed or developed to the point of licensing topical report review should not be included i \_eport.
- 7) Paragraph 3 (page 10) under Subsection 2.1.2 "Dry-storage Concepts" of Chapter 2, Background, should be expanded to indicate additional site license applications anticipated in 1989. Optionally, the above expansion could be applied to the second paragraph on page 13 (i.e., where an additional license application is referenced).
- 8) Section 4.1 It is stated that "These methods have been or are being reviewed by the Nuclear Regulatory Commission."
  Only metal casks, modular concrete storage, modular vaults, and unventilated concrete casks have been or are being reviewed by the NRC.
- 9) Subsection 4.1.1.1 (page 28) Based on 10CFR72 licensing actions to date, water is not a typical candidate neutron-absorbing material in metal dry storage casks.

- 10) Subsection 4.1.1.1 (page 29) The last paragraph on page 29 should be revised to clarify the loading method for horizontal concrete modules (i.e., dry loading is not used for horizontal concrete modules and is not discussed in Section 4.1.4).
- 27-11 Approval of the Castor IC metal storage cask by the NRC should be identified in Section 4.1.1.3 on page 31.
- The reference to Section 4.2.4.3 under Section 4.1.3.3,

  "Certification and Licensing" on page 38 is incorrect. No
  Subsection 4.2.4.3 exists, and no discussion of concrete
  temperatures is included in the licensing status of concrete
  modules (Section 4.1.4.3).
- 13) The second paragraph under Section 4.1.4 \*Horizontal Concrete Dry-storage System\* on page 40, should be revised to more accurately reflect the licensing review status of the NUHOMS\*-24P system, including both the Topical Report and the Oconee Site License application.
- 14) The second paragraph under Section 4.1.4.1 on page 41, should explain that the NUHOMS®-24P system does not contain neutron-absorbing materials based on burnup credit, and reference Section 4.1.4.3. Also, the heat generation rate should be 0.66 kilowatt.
- 15) Section 4.1.4.3 Licensing status and issues on page 42 should reference specifically the NUHOMS-24P system Topical Report and Duke Power's Oconee site license application, both of which should be included in the references starting on page 59 of the report.
- 16) Section 4.1.4.4 The first paragraph on page 43 (under Section 4.1.4.4) needs to be revised to clarify transfer cask and hydraulic ram costs. Table 4-3 is not consistant with the preceeding paragraph. No transfer cask is itemized in the Table, and the transporter cost is described in the preceeding paragraph as included in other fixed costs.
- 17) Section 4.5.1.5 Cost should reflect the conclusions that can be drawn from the cost comparison table given in the Executive Summary section i.e., that horizontal concrete module storage presently represents the most economical Cry storage method.
- 18) Section 4.5.3 Summary should be revised to indicate present utility trends, based on actual utility systems selections, toward dry storage and predominately toward horizontal concrete modular storage.

19) Section 5.3.1 - Potential effects of using dual-purpose casks, gives a misleading conclusion regarding the savings that could result from use of dual-purpose casks. Based upon the relative costs of dry storage presented in the report, utilities would pay a significant penalty of millions of dollars in storage casks (based on the comparative casks presented in the Executive Summary, and the additional dual-purpose cost of \$7/kg) in return for the DOE's transportation cost savings.

Please let us know if any of our comments require explanation or clarification.

Very truly yours,

W. J. McConaghy, P.E.

Vice President

Waste Management Business Group

WJM:wp

27-13



ONS Gesellschaft für NickleonService mbH - Goethern \$8 - 4300 Essen?

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S. W. Washington, D.C. 20585

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#### Initial version of Dry Cask Storage Study

Dear Sir,

as requested by Mr. Clay we would like to transmit the following comments to you, referencing each time to the corresponding page of your study:

#### Page 1x

The metal casks at Surry may still lead to costs a ound 110 \$/kg U; the reason for this cost-level lies in the fact, that the casks are built as dual-purpose (transport/storage) casks in correspondance with IAEA regulations.

In the US they are only licensed so far as ringle purpose/storage wasks. GNS ist actually introducing a new cask type - CASTOR V 12 - in the US market, which raduces the costs already today to 60 \$/kg U. In this figure the potential for cost reduction in case of serial production is not yet reflected.

#### Page 37/42

The ventilated concrete cask and the NUHOMS concept, both rely for heat removal on the surrounding air which passes

23-1

the main shielding (concrete) through special ducts, which apparently have no inlet or outlet filters. The unfiltered air cools the basket on whose surface of stainless steel a dose-rate of >1500 rem/h exists. The unfiltered air may allow the entrance of insects or other animals which may be killed - eventually plugging the ducts - or at least risk mutation.

If filters are foreseen to avoid this scenario, then the advantage of completely passive cooling is lost as the filters need replacement or surveillance for plugging as this may lead to thermal overloads.

I suppose that these questions have been asked by NRC, but in no evaluation could we see any response to them.

Perhaps you could clarify prior to the emission of a final statement.

#### Page 53

25 3

The demonstration list for FRG omits the following: CASTOR-AVR loaded with HTR-fuel since 1983 and the one-year storage demonstrations with BWR-MOX-fuel in 4 CASTOR KRB-MOX casks in 1986/87.

Another storage demonstration took place with CASTOR WWER 1000 in 1984 in the Voronesh power station in the USSR. Furthermore, casks are foreseen as emergency storage capacity of the French fast breeder Super-Phenix.

Please feel free to use these informations as seems best for your purposes.

Very sincerely Yours,

III-83



### FW ENERGY APPLICATIONS, INC.

8 PEACH TREE HILL ROAD + LIVINGSTON, NEW JERSEY 07039 + PHONE 201-535-2354

October 24, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW 322, Forrestal Building 1000 Independence Avenue, S.W. Washington D.C. 20585

Reference: Initial Version - Dry Cask Storage Study (DOE/RW-0196)

Dear Mr. Head:

We appreciate the opportunity to review the referenced report and are pleased to submit the following comments for DOE's consideration:

- Title of the report "Dry Cask Storage" is not very appropriate when consolidation, vaults and horizontal concrete systems are embraced.
  - 2. Page vi Executive Summary: Estimate for additional at-reactor storage requirements.

It would be useful and appropriate to explain exactly how the use of a fuel assembly capacity standard as opposed to Metric Ton of Heavy Metal (MIHM) standard will affect cost comparisons between systems.

3. Page vii para 6 Modular Vault Dry Storage Systems

FWEA would like to suggest that the paragraph be modified to read, "This concept has received NRC Topical Report approval but as yet there has not been the time to implement the modular vault system in the United States. The system has been utilized for 17 years at the Wylfa facility in the U.K."

- Section 4.1.5.3 Licensing Status and Issue s Modular Vault Dry Storage System.
  - a. FW Energy Applications, Unc. (FWEA) does not understand why the licensing issues cuscussed by the NRC in approving the modular vault dry store are so fully reported as compared

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29-2

#### 4. a. cont'd

to the other systems. For example, "safety evaluation report for NUTECH Horizontal Modular System for Irradiated Fuel Topical Report" issued by the NRC, dated March 28, 1986 discusses issues such as the need to annually inspect the inside surface of HSM concrete because of non compliance with the concrete temperature limits of ACI-349-80, and operating procedures, radiation levels, maintenance/acceptance tests all requiring site specific development.

b. First paragraph of section 4.1.5.3 seems to imply that cover gas is an NRC concern for the MVDS system. In the base submittal of the MVDS topical report, use of nitrogen as a cover gas was included and approved by the NRC. As a separate item we seeked approval by the NRC of the procedure that will allow use of air as the cover gas. This procedure is subject to further research and review. Use of air as the cover gas enhances reliability of the dry storage system and MVDS is the only system where fuel temperatures are low enough (160°C vs approx 340°C) and use of air is feasible.

On the contrary to the presentation in the report, MVDS offers a significant advantage in storing the fuel in an inert atmosphere at 160°C vs 340°C providing larger margin of safety for the prevention of degradation of the fuel assembly during the long term storage.

With regards to the sample testing of the o-ring seals after 5 years, FWEA has made provisions for this operation to be carried out efficiently and safely.

Second paragraph of section 4.1.5.3 leaves the reader uncertain if the concrete temperature in the MVDS are acceptable to ACI-349-80. The issue was raised only because the incorrect code had been referenced and not because of a concern over the normal or fault condition temperatures. MVDS meets ACI-349-80 concrete operating temperature limit of 150°F for ambient air temperatures up to 100°F.

d. Third paragraph of section 4.1.5.3 implies that inadequate operating procedures, maintenance programs, public and worker radiation exposures pertain to the MVDS. This is not the case and similar to any other system, NRC commented that these items can only be finalized on a site specific basis.

29-5

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- Section 4.1.5.4 Estimated unit costs of Modular Vault Storage at reactor sites.
  - a. The first paragraph is misleading and inaccurate in the view of FWEA. There is no relevant experience of horizontal concrete cask systems even at the minimal site storage capacities of 100 MTHM. The C.P. & L demonstration which has not been demonstrated as yet with current capacity of less than 10 MTHM does not provide significant or relevant data base for costs. The Oconee project would not provide "experience" based data until further into the construction. There is a great deal of experience of construction and operation of vault dry stores in the UK over 20 years from which FWEA has derived their vault technology. FWEA is prepared to offer firm price proposals for the MVDS system.
  - b. Based on comment a, FWEA does not understand the basis of the assumption that modular vault dry storage costs could be 50% higher whereas costs published by other system vendors are more accurate.
    - c. The second paragraph presents the published cost data for the vault storage option but in a way that is not consistent with the presentation of alternative system costs. The DOE draft provides total unit cost (\$/Kg) for three vault storage capacities. Alternative systems (cask and horizontal concrete) have fixed costs and an incremental rate. The data published by FWEA (ref. 25) allows presentation of vault costs in the same way (see table below) as cask and horizontal concrete and we request that this is done.

Table - Factors Used In Estimating Unit Cost Range For Storing Intact Fuel in Modular Vault Store

	Low (	Cost	High	Cost
Factor	Fixed	Variable	Fixed	Variable
NRC Licensing	507,000		659,000	•
Equipment & Installation	6,632,000		8,621,600	
Total Fixed Cost	7,139,000		9,280,700	
Cost of Modules (a	a)	30		38
Loading Unloading		2 2		3 3
Total Fixed Cost	7,139,000		9,280,700	
Total Variable Cos	st	34		€4

(a) Cost in dollars per kilogram of heavy metal.

29-12

29-13

In addition, on studying the cost make up for the various dry storage schemes, they do not seem to be made to the same level of total cost. For example horizontal concrete storage modules does not seem to consider the cask loading, unloading or placement cost. There does not seem to be any quantification on the ongoing cost e.g. annual inspections recommended by the NRC or any monitoring equipment needed.

6. Section 4.4 - Dry Storage Experience in Other Countries

Two types of dry storage facility have been extensively tested in the United Kingdom. The five storage vaults of Wylfa N.P.S. have been in operation for an extended period (over 17 years in the case of three of the vaults) and have received and discharged hundreds of thousands of fuel assemblies in their role as interim storage facilities between the reactors and UK reprocessing. This experience has allowed FWEA in conjunction with GEC Energy Systems to have complete faith in the performance of their modular vault dry store (MVDS) as a safe and economical interim storage facility for irradiated fuel.

The United Kingdom's first three vault dry stores went into commercial operation in 1971 at Wylfa Nuclear Power Station, North Wales. Each storage vault has a capacity of 83 MTHM and is used for the initial cooling period of the fuel when first removed from the on load reactor. Two further vault facilities were added in 1979 and 1980, these were much larger and each had a capacity of 350 MTHM, these interim storage vaults were to act as a buffer for the reprocessing plant at Sellafield.

The original three vaults used natural thermosyphon cooling with the fuel stored in a storage tube with a carbon dioxide environment. The additional vaults store the fuel in air, and are of a forced cooled type due to physical constraints imposed by constructing them as an extension to the operational reactor building.

The Central Electricity Generating Board in conjunction with the South of Scotland Electricity Board is in the process of finalizing the design for a centralized vault storage system for the storage of irradiated AGR fuel for periods up to 50 years.

FWEA, therefore requests that the DOE report be amended to reflect this experience.

Section 4.5.1.2 - Time needed for implementation.

In the second paragraph we accept that NRC Topical Report approval of a dry storage system removes an element of uncertainty in the site specific licensing schedule, but do not understand why the modular vault dry store system (i... the Foster Wheeler MVDS) is not cited as having this advantage following NRC approval in March 1988.

29-1

8. Section 4.5.1.3 and 4.5.1.4

FWEA agrees that certain conditions could be specific to a particular reactor site such as the absence of large fuel-handling cranes or an insufficiently large storage pool handling. In addition utilities are reluctant to undertake any secondary activities that could interfere with the operation of their nuclear reactors. Modular Vault dry store system caters specifically to these needs and does not require any modifications to the existing pool equipment and achieves high production rates using small casks.

 Chapter 5.1 - Estimated Aggregate Costs of providing additional attreactor storage

The unit cost estimate data included in Table 5-1 is not apparently consistent with the figures quoted in chapter 4. For example, using data in chapter 4, lower cost for 100 MTHM case for horizontal concrete modules results in \$58/kg; 1,800,000+40. instead of \$45/kg.

Once again, FWEA appreciates the opportunity to review and comment on the initial version of the dry cask storage study. If you have any questions or need additional information, please contact me on (201) 55-2372. Also we will welcome the opportunity to discuss our comment with you or your staff.

Very truly yours,

BKA/qd

Program Manager

B. K. Agarwal

Two World Trade Center, New York, N.Y. 10048-0752

October 27, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

> SUBJECT: U.S. Department of Energy Report DOE/RW-0196, "Initial Version -Dry Cask Storage Study", August 1988

Dear Mr. Head:

In accordance with the request of OCRWM Acting Director Charles E. Kay in the August 22, 1988 cover letter to the subject report, Ebasco is pleased to provide our comments (attached) on this Initial Version of the Dry Cask Storage Study. As you may know, Ebasco has been active in all aspects of spent-fuel storage for many years, including reracking of utility spent-fuel pools, Independent Spent Fuel Storage Installation design and evaluation, Monitored Retrievable Storage Facility safety and licensing evaluation for the Nuclear Regulatory Commission, and as Licensing Project Manager and Environmental Project Manager for the OCRWM geologic repository programs. Of most relevance to the Dry Cask Storage Study is Ebasco's recent completion of a Spent Nuclear Fuel Storage Feasibility Study for the Oyster Creek Nuclear Generating Station. This study, which evaluated the feasibility of dry metal cask and horizontal storage module (NUHOMS) Independent Spent-Fuel Storage Installations at the Oyster Creek site, described the dry storage design concepts and their interface requirements with the operating reactor, located suitable dry storage facility locations at the Oyster Creek site, developed independent cost and schedule estimates, and addressed cask handling safety issues and estimated occupational and off-site doses resulting from utilization of the dry storage facility. Ebasc. has utilized all of the above experience in the preparation of these comment and appreciates the opportunity to provide them.

Overall, Ebasco found the report to be an excellent summary of the topics required to be covered, lacking only in a definitive answer to the question, "should the nuclear waste fund be used for at-reactor storage?"

Should further expanation or information be required, please contact the undersigned at (212) 839-3280.

Very truly yours,

Herold L Rottoteni

Harold L. Rothstein Manager, Nuclear Fuel Storage Systems Engineering

HLR/amw Enc.

# EBASCO COMMENTS ON DOE/RW-0196,

# "INITIAL VERSION - DRY CASK STORAGE STUDY"

			·
COMMEN	T REPORT PAGE	REPORT SECTION/PARAGRAPH	COPMENT
30-2	-4-	Executive Summary/ end of second paragraph	The words, "including consolidation of spent-fuel assemblies", should be added to the end of this paragraph.
30-3	<b>-vi-</b>	Executive Summary/ second paragraph third line	The words, "assumed" or "reference date of" should be added before the words "start of spent-fuel acceptance by the DOE", to reflect the uncertainties in timing of such acceptance mentioned in the succeeding paragraph.
30-4	-viii-	Executive Summary/ first paragraph	Time durations for the process of licensing dry storage at the reactor site should be clarified by examples from actual experience by Virginia Power and Carolina Power and Light, with added explanation that these may be atypical because of the lack of intervention.
30-5	-x-	Executive Summary/ first partial paragraph, next to last line	Note the typo on the word "acceptance"
30-8	<b>-x-</b>	Executive Summary/ first complete paragraph, first sentence	There is no need for two ast: sks for one reference; suggest de ction of the first of these asterisks.
\$0-7	7	2.1/second paragraph, third sentence	The statement that the Standard Review Plan "specifies" minimum design capacity of the Spent-Fuel Storage Pool is misleading, as the Standard Review Plan presents guidance rather than regulations, and there are several reactors that have already lost full-core reserve capacity.
30-4 7	<b>7</b>	2.1/end of third paragraph	The contrary, successful experience in transshipment without significant public resistance by Carolina Power and Light from their H.B.Robinson to Brunswick Stations should also be mentioned. Also the "and" should be removed and this last sentence broken into two sentences; otherwise the public resistance issue appears to predominate the consideration of the study of transshipment.

CCI	<u>MENT</u>	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
\$0-9	8	8 . ,	2.1/first paragraph	Mention should be made of the 1987 Amendments to the NWPA restricting MRS construction until NRC issuance of a license for construction of the repository.
	9	<b>g</b>	2.1.1/first paragraph, last sentence	Suggest changing "will" to "may" to reflect the current uncertainty as to the general applicability of the results of the Brookhaven National Laboratory report NUREG/CR-4982, Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82.
<b>3</b> 0-11	10	16	3.1.1/first paragraph	Reference should be made to other DOE publications supplying the same or more detailed information as the RW-859 forecasts, such as DOE/RL-87-11, with any differences (e.g. incorporation of later updating information) noted.
\$0-12	11	16	3.1.1/third paragraph	A sentence should be added to define and clarify the intent of the unit "MTHM" for the understanding of the general public.
80-13	12	17	3.1.1/first partial paragraph	Some reason should be given for the use of the RW-859 forecast rather than the EIA upper reference beyond the year 2013.
80-14	13	17	3.1.2/second paragraph	Additional remarks should be provided to the effect of the following:  -The history of utility estimates of additional Spent-Fuel Storage requirements reflects a continual decrease in near-term requirements for each succeeding survey year (see attached Figure 2.3 from DOE, FL-B7-11) This implies more Spent Fuel Storage Pool capacity can frequently be accommodated as the need for it approaches. Therefore, the "aggregate RW B59 Forecast" of maximum fuel capacities should be considered as more of a lower bound.

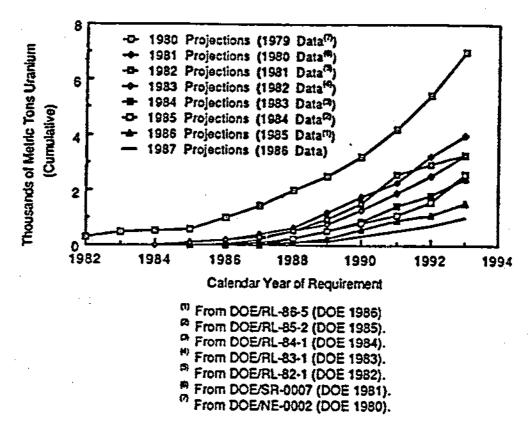


FIGURE 2.3 Comparisons of Annual Projections of Additional Spent Fuel Storage Requirements

		• •	
COMMENT	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
go-15 14	27	Introduction for Chapter 4, second paragraph, next to last sentence	Suggest adding the word "recent"; before the last word "year", to justify the absence of escalation mentioned in the next sentence.
25-16	29	4.1.1.1/first complete paragraph	In the first sentence, the word "boron" should be replaced by "neutron absorber", as boron is not necessarily required. In the last sentence, suggest adding the words "or eliminate the need for the neutron absorber" after the words "increase the number of assemblies"
\$0-17	31	4.1.1.2/first complete paragraph	Until release of the topical report, any other intial reports or papers on the results should be referenced. This comment also applies to other unreferenced data from future reports in following subsections.
17 st-16	31	4.1.1.3/first paragraph, first sentence	Topical Safety Analysis Report approval has also been issued by the NRC for the Castor IC cask.
30-19	32	4.1.1.4/third paragraph	Ebasco's recent independent cost estimates are generally in accordance with the costs quoted. However, a 50% adder for the high cost range of initial facility costs is recommended. Also, the vendor design and topical report licensing costs in a new design (e.g., for a BWR) should be mentioned, as these license-related costs would add on the order of double the quoted high range license-related costs.
30-20	32	4.1.1 4/fifth paragraph, second sentence	Mention should be made that loading and placement costs could vary greatly depending on utility practice. Ebasco estimates indicate these costs, including pre-operational testing and training, could be double thuse quoted.

COMMENT	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
20	40	4.1.4.1/first paragraph, third sentence	The words "it contains a hydraulic ram for loading the canister into the concrete module" should be moved to the end of the next sentence, as it refers to the special-purpose trailer rather than the transfer cask.
<b>x-22</b> 21	40	Figure 4-4	The word "Door" on top of the building should be removed.
30-23 22	41	4.1.4.2/second paragraph	Mention should be made that the reason for the difference stated was to utilize the CP&L 1F 300 cask.
23 24 23	38	4.1.3.4	Refer to Comment number 18
24	42-43	4.1.4.4	Refer to Comment number 18
30-25			In addition, Ebasco's estimate for the transfer cask based on costing of the necessary materials and fabrication amounts to about half the quoted estimate; and mention should be made of loading and placement costs, estimated by Ebasco to be similar to but about 10% above the corresponding range of costs for metal casks.
25	44	Figure 4.5	This figure can be cleaned up to remove the letters "FHM" wherever they appear and explain what "5 Off" means.
30-27 25	44	4.1.5.1/first paragraph, next to last sentence	Suggest adding the words "truck-type" between the words "standard" and "transportation casks".
20-21 27	45	4.1.5.4/last sentence	Ebasco's estimates indicate the upper bound should be considerably higher than 1.5 times the lower estimate.
28	46	4.2.2/first paragraph, first sentence	The words "without any spacer grids" make the sentence inapplicable to the Maine Yankee Consolidation License Application which assumed re-orienting the rods in a closer spaced simple grid array.

COMMENT	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
£30 29	49	4.2.4/last paragraph. last word	"accidents" should be "accident"
20.31	50	4.2.4/ second complete paragraph	With regard to Millstone Unit 2 Consolidation intentions, since 688 locations represents less than 1/2 of "he total pool storage capacity, an explanation where the number 688 comes from seems appropriate. Also, in the last sentence, the words "will have to start" appears to prejudge if dry storage or other methods might not be utilized instead.
gc-32	53	4.3/last paragraph	Mention should be made that it is expected that significant savings in dry storage facility costs could be achieved by many utilities by storage of consolidated fuel in the dry storage facility.
32	53	4.4/third sentence	Remove "the" before the word "Transnuclear". Also, next to last sentence should say "Canada is interested and has demonstrated".
<b>20-34</b>	56	4.5.1.2/first complete paragraph, third sentence	Suggest adding the words "and constructed for U.S. ISFSI applications' after the word "approved", as otherwise the MVDS would have to be included.
34 20-35	56	4.5.1.2/second complete paragraph	The words "a decontamination area" should apparently be removed, as it would not typically be part of the dry storage facility.
<b>3</b> 5	56	4.5.1.3/second sentence	This sentence should be revised, as it is unfair to compare timing for consolidation to past timing for cask loading. Instead, an overall cask handling and ISFSI placement time of about 5 days (Ebasco's estimate) per cask would be more appropriate. Also, in the third line of the last sentence, the words "fuel-handling cranes" should be replaced by "cask-handling cranes"

COMMENT	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
æ <sub>-37</sub>	57	4.5.1.4	Underlining for the title should be removed.
20-SI 37	58	4.5.3/second sentence	The implication that large requirements of storage may favor consolidation contradicts the statement at the end of Section 4.2.5 that 350 MTHM is essentially the maximum amount of additional storage that can be accommodated for a pool.
30-39 38	71	5.2.1.1/third paragraph, third sentence	Suggest changing the word "are" to "include".
39	71	5.2.1.2/first paragraph, next to last sentence	Suggest adding the words "fuel handling" before words "shielding purposes" and the words "with typically about 25 ft. above the stored spent fuel" at the end of the sentence.
30-41	73	5.2.1.3/first complete paragraph	Mention should be made of the need to compare the doses resulting from the ISFSI with those from the operation of the co-located nuclear reactors at the site or "other radiation from uranium fuel cycle operations within the region", per 10CFR 72.67
30-42	77	5.3.2/first paragraph, last sentence	The statement that NFBC canisters will contain a larger source of gamma rays than a fuel assembly does not appear to be generally true and should be justified further if it is true.
<b>30-43</b>	77	5.3.2/third paragraph, third sentence	The three PWR or seven BWR assembly truck cask capacities mentioned are for maximum capacity overweight truck casks. If legal weight truck casks with one PWR or two BWR assembly capacity are used, consolidated fuel should double these capacities.

	COMMENT	REPORT PAGE	REPORT SECTION/PARAGRAPH	COMMENT
نتو	43	81- 84	6.1	With respect to the NNPA uses of the Maste Fund, mention should be made of the DOE contract with utilities for disposal of spent nuclear fuel by DOE "beginning not later than January 31, 1998". In particular, the question whether the Maste Fund can be used for post-1998 at-reactor storage as a means of fulfilling this contractual requirement should be addressed.
p 4 <sup>1</sup>	44	85	6.27final two paragraphs, first sentence	Reference should be provided for the DOE expression of willingness to consider support for at-reactor-storage options and the systems-integration studies being conducted.
<b>9.8</b>	<b>745</b>	85	6.2/final paragraph	The answer to the question "should the Nuclear Waste Fund be used for at-reactor storage?" appears to be missing. A more direct answer, even if the answer is "it cannot be determined at this time" should be provided.

220 Stoneridge Drive . Columbia, South Carolina 29210

October 25, 1988 YJB-0173-88

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

We appreciate this opportunity to comment on the U.S. Department of Energy's Interim Version of the Dry Cask Storage Study. We also appreciate very much the recognition of our activities in your last annual report.

The Department is to be complimented on the completeness and depth of analysis of this study. It is evident that every effort has been made to give a balanced evaluation of the concepts reviewed.

We at Chem-Nuclear Systems and our subsidiary of General Nuclear Systems, Inc. (GNSI) take particular pride in the fact that we supplied all of the storage casks for the only fully licensed and functional dry storage activity in the U.S. This facility at Virginia Power's Surry Station has had over two years of operating experience and now has approximately one full core of fuel elements in dry storage. We are looking forward to participation in additional applications in this most critical area of spent fuel storage.

Although the Department's study covers all of the published concepts for dry cask storage, we would suggest that the next version of this report include a concept that we have developed. This concept was developed with the objective of achieving minimum total system costs. By this we mean the sum of the direct utility costs and the government waste fee costs are minimized.

This optimized concept is centered around a downsized version of our GNSI licensed Castor Y/21 cask. This cask, the Castor Y/12, is described in the attached Appendix A. Although our Castor Y/21 casks are licensed for both storage and transportation outside of the U.S., we recognize it could take considerable time and effort to license them in the U.S. for storage and subsequent transportation. We believe, however, that we can demonstrate in a very expedited process that the Y/12 cask can be licensed for storage and that a transportation overpack of a suitable material that would provide additional shielding, sealed containment, and structural enhancement would be accepted by the NRC. This concept would:

Mr. Charles Head October 25, 1988 Page Two

o provide for licensed, economic storage at reactors with minimized handling at the reactor site. Once in a storage cask, the fuel would not need further transfer or manipulation.

o eliminate the requirement to demonstrate seal integrity after storage. The overpack would provide a new seal for transportation.

o allow for shipment to either an MRS or geologic repository without

further manipulation of fuel elements at a reactor site.

radically reduce transportation equipment costs. If the dry cask storage container is subsequently used as a portion of the transportation container, it would substantially reduce the costs of transportation casks.

provide reimbursement to utility if equipment is transferred to the government. There should be an incentive for the government and utilities to transfer title and reimburse for equipment of common

usage.

o allow for the potential use of the cask without the transportation overpack as a repository package. The ductile from storage cask has a potential for being-the repository overpack. This could provide a system component at no additional cost.

o potentially eliminate D&D for onsite storage. Other systems would have D&D costs, while this concept could eliminate this cost if the cask was suitable for a repository overpack. If not, after decontamination of the interior, it could be remelted for a credit.

The Castor V/12 cask can be built in the U.S. This eliminates the concern of our fuel storage program being dependent on foreign suppliers, and it also eliminates the balance of payments issue.

Distinct cost savings in a mass or serial production mode are possible. In addition to cost savings, this design and fabrication process has distinct advantages of rapid deployment. Now that our costs are in the competitive range, we view this concept to have all the ingredients of success - cost, schedule, and regulatory acceptance. The rate-making entities will endorse a program that has all of these attributes.

Further, the concept we have developed will help to eliminate the concern of the public that any type of storage is perceived to be permanent. There is a potential that storage in mobile containers would be more acceptable. Recent experience in both Tennessee and South Carolina indicate there is a need to overcome the "permanence" issue. Mobility will allow for a specific time commitment of dry cask storage; both at a reactor site or MRS.

We are very enthusiastic about this concept. We stand ready to support the Department in furthering its objectives of safe and economic storage of spent reactor fuel until a geologic repository is available.

We would be pleased to provide you or your staff with further information or briefings at your convenience.

Very truly yours, Vulla Darnkart

Victor & Barnhart

III-99President



# APPENDIX A

CASTOR V/12 SPENT FUEL CASK



# CASTOR V/12 DRY STORAGE CASK OPTIMIZED FOR U.S. APPLICATIONS

General Nuclear Systems, Inc. (GNSI) is developing a new series of CASTOR dry storage casks, totally aimed at meeting the broadest spectrum of U.S utility needs for at reactor, dry storage of spent fuel. This cask, called the CASTOR V/12, utilizes the licensed and proven ductile cast iron technology. It can store 12 PWR fuel assemblies, cooled for as little as five years, for an indefinite period of time. GNSI is aiming for obtaining NRC approval for this cask in 1989 with production and availability by 1990. As many as 12 casks per year could be delivered to a reactor to meet utility priority needs.

# Some of the key features of this design are:

- o UNIVERSALITY Reduced cask weight permits rapid, direct pool loading at all U.S. reactors.
- U.S. FABRICATION Cask design will permit manufacture of all components in the U.S.
- o LOW COST Smaller cask leads to excellent economics particularly with serialized production.
- o DUAL PURPOSE USE A stainless steel overpack with wooden "shock absorbers" will permit transport to DOE sites. The cask can be rapidly made ready for off site shipment.
- COMPATABILITY WITH DOE PROGRAMS No need to repackage or inspect the fuel prior to shipment.
- o PROVEN TECHNOLOGY CASTOR casks using identical materials have been approved by the NRC and have been in-storage at a U.S. utility for over three years. Over 70 CASTOR casks have been fabricated worldwide.
- MAINTENANCE FREE Virtually zero maintenance or inspection is required for the loaded cask.



We know that the CASTOR V/12 will fulfill a real utility need in the 90's and are anxious to tell you more. The enclosed information presents summary data on this design. For more detailed information on CASTOR casks, contact Mr. Glen Rae or Albert Bonifacio at:

General Nuclear Systems, Inc. 220 Stoneridge Drive Columbia, S.C. 29210 (803) 256-0450



# TECHNICAL DESCRIPTION OF THE CASTOR V/12 SPENT FUEL CASK



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  - 2.1 Cask Body
  - 2.2 Cask Lids and Seal System
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- 3.0 MATERIAL TO BE STORED FUEL ASSEMBLY DATA
- 4.0 CASK DESIGN CRITERIA
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  - 4.4 Criticality Safety

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#### 1.0 INTRODUCTION

The CASTOR V/12 belongs to a cask family which has already received a NRC 10 CFR, Part 72 license for storage of spent fuel. The first license was obtained for a CASTOR Ic in July, 1985, and the second license of a CASTOR V/21 was received in September, 1985.

The CASTOR V/12 cask is designed for the storage of a maximum of 12 PWR spent fuel assemblies of various types with a decay time of approximately five years. The cask is made of ductile cast from with a carbon-steel double-lid system. A basket made of steel holds the fuel assemblies in place.

This cask is the latest development in the fleet of CASTOR-type casks and an optimized version for low specific costs has a potential for serial production in the United States. It can preferably, but not exclusively, be used for those power stations with limited crane capacities.

If a certain minimum number of casks is used (to allow serial production), the specific storage costs (\$/Kgu) are lower than for large storage casks. This development results from experience with the licensing and fabrication of smaller waste casks (MOSAIK-Type), which are extensively used in Europe. The cask can also be used for transport of spent fuel with minor and inexpensive modification.

# 2.0 DESCRIPTION OF THE CASTOR V/12 CASK

The CASTOR V/12 cask consists of a monolithic, ductile cast iron body with double lids. The cylindrical cask is approximately 14.4 ft. (4.4 m) high, 68 in. (1.7 m) in diameter, and weighs approximately 123,000 lbs. (62 tons) fully loaded. The cask has a cylindrical cavity which holds a fuel basket designed to accommodate twelve (12) spent PWR fuel assemblies.

The CASTOR V/12 has a double lid system, consisting of a primary and secondary lid. Both are made of carbon steel with a corrosion-resistant treatment. The lids, containing metal seals, are bolted to the cask body to form the leak-tight containment. The leak-tightness of the cask is permanently monitored by means of a pressure switch.



For handling, the cask has four removable trunnions, two in the upper region and two in the bottom region. When the cask is placed into storage, the trunnions are removed and blind flanges are inserted.

Figure 2.1 shows a schematic diagram of the CASTOR V/12 cask body. Overall dimensions and weights are given in Table 2.1.

#### 2.1 CASK BODY

The cask body is made of ductile cast iron, has a cylindrical shape, and a cylindrical cavity. The cask has integrated neutron shielding in the form of graphite nodules, which constitute 3% of the weight and 10% of the volume of the cask material. The mass of the cask body is approx. 84,000 lbs. (38 tons).

The outer surface of the cask is coated with a multi-layered, easily decontaminable paint. The inner surfaces of the cask cavity are protected from corrosion with a radiation resistant zinc silicate or similar coating.

#### 2.2 CASK LIDS AND SEAL SYSTEM

The primary and secondary lids of the CASTOR V/12 cask are made of carbon steel. The lids contain grooves for holding metallic seals (O-rings). The thickness of the primary lid is 8.7 inches (220 mm), while that of the secondary lid is 3 inches (75 mm).

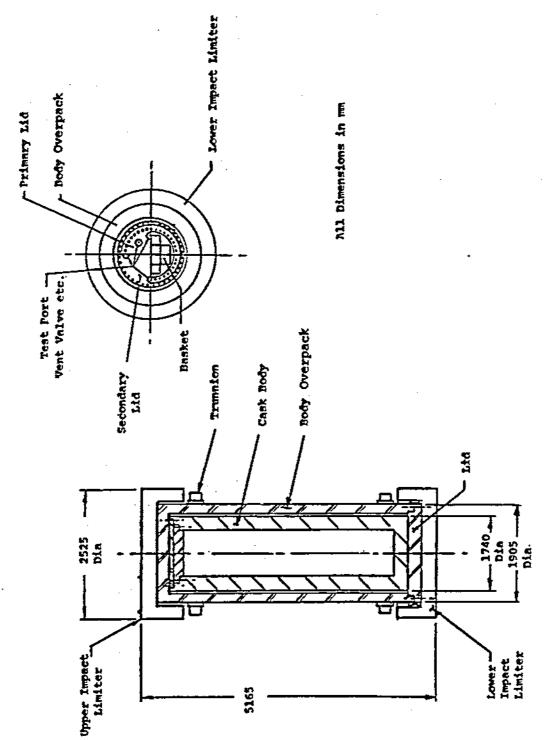
#### 2.3 FUEL BASKETS

The fuel basket inserted into the cask cavity is made of steel. The basket serves to physically separate the fuel, promote heat transfer, and provide nuclear criticality control. The basket has a total of twelve square fuel cells for PWR fuel assemblies and is shown in Figure 2.2

The basket height can be fitted to the fuel assemblies to be loaded into the cask. The fuel assembly positions have a square envelope of  $8.25 \times 8.25 \text{ in}^2$  (210 x 210 mm<sup>2</sup>). The empty basket weighs 7,000 lbs. (3.1 m.t.).



FIGURE 2.1 SCHEMATIC DIAGRAM OF CASTOR V/12 CASK





## TABLE 2.1 CASTOR V/12 DIMENSIONS AND DESIGN CHARACTERISTICS

	<u>min</u>	inch
Overall length (w/o impact limiters)	4,405	173.4
Cross section (w/o trunnions)	1,730	68.1
Cavity length	3,850	151.6
Cavity diameter	1,130	44.4
Wall thickness	300	11.8
Bottom thickness	270	10.6
Total lid thickness	<b>295</b>	10.8
Cask canacity (fuel assembly)	Max. 12 PWR F/A's	

# **Weights**

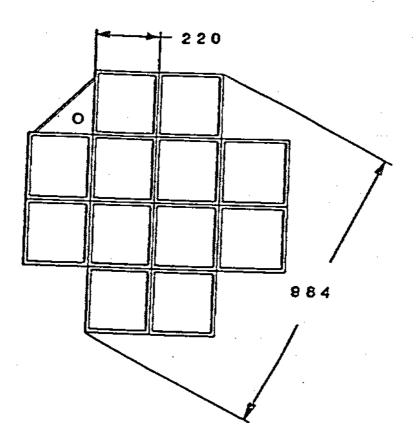
Cask	45.6 m.t.	100,300 lbs.
Basket	3.1 m.t.	7,000 lbs.
Fuel Assemblies	7.4 m.t.	16,300 lbs.
Total Weight	56.1 m.t.	123,600 lbs.

# **Materials**

Ductile cast iron
Carbon at rel with corrosion protection
Carbon Steel/Borated Steel
Stainless steel



# FIGURE 2.2 BASKET CROSS-SECTION FOR CASTOR V/12





### 3.0 MATERIAL TO BE STORED

The material to be stored in the CASTOR V/12 cask consists of PWR fuel assemblies of the CE 15 x 15 type or of the Exxon 15 x 15 type. Fuel data is summarized in Table 2.2.

#### 4.0 CASK DESIGN

#### 4.1 STRUCTURAL DESIGN CRITERIA

The cask structures are designed, fabricated, and tested to maintain the confinement of the fuel assemblies, both for normal operation and under accident conditions. The structural design is based on the licensing criteria defined in 10 CFR, Part 72.

The structural design criteria of the non-cast iron metal components of the cask are based on the criteria of Section III of the ASME Boiler and Pressure Vessel Code. Criteria for normal and accident conditions are given in Table 2.3.

The ASME Code does not provide for design stress values for use in design by analysis for the cask body constructed of ductile cast iron. In absence of a definitive guideline for the allowable stress for ductile iron, a conservative value equal to one-quarter of the ultimate strength is used. This approach was approved by the US NRC during the licensing of CASTOR V/21 & Ic cask. This provides a safety factor of four based upon ultimate strength as compared to a safety factor of three. This serves as the design criteria for the cask body and is given in Table 2.4.

#### 4.2 SHIELDING DESIGN

The design criteria for the shielding of the CASTOR V/12 cask are:

o Maximum dose at any point on the cask surface less than 200 mrem/h (neutron + gamma)

Results of preliminary shielding analyses yield a total dose rate at the cask wall surface of less than 100 mrem/h.



# TABLE 2.2 PWR F/A DATA FOR CE AND EXXON FUEL

Fuel Assembly Type	CE	Exxon
Rod Array	15 x 15	15 x 15
Fuel Material (Sintered Pellets)	Uoo	Uo,
Active length, inches	140 x 353	140 x 65
Total lengths inches	148.951	148.90
Number of Active Fuel Rods per Assembly	212-216	216
Fuel Rod Pitch, inches	0.550	-10
Weight of Fuel Assembly, Pounds	1,350	
Weight of Contained Uranium, kg U	413.38	
Fuel Rod to Fuel Rod, inches	8.1135 x 8.1135	



## TABLE 2.3 STRUCTURAL DESIGN CRITERIA FOR NON-CAST IRON COMPONENTS

	LOADING	CRITERIA	
1.	Normal Operation	Primary membrane stress less than design stress intensity (Sm)	
	•	Sum of primary membrane and primary bending stresses less than 1.5 Sm)	
		Fatigue stress - usage factor < 1.0	
		Sum of maximum primary and secondary stresses $< 3 S_{m}$	
		Shear stress < 0.6 Sm	
	Lifting Devices	Primary membrane and sum of primary membrane and bending stresses $< S_y/s$ or $S_u/s$	
		Shear stress $< 0.67 S_{11}/3$	
2. Accident Condi	Accident Conditions	Primary membrane stresses < (2.4 Sz or 0.7 Su)*	
		$S_u = \text{ultimate stress}$	
		Sum of primary membrane and bending stresses < (3.6 Sm or < Su)*	
		Pure shear primary atress $< 0.5 S_y$ )	
3.	Puncture of external surface	Outer cask surface stresses less than $S_{\rm u}$	
<b>4</b> .	Brittle fracture	Selection of materials with adequat toughness	

Smaller cf



## TABLE 2.4 STRUCTURAL DESIGN CRITERIA FOR CASK BODY

LOADING		CRITERIA	
1.	Normal Operation	Primary membrane stress less than design stress intensity (S <sub>m</sub> )	
	•	Sum of primary membrane and primary bending stresses less than 1.0 Sm)	
		Fatigue stress - usage factor < 1.0	
		Sum of maximum primary and secondary stresses < 2/3 oy	
<b>2</b> .	2. Accident Conditions	Primary membrane stresses < (2.4 Sm or 0.7 Su)*	
		$S_{u} = ultimate stress$	
	· · · · · · · · · · · · · · · · · · ·	Sum of primary membrane and bending stresses < (2.4 Sm or < 0.7 Su)*	
٠		Pure shear primary stress $< 0.5 S_y$ )	
3.	Puncture of external surface	Outer cask surface stresses less than Su	
€.	Brittle fracture	See Section 8.2 of the Topical Safety Analysis Report for CASTOR V/21 cask.	



#### 4.3 THERMAL DESIGN

The decay heat of the fuel elements is conducted through the cask body and transferred to the air surrounding the cask by natural convection and radiation from the exterior surface.

The thermal design of the cask is based upon a peak cladding temperature of 340°C (644°F) for the hottest fuel rod, at an ambient temperature of 54°C for the cask environment. This leads to a heat output of approximately 1 kw per fuel assembly, with a cooling time prior to storage of approximately five years.

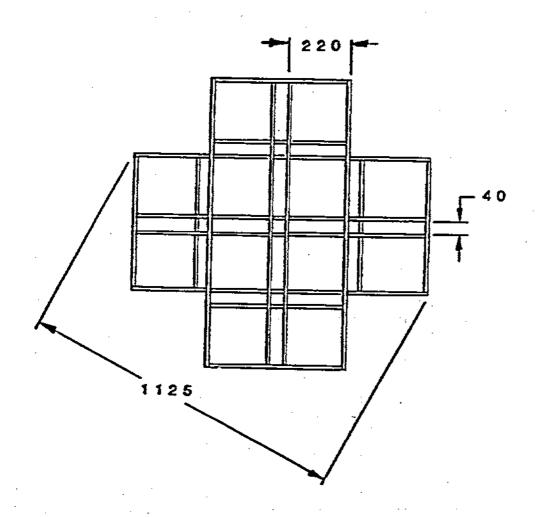
#### 4.4 CRITICALITY SAFETY

The design criteria for criticality safety is that the effective multiplication factor,  $k_{\rm eff}$  is below 0.95, assuming optimal reflection and fresh, undepleted fuel.

The basket design as shown in Figure 2.2a can hold fuel with limited initial enrichment (approx 2.2% U-235) if fresh fuel conditions have to be considered in the licensing procedure. If burn-up is applicable with the same design, higher initial enrichments up to 3.5% are possible. For higher enrichments assuming fresh fuel conditions, minor modifications of the basket (flux-traps and borated steel) are foreseen. See Figure 2.2a.



# FIGURE 2.2a BASKET CROSS-SECTION WITH FLUX-TRAPS FOR CASTOR V/12





3315 Old Forest Road P.O. Box 10935 Lynchburg, VA 24505-0935 (804) 385-2000

October 24, 1988 SFHLW88.197

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Charlie Dear Mr. Head:

The B&W Fuel Company, a part of Babcock & Wilcox's Nuclear Power Division, has reviewed the Initial Version Dry Cask Storage Study, DOE/RW-0196, and has several comments on it that we wish to share with you.

Our first comment is that the scope and depth of the document is excellent. The DOE did a fine job in reviewing the alternative technologies for spent fuel storage and in presenting the impact of differing repository/MRS acceptance schedules. Notwithstanding the overall high quality of the study, B&W has identified some specific areas where clarifications could be made:

- On page vii and page 35 (section 4.1.3.1) concrete dry storage casks are referred to as having a "...body made of heavily reinforced concrete." While this type of cask uses a special concrete for shielding, the containment is a metal liner/lid. We suggest adding a reference to the metal liner with the concrete; perhaps using the term "concrete/metal cask" would be a more accurate description.
- 2. The cost of concrete/metal casks shown on pages ix and 39 appear not to reflect some of the possible economies of this type of design. B&W projects our cask design to cost about \$5/kg less than your low-cost projections for both 100 MTHM and 300+MTHM capacities.
- Also on page ix, the unit costs are given in dollars per metric ton-heavy metal. While this is a common approach, perhaps a more useful unit would be dollars per space-made-available for storage at-reactor. This eliminates confusion of different design fuel assemblies with different weights of uranium, and it allows better comparisons between technologies such as consolidation and dry storage.

- 3. Section 4.1.1.4, at the end of the fourth paragraph, states that the low costs quoted assume credit for burnup will be allowed. While this is a possible assumption, such burnup credit from the NRC is not a foregone conclusion, and the additional design or administrative costs required for NRC approval may be substantial. Such costs should be evaluated and quantified, as well as the risk of no burnup credit being allowed.
- 4. There is no mention of competing designs of concrete/metal casks in section 4.1.3, despite such designs being submitted in response to DOE-Richland Operations Office SCAP No. DE-SC06-87RL11394. B&W's design, the CONSTAR series, has been further described in a paper presented to the 1988 Joint ASME/ANS Nuclear Power Conference (April, 1988) and has been the subject of a meeting with the NRC. The Topical Report for CONSTAR is projected for submission to the NRC in mid-1989. I have attached a paper on CONSTAR for your information.
- 5. Section 4.1.3.4 describes the dry loading of a concrete/metal cask as requiring the fuel to be loaded into canisters and then into a transfer cask. We are not aware of any requirement for canisterization of intact undamaged fuel.
- 6. The use of the word "optimum" in section 4.2.2, paragraph 2, implies that 2:1 fuel rod consolidation is a physical limit which is not entirely realistic. Indeed, consolidation ratios of greater than 2:1 are achievable with some systems, B&W's included. Most canisters will contain two assemblies worth of rods to maintain easy traceability and to simplify operations. Perhaps a more accurate term to use in this application is "design."
- 7. The cost analysis of consolidation (section 4.2.5) examined only the option of utility purchase of the required equipment. Another option which may be more economic for some applications is where a supplier provides equipment and manpower for a specified period or campaign size for a fee. This fee will vary based on the size of the campaign, but would be cheaper than purchase for small campaigns and would not leave used equipment in the reactor pool for storage and disposal. This option is mentioned later in section 4.5 1.2, Time Needed for Implementation.
- 8. The storage of consolidated fuel in concrete/metal casks should be included in the section 4.3 discussion. The CONSTAR casks have the capability to store consolidated fuel. The use of consolidation would also affect the LCC of this option, which should be illustrated by an example as with the other options.
- 9. The conclusion in section 5.3 that the use of horizontal concrete systems will have no effect on transportation does not account for the fact that either the utility will have to unload the spent such back into their pool for transfer to the transportation cask or have the dry shielded canisters (DSC) compatible with direct loading into the transportation casks. The first option is likely to be significantly more complex and costly than the same operation with metal or concrete/metal casks. The second option requires that the dimensional and structural characteristics of the DSCs be matched to shipping cask designs to ensure compatibility with 10 CFR 71 requirements. Additionally, casks have the potential for dry transfer of such transportation casks, thus eliminating a trip for the such back into the pool; this would be extremely difficult with DSCs.
- 10. The discussion of dual-purpose casks in section 5.3.1 does not clearly state the assumptions for a Life Cycle Cost. ICC) Analysis; that is, are utilities paid for the casks (and if so, how much and when), are any potential costs included to upgrade

**B&W Fuel Company** 

-3-

October 24, 1982

existing casks to meet 10 CFR 71 requirements, and are the different capacities inherent in casks optimized for storage and transportation factored in.

32-12

11. Section 5.3.2 states that, for a set weight limit, a 33 to 50% increase in transportation eask spent suel capacity could be accomplished by using consolidation. We believe this magnitude of increase could only be obtained by optimizing the transportation cask design for consolidated suel, rather than simply shipping consolidated suel in easks optimized for standard intact suel (an eventuality considered surther down on the same page). On the other hand, the shipment of consolidated suel with a matching cask would yield considerable LCC savings.

I hope these comments will be useful to you and will be glad to answer any questions you may have on them. Please contact me at (804) 385-3138 or John Matheson at (804) 385-3444 if you or your staff desire a dialogue.

Sincerely yours,

Ton Ster

Thomas R. Stevens, Manager Spent Fuel & Waste Technology Services

TRS:wwh
Attachment

cc: w/o Att.

F. M. Killar, USCEA

S. T. Hinschberger, DOE-ID

The attachment contains proprietary information. Furthermore it is not critical for the reader to have the attachment in order to understand the comments contained in this letter. Therefore the attachment is not reproduced here. (U.S. Department of Energy)

# UNWMG

Utility Nuclear Waste Management Group 1111 19th Street, N.W. & Washington, D.C. 20036-3691 # (202) 778-6512

PERSON Atabama Power Company Arizona Public Service Company Estimore Cas & Electric Company Boston Edison Company Carolina Power & Light Company The Cleveland Electric Elluminating Company Commonwealth Edison Company Consolidated Edison Co. of fier fork inc. The Detroit Edison Company Duke Fower Company **Buquesne Light Company** Plorida Port: Corporation Florida Power & Light Company Georgia Power Company Gutf States L'tilities Company Mouston Lighting & Fower Lombany Indiana & Michigan Electrit Сотралу fore Liettric Light & Porer Compan) Los Angeles Department of Rater & Power H. Life South Services, Inc. Mebraska Public Power District New York Power Authority Ringers Hohawk Power Corporation Northeest Utilities Porthern States Fower Company Omaha Public Fower District Pacific Cas & Electric Company Pennsylvania Power & Light Company Philadelphia Electric Company Portland General Electric Company Public Service Company of Colorado Public Senice Electric & Gas Compares Rochester Gas & Electric Corporation Sucremento Runicipal Utility District SHUPPS **Union Electric Company** Kansas Gas & Electric Company Renses City Fower & Light Company South Carolina Electric & Gas Company Southern Cattlornia Edison Company Reads Utilities Company Toledo Edison Company Mirginle Force **Bushington Public Power Supply** System Wisconsin Electric Fower Company Wisconsin Public Service Corporation

**Varace Atomic Electric Company** 

October 28, 1988

Mr. Charles Head Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20505

Dear Mr. Head:

Re: Initial Version Dry Cask Storage Study

Edison Electric Institute (EEI), the Utility Nuclear Waste Management Group (UNWMG), and the Electric Utility Companies' Nuclear Transportation Group (NTG) appreciate the opportunity to submit comments on the <u>Initial Version Dry Cask Storage Study</u> <u>(IVPCSS)</u>, dated August 1988, which was published by the Department of Energy (DOE) in accordance with the requirements of Section 5064 of the Nuclear Waste Policy Amendments Act of 1987 (NWPAA).

EEI is the association of the nation's investorowned electric utilities; its members generate about seventy-three percent of the Nation's electricity and serve over sixty-seven million customers. UNWMG is a group of forty-five electric utilities providing active oversight of the implementation of the federal statutes and the regulations governing radioactive waste management. NTG is a group of twenty-nine utilities providing active oversight of implementation of the federal statutes and the regulations governing transportation of radioactive materials. Together, EEI/UNWMG/NTG represent the majority of the holders of contracts with DOE for disposal of spent nuclear fuel under the Nuclear Waste Policy Act (NWPA), as amended. To date, electric utilities (and others) have paid over \$3.3 billion into the Nuclear Waste Fund. These funds are collected from electricity consumers.

Given the significant increase in additional onsite storage requirements and related costs associated with each year's delay in spent fuel acceptance, it is extremely important that the waste program be carried

Mr. Charles Head October 28, 1988 Page Two

out on a schedule consistent with DOE's statutory obligation and contractual commitments. However, even today a number of electric utilities are actively involved in the expansion of their on-site storage capacity and many more are now exploring alternatives and will be making commitments to one or more of these technologies during the next several years. EEI/UNWMG/NTG believe, therefore, that the DOE was very timely in its release of the IVDCSS.

The DOE deserves to be complemented for its efforts in performing this study and in preparation of the resulting report. We found it to be informative with respect to the individual technologies for expanding on-site spent fuel storage capacity. Electric utilities requiring additional on-site spent fuel storage capacity need to make many decisions in the face of present technical, economic and political uncertainties. The decisions made by one utility may not be appropriate for another. The comprehensive presentation of information on each technology should provide each utility with a good starting point from which to proceed with their individual evaluation of the available alternatives.

The NWPA does not appear to authorize use of the Nuclear Waste Fund to provide funds for at-reactor dry storage. However, while DOE, under Section 302(d), must receive express Congressional authorization for the "construction or expansion of any facility," it may use the Nuclear Waste Fund to fund "any costs that may be incurred by the Secretary in connection with the transportation, treating, or packaging of spent fuel or high-level radioactive waste to be disposed of in a repository," as well as "the costs...incident to such a repository [or] monitored retrievable storage facility...". This language would appear broad enough to authorize DOE to fund certain activities that would be considered to be "in connection with transportation, treating or packaging of spent fuel" or "incident to" a repository or MRS.

EEI/UNWMG/NTG also agree with the DOE's second conclusion, i.e., that only those activities that provide overall benefit to the waste management system should qualify for buclear Waste Fund support.

It is important to emphasize that any discussion regarding the use of funds from the Nuclear Waste Fund must be conditioned on whether the discussion addresses costs that are incurred: (1) for on-site storage prior to the DOE taking delivery of spent fuel starting in 1998, or (2) because the DOE did not meet its statutory commitment to begin to take spent fuel starting in 1998. It is appropriate that this report does not address the

Mr. Charles Head October 28, 1988 Page Three

statutory commitment to begin taking spent fuel in 1998. However, EEI/UNWMG/NTG view this as a very important issue that will be addressed further in the appropriate forum and at the appropriate time.

EEI/UNWMG/NTG have additional specific comments regarding the IVDCSS that are identified in the enclosure to this letter.

We appreciate this opportunity to respond to the DOE request for comments on the <u>IVDCSS</u>. We would be pleased to respond to any questions or otherwise be of assistance to the DOE as it finalizes its study. Please do not hesitate to call us.

Sincerely,

S. P. Kraft Director

SPK/mlf Enclosure EEI/UNWMG/NTG

Enclosure to Letter to Mr. Charles Head October 28, 1988

# EDISON ELECTRIC INSTITUTE UTILITY NUCLEAR WASTE MANAGEMENT GROUP and ELECTRIC UTILITY COMPANIES' NUCLEAR TRANSPORTATION GROUP

## Additional Comments on Initial Version Dry Cask Storage Study, August 1988

23-2 Page v, item 3, at bottom	What destination(s) was assumed, MRS or repository.
Page viii, paragraph 1	While it is agreed that safety must be demonstrated, it is not clear why an application for license under 10CFR Part 72 must demonstrate <u>feasibility</u> .
Page xi, paragraph 2	It is not clear from the text whether the statement is suggesting that there is a minimal cost and risk increase or minimal cost and risk decrease. It is also not clear how much of a change would be considered by DOE to be "minimal".
Page 10, paragraph 4	In practice spent fuel is generally stored in the spent-fuel pool for as many as five years before being transferred to dry-storage facilities, not one year.
Page 21, Figure 3-4	The label on this figure reading "Acceptance begins in 1988" should read "Acceptance begins in 1998." Also the "Year" axis should be corrected by reversing 2010 and 2005.
Page 27, Chapter 4	The issue of land use requirements for the various dry at-reactor storage options was not addressed. Estimates of land use requirements, even if similar among options, would be useful.
234 Page 28, paragraph 2	The date 1984 should be changed to 1983.

EEI/UNWMG/NTG

Enclosure to Letter to Mr. Charles Head October 28, 1988

Page 29, paragraph 2 Does NRC specifically require the use of boron to prevent nuclear criticality, or does NRC simply require that the licensee assure that nuclear criticality will not be a problem by justifying the approach it selects to deal with this issue? Page 31, paragraph 6 It should be noted in the text that the vendors of casks and utilities are attempting 23-10 to obtain NRC approval to take credit for fuel burnup. Page 32, paragraph 4 It is not obvious how to derive the final \$50 to \$90 per kilogram unit cost range from the cask purchase unit costs of \$90 to \$105 per kilogram. #3-12 Page 33, line 1 Please define "large capacity increase." Page 35, paragraph 4.1.2.4 Why isn't there a range on the \$7 per kilogram additional cost for dual-purpose CZEKS. Page 50, paragraph 5 It should be noted that Rochester Gas and Electric Corporation received a license amendment allowing storage of consolidated fuel in the spent-fuel pool of Ginna in December 1985. This was done without intervention. Page 50, last paragraph It should be noted that the cost range of \$200,000 to \$500,000 includes **\$**3-15 license-amendment action for reracking as well as consolidation, with consolidation comprising only a small part of this total amount. Page 51, paragraph 3 A statement should be added at the end of this paragraph to the effect that "Efforts have been started by EPRI and utilities to look at other methods for disposal or storage of non-fuel-bearing hardware components such 23-18 that the consolidation ratio of fuel is a true 2:1. The costs associated with these other disposal or storage alternatives would

be included in the consolidation costs. These studies have not been completed, but the identification of economical alternatives could lead to lower consolidation costs.

EEI/UNWMG/NTG

Enclosure to Letter to Mr. Charles Head October 28, 1988

13-17 Page 72, paragraph 1

page 76, paragraph 5

What is the basis for this statement pertaining to action taken after the expiration of the reactor's operating license?

Add the words "or barge" to the first sentence following the phrase "railroad and rail-handling capabilities."



U.S. Councilior Energy Awareness

John Siegel Vice President Technical Programs

October 28, 1988

Mr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
RW-322, Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Re: Initial Version Dry Cask Storage Study DOE/RW-0196

Dear Mr. Head:

These comments are submitted on behalf of the Transportation Task Force of the U.S. Council for Energy Awareness (USCEA) in response to the above-referenced study. We have reviewed the study and have several comments.

We believe the overall scope and depth of the document is excellent. The study responded to Section 5064 of the Nuclear Waste Policy Amendments Act of 1987 in the area of storing spent fuel at civilian reactor sites, considering factors of costs, effects on human health and the environment, and the extent to which the nuclear waste fund can and should be used to provide funds for at-reactor storage.

However, there are two areas which could use additional emphasis. The first area is the integration of at-reactor site storage concepts with the DOE program for off-site shipments. The study should provide information that a utility can use in planning an at-reactor site storage facility for compatibility with the DOE shipping fleet.

The second area that could use additional clarification is the use of the Waste Fund to cover at-reactor site storage costs. In the context that spent fuel shipments from the reactor sites to DOE facilities were to begin in 1998, the study is appropriate. However, due to the delay in shipments until 2003 this should be reconsidered. The delays in the program from 1998 to 2003 generate additional storage costs for the utilities. Because the change in schedule occured during the late stages of drafting this report, plus this report is past due to Congress, it is recommended that rather than address it in the Dry Cask Storage Study a response to this question can be provided in next years Annual Capacity Report.

If you have any questions or desire additional information, please let me know.

Sincerely.

John Siegel

Mr. Charles Head V. S. Department of Energy Office of Airlian Ladionatic waste Munayet RW-322, Forsestel Building 1000 Independence are., S.W. Washington, D. C. 20585

Dear Mr. Head,

My comments on the ocean regard entitles. "Initial Version Dry lash Storage Study" fellows.

The seport assumes a high-level muchen waste separating in operation in the year 2003 specifically at Junea Mountain, morabe. This assumption is very weak for the following Alascone: at it appearable morale legislation will not downtood to the meeted Bear land anotherward—some 52, not rece weeked (b) the designation of queen mountain is separately many ". Constitution a thorties as a realise of the 10th amountainent because beginst the lisur is president. (c) it is a violation of the trusty the v. S. Hopernment signal with the western Shockhone Incline nation in 1896. (d) the astronomical transportation looks especially when said access to

Juce mountain, no Tray not be a reable option as well as over load transportation by truck (C) nEPA requirements, that formulation of an E15 must be scoped on a notional bases (+) preliminary undication that you an mountain will not meeter the requirements of NW Pa. no earth science effect would testify to Day that the site is safe but rather they will testify to stastical probabilty. This would be Challenged in Court which looked take years. (9) 5CP studies will take at least 10 years or more because contraction will tend to stretch out the process (6) the probest defect and trade defect as So huge that funding will to limited, states will no larger negotiate on promises but will want agreements eg sigheray improvement ete Syported by law (1) it now appears because of the heat generated by spent fullware that much less than 70,000 metric time can We stored at Juca mountain. (5) the OOE policy of decide, announce, and defend has Collespest as indident ofter incident of mir-management Currently being reported on in the new medica will enspire opposents to rally and take to the courts.

35-1

The report does not cover other alternative eq utilization of known technology to semore 1811 the tension -- 100%, entombreat on site as less costly to a waste damp thousand of miles from the generation points.

Thank you for the opportunity to demnent. Sincerely,

Frank Clements
609 avc. L.
Beriller City, NV 89005

Executive Director

CHARD H. BRYAN



# AGENCY FOR NUCLEAR PROJECTS NUCLEAR WASTE PROJECT OFFICE

Capitol Complex
Carson City, Nevada 89710
(702) 885-3744

October 28, 1988

Mr. Charles Head Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue Washington, D.C. 20585

Déar Mr. Head:

RE: INITIAL VERSION, DRY CASK STORAGE STUDY, AUGUST 1988

We have received the subject report (DOE/RW-0196) and have reviewed it from a number of perspectives in regard to Section 5604 of the Nuclear Waste Policy Amendments Act of 1987, which requires the Secretary of Energy to prepare and submit such a report to the Congress.

For a number of reasons which will be discussed below, it is the conclusion of this Office that the report, in its present form, does not provide an analysis of dry cask storage in a context sufficiently realistic to be useful to the Congress and the public in future policy decisions, nor does it provide a great deal of information of use to the nuclear power utilities in their current and future spent fuel management and storage planning. This flaw in the report could have been mitigated to some extent if the DOE had solicited the views of State and local governments and the public in an early scoping process, prior to preparation of the report, rather than issuing this Initial Version for our review just two months prior to the statutory deadline for its submission to Congress.

In general, the report seems to serve primarily as a means to mold selected interim storage scenarios and technology to DOE's preferred high-level radioactive waste management and disposal program, rather than to recognize first, the requirements of the Nuclear Waste Policy Act as amended, and then the potential for achievement of either the requirements of the Act or the elements and schedule of the DOE' preferred program. The report takes considerable liberty in its selection of scenarios for analysis, and assumptions of various elements and events which may enter into the analyses. However, significant likely scenarios and contributing elements have either been

ignored or misrepresented in the report.

The most obvious shortcoming of the report is its failure to analyze the most likely scenario in the future of the nuclear waste disposal program. That scenario is the case in which the DOE cannot begin accepting waste at a geologic repository in 2003, as projected in the DOE's schedules, and as anticipated by the Congress, based upon DOE's assurances. Furthermore, the more realistic situation may be an indefinite postponement of geologic disposal. For this reason, the report should analyze at least two additional conservative scenarios: 1. a situation, without an MRS, in which repository waste acceptance is delayed on the order of 10 or more years; and 2, a situation in which the plants are obligated to store spent fuel up to 30 years beyond the expiration of their operating licenses, as reviewed by the NRC in its Waste Confidence Decision. These types of analyses are certainly not prohibited by the NWPAA, and, in fact, may provide a useful, and even realistic perspective to the report.

The MRS schedule scenarios chosen for analysis offer some interesting suggestions. The scenario for waste acceptance in 2003 conforms to the authorization of the Act, yet, without presuming the recommendation of the MRS Review Commission and Congressional action, there is no assurance that this scenario will be achieved. The 1998 scenario for waste acceptance, while possibly being an acknowledgment of the DOE's legal dilemma regarding waste acceptance contracts with the utilities, not only would require additional Congressional action, but is probably impossible to achieve. Therefore, it is misleading of the report to present it as a meaningful scenario with the implication that, if authorized, the DOE could bring it to reality. The 2008 scenario is clearly a recognition that, even if approved, there may be a five year delay in implementing the MRS relative to the statute and DOE's waste acceptance plans. One can only question why, if the DOE suggests a scenario of delay in the possible implementation of an MRS, it does not anticipate the likely delay or postponement scenarios for a repository, discussed above. Furthermore, there is no discussion of the basis for a possible five-year delay, as opposed to some other number of years of delay. The five-year figure appears to be simply arbitrary and convenient.

The uncertainty in the cost analyses for the described technologies, and associated assumptions, are acknowledged in the report, however there appear to be a number of significant omissions and misrepresentations in addition to the stated uncertainties. Additional elements which should be analyzed or clarified in the DOE's final Dry Cask Storage Study include the following:

- Costs should be reported with a stated inflation factor included. In the Initial Version, it is not even clear whether the costs reported are in 1988 or 1987 dollars. Furthermore, it

is difficult to place the costs reported in a meaningful context of the waste management and disposal program when the existing version of the DOE's Analysis of the Total System Life Cycle Cost for the Civilian Radioactive Waste Management Program (DOE/RW-0047) is obsolete.

- The cost analyses for the fixed-facility storage technologies do not seem to include the final costs of

decontamination and decommissioning.

- There does not appear to be a recognition that there likely will be a significant additional cost and time factor involved in storage cask certifications if the concept of extended burn-up credit is intended to be employed in cask design.

The cost factor involved in design and certification of casks for consolidated fuel and associated scrap elements does not appear to have been analyzed in relation to the uncertainties associated with consolidation and compaction ratios. In addition, the report does not recognize the fundamental problem of cost-effectiveness in rod consolidation. It is currently unknown by the utilities whether the specific consolidated waste form produced will meet the DOE's yet to be determined waste acceptance criteria for a repository.

The DOE's legal position regarding the inability of the Nuclear Waste Fund to finance at-plant dry cask storage is clearly stated relative to the provisions of the Nuclear Waste Policy Act, however the report is unnecessarily vague regarding how DOE will determine if and when it might suggest to Congress that the policy be altered. The stated position is "The DOE will consider requesting authorization to use the Nuclear Waste Fund for at-reactor storage if such a use is demonstrated to be beneficial to the overall waste management system." (page 89). This position must be clarified, at least to the extent of the definition of its terms, and the criteria which will be applied in DOE's considerations. Lacking such clarification, the statement of position is of no use to any of the affected parties, including the Congress.

We appreciate the opportunity to comment on this Initial Version Dry Cask Storage Study, but, as stated above, it is our belief that the report could have been at a much advanced state of maturity and usefulness at this late data had the views of State and local governments and the public been solicited prior to its drafting. For this reason, it is our recommendation that the report be redrafted, and circulated again for comment, before DOE seeks final comments from the U.S. Nuclear Regulatory Commission and then submits it to Congress.

Struck ASL Robert R. Loux, Director



OCTOBER 3 1 1988

L-88-484

Mr. Charles Head
U. S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322 Forrestal Building
1000 Independence Avenue S.W.
Washington, D. C. 20585

Dear Mr. Head:

Re: Dry Cask Storage Study

This letter is submitted in support of the Edison Electric Institute (EEI) Waste Management Groups comments on the Dry Cask Storage Study. FPL agrees with all of the conclusions presented in the EEI paper to be submitted by the October 28th comment date.

Thank you for the opportunity to comment on this matter.

Yours truly,

W. F. CORDAY

Senior Vice President - Nuclear

WFC/JAD/gp.



# Arizona Nuclear Power Project

P.O BOX 52034 . PHOENIX, ARIZONA 85072-2034

162-02815-PFC/SLS November 1, 1988

Mr. Charles Head U. S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Ave., S.W. Washington, D.C. 20585

Pear Mr. Head:

Subject: Initial Version Dry Cask Storage Study File No.: 88-070-220/88-017-419.16

Arizona Public Service Company (APS) is pleased to submit the attached comments on the Dry Cask Storage Study. APS is the operating agent for Palo Verde Nuclear Generating Station. We must emphasize the following six points:

- 1. APS must be assured that there will be shipping casks undeveloped which can handle its fuel.
- APS concurs that the Nuclear Waste Fund should not be used arbitrarily to fund at-reactor site storage. However, if utilities must expand storage as a result of delays in DOE's waste program beyond the 1998 commitment date, utilities should get some form of relief from the DOE.
- 3. The proposed NRC rule to allow utilities licensed under 10CFR50 to apply for a general license to store spent fuel in NRC-certified casks without further licensing activities is a positive development.
- Reimbursement for the utility's purchase of dual-purpose casks, if the casks are approved by DOE, must be done and dealt with in an equitable manner between DOE and the utilities.
- 5. Consolidated canisters and non-fuel bearing canisters should be considered as the equivalent of standard fuel assemblies.

  3-1 Otherwise, utilities need to be informed if there are technical difficulties associated with the handling of these canisters.
- 6. APS encourages the development of standard methods to verify fuel burnup.

III-133

Charles Head Page Two

162-02815-PFC/SLS November 1, 1988

Details of these comments are provided in the attachment.

APS appreciates the opportunity to submit these comments, and would welcome the opportunity to discuss our comments with you or your staff.

Very truly yours,

Paul F. Crawley, Manager Nuclear Fuel Management

PFC/SLS/cvh

#### Attachment

cc: D. B. Karner

J. G. Haynes R. R. O'Laughlin J. D. Wade

G. W. Duede

#### APS COMMENTS ON DOE DRY CASK STORAGE STUDY

### AT-REACTOR STORAGE OPTIONS

#### A. LICENSING CONCERNS

The proposed rule by the NRC, which would allow utilities licensed under 10CFR50 to apply for a general license to store spent fuel in NRC-certified casks without further licensing activities, is a positive development. This should prevent delays in licensing resulting from litigation based upon unfounded concerns.

APS would like to encourage the development of standard methods to verify fuel burnup. This would allow more fuel assemblies to be stored in casks, and result in a more efficient storage and transportation system.

#### B. COSTS ASSOCIATED WITH AT-REACTOR STORAGE

Costs for the various technologies are difficult to anticipate due to the many uncertainties in the future; such as market dynamics, inflation, development of new technology, storage needs of individual utilities, etc. However, the analysis which was performed was useful for comparison of costs between the different technologies.

If DOE ultimately approves the use of dual-purpose casks, the cost of these casks must be dealt with in an equitable manner between DOE and the utilities. Either DOE should purchase the casks, or the utilities should be reimbursed for the casks when the spent fuel is transferred to the DOE.

#### C. CONSOLIDATED CANISTERS AND NON-PUEL BEARING CANISTERS

Consolidated canisters and non-fuel bearing canisters should be treated as the equivalent of a standard fuel assembly in terms of shipping allocations. The DOE report states that "canisters for consolidated rods and \$4-10 non-fuel bearing hardware will be sized to fit into existing spent-fuel storage racks." These consolidated canisters have different radiological characteristics than standard fuel assemblies. The varying radiological characteristics can be accounted for by additional shielding, if necessary. If there are other negative impacts on the storage and transportation system which would make handling of consolidated and non-fuel bearing canisters difficult, they need to be identified to utilities. If there are weight limitations which restrict the number of consolidated canisters which can be sent in one shipment, the utility needs to be informed ahead of time.

#### D. CASK DESIGN

The report does not state whether the casks which have been designed and/or developed are compatible with all existing light water reactor fuel assembly designs. As a contract-holder, APS must be assured that there will be shipping casks developed which can accommodate its fuel. APS is concerned due to a previous oversight by DOE, which resulted in ANPP fuel being classified as non-standard due to the length of the fuel assemblies.

# II. USE OF THE NUCLEAR WASTE FUND

APS concurs with DOE that the Nuclear Waste Fund should not be used arbitrarily to fund at-reactor site storage. As DOE states, this could lead to inequities, along with a more inefficient waste management system. However, DOE's study reports that a five year delay in the date at which waste management system operations begin will result in a 50% increase in at-reactor fuel storage requirements. If utilities must build additional at-reactor storage facilities as a result of delays in DOE's waste program beyond 1998 commitment date, utilities may be required to seek some form of relief from the DOE. This relief may have to come from the Nuclear Waste Fund.

# YANKEE ATOMIC ELECTRIC COMPANY



580 Main Street, Bolton, Massachusetts 01740-1398

October 28, 1988 FMD 88-814 GN-L03-04-01

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, DC 20585

Subject: Initial Version - Dry Cask Storage Study

Dear Mr. Head:

Yankee Atomic Electric Company (YAEC) appreciates the opportunity to comment on the subject study. YAEC owns and operates a nuclear power plant in Rowe, Massachusetts. Our Nuclear Services Division also provides engineering and licensing services for other nuclear power plants in the Northeast, including Vermont Yankee, Maine Yankee, and Seabrook. We have reviewed the study and wish to applaud DOE's efforts for doing a credible job. Also, please note that we fully endorse the comments submitted by the Utility Nuclear Waste Management Group and the Electric Utility Companies Nuclear Transportation Group.

In addition, we would like to emphasize one specific comment. We are very concerned about the potential additional cost of on-site reactor storage of spent fuel because of the possible delay in the waste acceptance date beyond 1998. The study shows such delay will indeed be costly. Table 5.4 shows upper bound aggregate costs of \$1.68 billion should waste acceptance be delayed until 2003 and \$2.68 billion should it be delayed until 2008. We stongly urge DOE to maintain the 1998 waste acceptance schedule. It is our belief that this is required by the Standard Contract and that DOE is obliged to use appropriate efforts to have the Waste Management System available in 1998 even when delays are caused by circumstances beyond DOE's control.

Thank you for the opportunity to comment.

M. Buchheit

Sr. Nuclear Fuels Engineer

JMB/cmb

9021 W. Sagemoor Road Pasco, WA 99301 October 18, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Kanagement RH-322, Forrestal Building 1000 Independence. Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

Thank you very much for the opportunity to comment on the initial version of the Dry Cask Storage Study. I have two comments.

First, the report appears to be well written and appears to inclue all of the important aspects that it should contain.

Second, the report appears to be conservative because it represents only the current state-of-the-art for the storage methods. This conservatism apparently results from the limitation of the identification and evaluation of the various storage concepts to the use of published reports as well as experience in both the United States and other countries, as stated at the bottom of page vi.

Because four of the five storage methods discussed have not been fully developed, the final designs are not known. Use of the current published reports could result in cost estimates as much as twice as large as the actual costs would be if and when those concepts are fully developed. As an example, there does not appear to be any consideration given to the use of high density concretes in the concrete casks, even though the Canadians have investigated it and tested prototype casks. Use of that type concrete might reduce the concrete cask costs by up to one-half because the cask wall might have to be only a half as thick. This could more than double the amount of fuel stored in one cask.

The main disadvantage from using a conservative approach that overestimates the total costs is that it makes those methods of storage appear much more costly than they might be after they are fully developed. In comparisons with other alternatives for spent fuel storage, those dry storage methods might lose when they actually might be the best choice when fully developed.

It is suggested that the executive summary, and the text, emphasize the possibility that the costs listed on page ix might be reduced substantially by fully developing those storage concepts.

Sincerely yours,

Mound J. R. Young



#### BOSTON EDISON

Pilgrim Nuclear Power Station Rocky Hill Road Plymouth, Massachusetts 02360

Raiph G. Bird Senior Vice President — Nuclear

November 4, 1988

Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

Mr. C.E. Kay's letter of September 1, 1988 provided to our Mr. Stephen J. Sweeney a copy of the initial version of the Dry Cask Storage Study, DOE/RW-0198, and requested our comments. Mr. Sweeney has asked that I respond to you.

The Utility Nuclear Waste Management Group analyzed the Study and commented in their letter of October 28, 1988. Boston Edison supports their comments.

In addition we offer the following comments related to the Study:

The Department of Energy, in cooperative projects with the Electric Power Research Institute and participatory utility companies, has developed technology for dry storage of spent fuel. The Department's aggressive action is encouraging. However, the need for at-reactor storage facilities has been increased by the announced delay in operation of the DOE storage facility. We urge DOE to continue to support work on dry storage and similar storage measures to assist the industry in accommodating the DOE delay.

- b. The Study concludes that the additional at-reactor storage facilities to accommodate the DOE delay will require substantial funding. Although present legislation may impose limits on use of the Nuclear Waste Fund for at-reactor storage, such limitations did not foresee the DOE delay. In equity, DOE should seek any needed authority for use of the Fund for at-reactor storage during the period DOE is contractually obligated to receive wastes.
- The Study does not cite the basic reason for the Various spent fuel storage activities treated in the report. We refer to the legislation that precludes reprocessing. A reader of the Study might perceive that the costly added storage facilities are an inherent disadvantage of nuclear power. They are not. Other countries, unhampered by such legislation, are reprocessing and handling any resultant real wastes. We suggest the study should give the reader an overall perspective of the reasons for the costly storage facilities.

We appreciate the opportunity to comment on this Study. If you need further information, please contact me or Mr. E.J. Wagner at 508-747-8805.

Rig. Bird

cc: S.J. Sweeney

J.E. Howard

x.L. Highfill

JOHN J CAREY Executive Vice President. Operations

October 28, 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322, Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

Dear Mr. Head:

We have reviewed the "Initial Version of the Dry Cask Storage Study" which was forwarded with your September 1, 1988 letter.

We believe that dry cask storage provides a method to safely store spent fuel elements, burnable poison assemblies, spent start up sources and control rods at reactor sites until such time as DOE completes its underground facility.

We are disappointed that DOE will fail to meet the original schedule which would have the first repository receiving fuel in 1998.

Considering that all operating nuclear utilities have been making significant contributions to the program on the basis of the assessed one mil per net kilowatt hour, the extra expense involved with at reactor storage represents an additional burden to the rate payers of electric utilities which operate nuclear plants.

Once again nuclear power will realize a shrinking of the cost advantage over alternate generation technologies which must be sustained to justify its continued utilization as a major energy source in the United States.

We urge the Department of Energy to complete the program Which was enacted under the Waste Policy Act of 1986 as rapidly as possible and observe that no increases in assessed costs should ever be required since the five year delay in the program will result in significant increases in project funding prior to incurring major development and operating expenses.

Yours sincerely,

#### STATE OF MICHIGAN

COMMISSIONERS
William E. Long
Echratecark
Steven M. Fetter
Ronald E. Russell



PUBLIC SERVICE COMMISSION 6545 Mercantile Way P.O. Box 30221 Lansing, Michigan 48909

JAMES J. BLANCHARD, Governor

# DEPARTMENT OF COMMERCE

DOUG ROSS, Director

November 15, 1988

Hr. Charles Head
U.S. Department of Energy
Office of Civilian Radioactive
Waste Management
RW-322, Forrestal Building
1000 Independence Ave., S.W.
Washington, D.C. 20585

Subject: Initial Yersion Dry Cask Storage Study

Dear Mr. Head:

On August 22, 1988, the U.S. Department of Energy (DOE) released the draft report, <u>Initial Version Dry Cask Storage Study</u> (DCSS), and requested comments on it. On behalf of the National Association of Regulatory Utility Commissioners (NARUC), the Staff Subcommittee on Nuclear Waste Disposal appreciates this opportunity to respond.

The NARUC is an association of all the public utility regulatory commissions in the nation. Its membership includes bodies regulating all investor-owned utilities that operate commercial nuclear power electric generators. All funds that have been and are paid into the Nuclear Waste Fund come from the pockets of the electric utility ratepayers, whose financial interests are the statutory responsibility of the public utility regulatory commissions. The NARUC is on record as supporting a safe, successful and cost effective nuclear waste disposal program.

The NARUC has recognized for some time the importance of at-reactor storage to the safe disposal of nuclear waste and to the costs of nuclear generation that are charged to ratepayers. The NARUC is concerned that more delays to the federal program in addition to those already announced may, in the absence of any other alternatives, turn generating plants into extended spent fuel storage facilities. Our report on at-reactor storage availability, issued early in 1988, is referenced in the DCSS.

#### Overview of the DCSS

In general, we believe the DCSS represents a responsible and responsive effort on the part of the DOF to provide the information required by the Congress in Section 5064 of the Acclear Waste Policy Amendments Act of 1987. We believe the important cost data summarized in the table on page ix of the Executive Summary is reasonable, i.e., the large range of costs for the various storage systems is

in agreement with the present very limited actual experience with these technologies. Recent vendor proposals received by one utility planning for expanded storage generally confirms the range of values given for the dry storage and consolidation options with one exception. If representative, bids for concrete cask systems at the low end of the DOE's range may reflect a recent reduction in the cost of this option.

More specific comments on the DCSS are given below.

## Impact of Program Delays

The tone of the study is, in our opinion, to confirm that temporary at-reactor spent fuel storage is a reasonable option until a repository and/or a Monitored Retrievable Storage facility (MRS) are available; we concur. We must add that the at-reactor storage option poses problems which are not adequately addressed in the DCSS.

The DOE disposal program has suffered many delays and, only very recently, another was announced in the date of drilling of an exploratory shaft in Nevada. We believe confidence in the DOE program has been affected (see the NARUC letter to the DOE and others, dated October 26, 1988). Further delays are entirely possible, and U.S. nuclear utilities must therefore contemplate the on-site storage of reactor spent fuel for an indeterminant period of time.

It should be noted that the 1998 or 2003 dates for federal spent fuel acceptance are in accordance with the current DOE plan, but these dates represent only the most recent projections of repository availability. For example, according to a 1973 publication, the spent fuel acceptance date then planned by the U.S. Atomic Energy Commission was 1982. It should be noted, therefore, that increased costs to ratepayers to support utility spent fuel storage should be understood to have begun many years ago. Expenses to date associated with increasing on-site storage reracking of existing pools and other operating expenses are part of the cost of the delays in the federal disposal program. Extended at-reactor storage, even if operated as planned, without accident or deterioration and without substantial public protest, will represent a further expense to be requested of utility ratepayers. It will also raise the cost and complicate the decommissioning of many reactors, an issue not addressed in the DCSS.

In summary, we are not satisfied that indefinite at-reactor storage is a low-impact, cost-effective interim alternative to the failure to develop a high level radioactive waste disposal capability on a timely basis.

## Reed for an Integrated Systems Plan

The DCSS reflects the fact that an integrated disposal system has not yet been developed. System integration and standardization have the potential of saving the nation's electric ratepayers millions of dollars, reducing worker radiation exposure and enhancing the safety of spent fuel disposal. It is also an

approach the success of which depends on close cooperation between the DOE and the utilities in the further development of at-reactor storage facilities. At its meeting on October 19, 1988, the U.S. Nuclear Regulatory Commission noted the problems resulting from lack of an integrated plan, reviewed some of the ramifications and registered concern over the possible proliferation of individual utility at-reactor storage programs because a defined national disposal system will not be in place.

It is noteworthy that Congress, in ordering this study, recognized the need for attention of the DOE management to this issue. Yet, the value of an integrated system was emphasized by the U.S. Office of Technology Assessment in 1985 in its definitive study of nuclear waste disposal. The role that additional at-reactor storage plays in the integrated waste disposal system as well as the potential benefits and problems that would result from standardizing the handling and disposal system should be discussed in the DCSS.

### Disposal Alternatives Examined

In the DCSS, the aggregate costs of providing additional at-reactor storage are studied for four cases. They are: 1) the repository opens in 2003 without an MRS; the repository and MRS both open, 2) in 1998, 3) in 2003, and 4) in 2008. Given that the future of the MRS is uncertain, at least two additional cases are recommended: 5) the repository opens in 1998 without an MRS; and 6) the repository opens in 2008 without an MRS. With further attention, these additional analyses will show the potential impact that an MRS could have on the as yet undeveloped integrated waste disposal system. It should not be assumed that the future of the MRS has been resolved; the Congress must still respond to the recommendations of the MRS Review Commission. Consideration of the MRS as a system design parameter is reflective of the fact that all aspects of the disposal system are interrelated.

The dates we have proposed for the additional studies are reflective of the dates the DOE has chosen. The basis for the DOE's selection of dates is not made clear in the study. Does the DOE's choice of 1998 imply the ability to have a facility in place by then? Does the 2008 date indicate further anticipated slippage in the overall program? The notion that the choice of dates is arbitrary troubles us in view of the huge expenditures in time and money that have occurred since the inception of this federal program.

## DCSS Financial Analysis

The methodology used in the DCSS to estimate the aggregate costs of increasing at-reactor storage for each of the federal waste acceptance scenario was to multiply estimates of the 1988 price of the storage technologies by the nation's aggregate additional storage needs. However, individual utilities will be increasing at-reactor storage at various times over more than a twenty year period and will be maintaining those facilities thereafter. The cost study must take account of the impacts of inflation over this time period, and a utility's finance costs which a close reading of the DCSS suggests have not been included in the calculations.

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The DOE has the necessary information to account for the time value of money in its analysis. The analysis should be performed utility by utility, imposing the fixed costs associated with the spent fuel storage option in the first year that additional storage is required and adding the variable costs that will accrue thereafter. The NARUC requests the DOE perform the analysis and also requests access to the detailed cost data from this study so that it may also perform such analyses. In addition to the value of the analysis for our own purposes, it may act as a verification of the underlying assumptions made for the DOE study of the cost figures quoted in the DCSS.

# Discussion of At-Reactor Storage Options

Due, in part, to the potential for public opposition (p. 7), the DCSS dismisses transshipment as a viable storage expansion option. Transshipment is an approved and utilized option and therefore is expected to be a part of future spent fuel management plans where feasible. The DOE's 1987 Spent Fuel Storage Requirements Study incorporates assumptions about transshipment as a means of reducing the need for additional storage space. Since there are a limited number of at-reactor storage options, it seems that the DCSS should not rule out this option, especially since there has been public opposition to the most popular method of increasing at-reactor storage, reracking. There are no guarantees against future protests over other options included in the DCSS.

# Effects on Human Health and the Environment

The DCSS review of the health and safety issue seems somewhat perfunctory in its coverage. There is a discussion of prior NRC studies, but no perspective on health and environmental impacts. In line with our earlier comments, we believe the value of the report would be enhanced by a comparison of environmental and safety aspects of at-reactor storage versus early disposal.

# Use of the Nuclear Waste Fund for At-Reactor Storage

The conclusion in the DCSS that the DDE has no express authority to pay monies out of the Fund for "short-term interim storage," as a general statement of the present law, appears correct. However, the DDE's analysis does not address all the possibilities raised by the Nuclear Waste Policy Act (NWPA).

The NKPA allows payments from the Fund for costs incurred in connection with transportation, treating or packaging spent fuel to be disposed of in a repository, HRS, et cetera. 42 U.S.C. \$/10222(d)(4). The existing contracts between the DDE and the utilities oblige the DDE to arrange for and provide casks suitable for use at the individual utility's site. 10 CFR \$/961.11, Art. IV 2.

In the DCSS, the DOE has defined interim storage so as to preclude claims for assistance from the Fund for storage costs incurred after 1998. The DOE claims

that it is the utilities who are responsible for spent fuel storage until "an operating federal facility is available to accept the fuel" (p. 84). However, it is conceivable that a utility which incorporates transportation packaging or necessary fuel handling measures into its on-site storage program may be legally entitled to payments from the Fund.

Although the NWPA has an entire section devoted to interim storage, 42 U.S.C. \$/10151-10157, the term is not defined. That interim storage was contemplated to last only until 1998 is suggested by the selection of the near-term date of January 1, 1990 as the final date for which contracts for interim storage may be made by the DOE. 42 U.S.C. \$/10156(a)(1). The conclusion in the DCSS as to the meaning of "interim storage" under the NWPA appears to be too expansive. We are concerned that the DOE, by this construction of the statute, has limited the payment options authorized in the present legislation.

We agree with the DOE's summary conclusion (p. 89) that the Nuclear Waste Fund should be used to support at-reactor storage only when it will benefit the waste management system as a whole. However, the phrase is cryptic and should be expanded so as to convey adequate meaning of the DOE's position. It may also be that a more complete analysis should be conducted so as to aid adequate depth of meaning to be communicated. It does appear to us that some on-site activities, for example those which would reduce some DOE disposal expenses, might be acknowledged via decreased payments by utilities who implement them. Care must be exerted to assure fairness to all utilities so that some groups of ratepayers are not penalized.

We appreciate your attention to the matters that have been raised. The NARUC Staff Subcommittee stands ready to assist you in these matters of importance to the safe and efficient handling and disposal of the nation's spent reactor fuel.

Sincerety, Amulel Co. Callen

Ronald C. Callen

Michigan Public Service Commission Chairperson, Staff Subcommittee on

Nuclear Waste Disposal

National Association of Regulatory

**Utility Commissioners** 

RC/kkf



# STATE OF NEW YORK PUBLIC SERVICE COMMISSION ALBANY

PETER A. BRADFORD

THREE EMPIRE STATE PLAZA (\$18) 474-8520

November 7, 1988

Mr. Charles Head U.S. Dept. of Energy Office of Civilian Radioactive Waste Management, RW-322 Forrestal Building 1000 Independence Avenue, SW Washington, DC 20585

Dear Mr. Head:

Thank you for the opportunity to review and comment on DOE's report, "Initial Version - Dry Cask Storage Study". We offer the following comments for your consideration in preparing the final version.

- 1. The report presents the cost of the various spent fuel storage options in terms of dollars per metric ton of heavy metal. It would be helpful to also present the cost in terms of mills per kilowatt hour as this is the unit of the fee imposed on the utilities by Section 302(a)(1), (2) and (3) of the Act. The relationship between dollars per metric ton of heavy metal and mills per kilowatt hour depends on fuel burnup. The amount of fuel discharged and stored also depends on fuel burnup. By expressing the storage cost in terms of mills per kilowatt hour, the additional cost for the delay of repository availability is more apparent.
- 2. At present, the utilities pay a one mill per kilowatt hour fee for the Nuclear Waste Fund (NWF) under the terms of their contracts with the DOE. The contracts state that DOE will begin to accept spent fuel in 1998. The one mill/kWh is supposed to cover all the DOE's costs for disposing of spent fuel, including the transportation costs.

The DOE has now acknowledged a five-year delay, to 2003, for its initial acceptance of spent fuel. Consequently, the

November 7, 1988 Page Two

utilities will have added costs for their at-reactor storage. These added costs are not funded through the NWF.

We recommend that the DOE request authority to use the NWF for the utilities' at-reactor storage costs. The added cost for at-reactor storage is largely due to DOE's inability to begin receiving spent fuel from utilities for disposal by January 31, 1998 as required by the Nuclear Waste Policy Act of 1982. We are mindful that both the cost to the individual utilities and to the DOE will ultimately be incurred by the utility ratepayers. However, having both costs paid by the NWF will present the cost of the back end of the fuel cycle in a more open manner.

- 3. Section 4.2 of the report presents rod consolidation as an option for increasing at-reactor storage. We suggest that DOE investigate the possibility of disposing a portion of the non-fuel-bearing hardware as low-level radioactive waste. This procedure may increase pool storage capacity for spent fuel.
- 4. Eventually, the at-reactor storage cask will have to be decontaminated and decommissioned. The cost for this should be presented.

Thank you for the opportunity to review this report.

Sincerely, -

Peter Bradford

me1/988-32



# NUCLEAR REGULATORY COMMISSION WASHINGTON, D. C. 20555

November 18, 1988

United States Department of Energy ATTN: Mr. Sam Rousso, Acting Director Office of Civilian Radioactive Waste Management RW-322 Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585

#### Gentlemen:

I am responding to your September 1, 1988 request for the comments of the Nuclear Regulatory Commission (NRC) on the Department of Energy's (DOE) Initial Version Dry Cask Storage Study (DOE/RW-0196). The Commission's detailed comments are enclosed. In general, we find it a well-balanced presentation of spent fuel storage requirements, of the in-pool consolidated fuel storage and dry storage technologies available to address those requirements in at-reactor storage, and of the impacts and costs of such storage.

The Commission is concerned, however, that inadequate attention is being given to ensure the compatibility of the various steps in the storage, transport, and disposal of spent fuel and thereby to enhance the safety and efficiency of fuel handling. With a proliferation of storage options, it appears likely that fuel to be removed from reactor sites in some instances may have to be 45-1 returned to reactor pools to be unloaded and then loaded into transportation casks for shipment off site. In addition, subsequent operations at the repository, or a monitored retrievable storage (MRS) site, may be needed to repackage the fuel for ultimate cisposal. The Commission believes that radiation exposures and other handling risks should be minimized in the entire process from removing the fuel from the reactor pool the first time to its ultimate disposal. System analysis and action at this early stage could result in minimizing these handling risks, and we suggest that DOE proceed on this course of analysis and action to achieve cask design compatibility to the greatest extent possible.

I hope that our comments on this draft report have been helpful. If you have any questions, please contact Hugh L. Thompson, Jr. (telephone number 492-3352). The Commission looks forward to commenting on your final report.

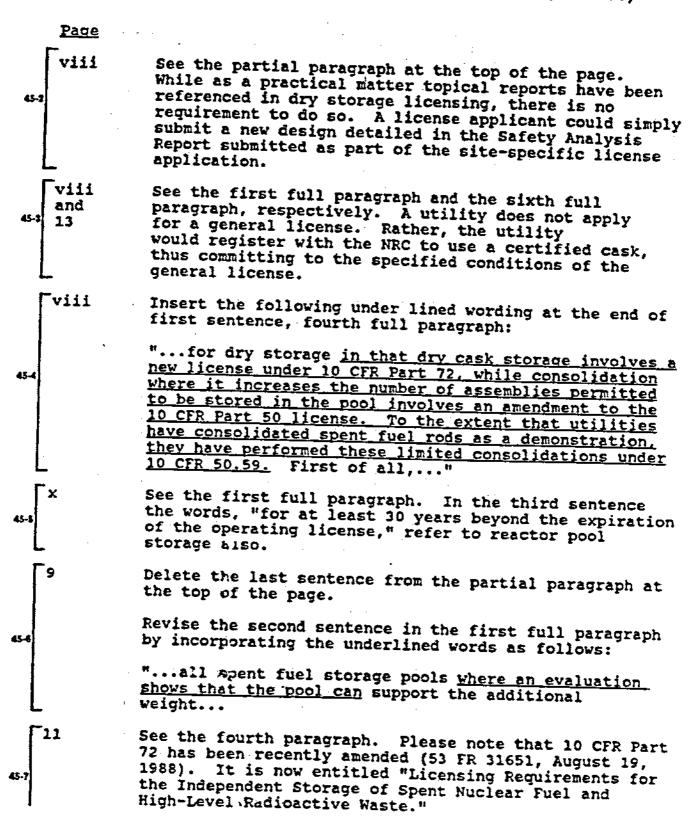
Sincerely,

Lando W. Zech Jr.

Enclosure:
Detailed Comments

cc: Charles Head, DOE

# NRC COMMENTS ON DOE DRY CASK STORAGE STUDY (DOE/RW-0196)



Delete the last paragraph (including the continuation at the top of page 12) and replace it with the (cont'd) following paragraph: "Consolidation where it increases the number of assemblies permitted to be stored in the spent fuel pool involves an amendment to the 10 CFR Part 50 45-1 license. To the extent that utilities have consolidated limited numbers of spent fuel rods as a demonstration, they have performed these consolidation programs under 10 CFR 50.59." See the second full paragraph. Again there is some lack 12 of clarity in explaining the use of a reviewed topical report as a reference in a site-specific application. It may be advantageous to a license applicant to do so, since it is an action that can reduce uncertainty (the 45-9 proposed design having been reviewed by NRC staff) and effort, but it is not required by regulation. Revise the first sentence in the third full paragraph 13 to read: "Consistent with this objective, the NRC staff is currently developing a proposed rule for consideration 45-10 by the Commission which would amend 10 CFR Part 72 to provide a process for ... " Revise the first sentence of the fourth full paragraph to read: "The proposal under development envisions an amendment to 10 CFR Part 72 to specify the following process... See the rirst full paragraph. The first sentence 29 concerning cask loading in the storage pool and boron is incorrect. Nuclear criticality analyses to date have not taken credit for the presence of boron in the 45-12 water. Section (.1.1.2, paragraph 3. Gesellschaft für Nuklear Service mbH is improperly identified. This should be General Nuclear Systems, Inc., the United States partnership. 45-13 Section 4.1.2.3, paragraph 1 (same comment as above for D 30).

Section 4.1.2.3, paragraph 1. This section should note 35 that the technical review panel set up by the NRC to investigate the acceptability of nodular cast iron for transportation casks has been completed. It was 45-14 concluded that nodular cast iron should not be used as the primary structural material in spent fuel shipping casks based on the material properties and available information at this time. Section 4.1.4.2, paragraph 2, line 3. The words, "safety analysis," should be topical report. Revise the first sentence in the second paragraph in incorporating the underlined words as follows: "...with rod consolidation are primarily economic in nature. They include the difficulties ... " Delete the first two sentences in the second full 49 paragraph and replace them with the following sentences: "As explained in Chapter 2, consolidation where it increases the number of assemblies permitted to be stored in the spent fuel pool involves an amendment to 10 CFR Part 50 license. To the extent that utilities have consolidated rods as a demonstration, they have performed these limited consolidations under 10 CFR 50.55." Delete the words "local or" in the third full paragraph, third sentence. Revise the wording in the second full paragraph, fourth sentence with the underlined words as follows: "...and will have to start by 1997 when a full-core..." 45-11 Reference: "Spent Fuel Storage Requirements (1987)" DOE/RL-87-11, page 3.13, Table 3.4 shows full core reserve at Millstone 2 not lost until 1997. 72 See the first paragraph. The reactor operating license may be amended at the end of plant operating life. Thus, spent fuel may be stored in the reactor pool under a "possession only" license pursuant to 10 CFR Part 50. The reactor license cannot be terminated until the reactor is decommissioned. To fully decommission the reactor, all spent fuel must be removed from the site.

81-85

In the Chapter 6, DOE discusses the use of the Nuclear Waste Fund to support additional at-reactor storage. The study finds that Nuclear Waste Policy Act of 1982 does not authorize DOE to use the Fund for providing such storage. DOE also finds, as a matter of policy, that the Nuclear Waste Fund should not be used for at-reactor storage unless such storage would provide overall benefits to the waste-management system. As these findings do not involve health and safety issues, NRC takes no position thereon.



DEPARTMENT OF HEALTH

KAY A. ORR GOVERNOR

GREGG F. WRIGHT, M.D., M.ED.

23 November 1988

Mr. Charles Head U.S. Department of Energy Office of Civilian Radioactive Waste Management RW-322 Forrestal Building 1000 Independence Avenue. SW Washington, DC 20585

Dear Mr. Head:

Governor Orr forwarded her copy of the August 1988 publication titled Initial Version Dry Cask Storage Study and asked the Department of Health to review and comment on it. We are pleased to have that opportunity.

It appears there are several issues that need to be addressed in detail, some of which have potential health and safety implications.

- The effect of temperature on the concrete needs to be evaluated and assessed, especially since there is concern that the structural integrity of the cask cannot be maintained. If so, this could result in breach of the cask during movement or handling leading to 46-1 substantial radiation exposure to personnel. There is also some question as to whether or not the integrity of the spent fuel would be maintained. This would depend on the amount and type of deterioration of the cask from thermal interactions.
  - The use of the casks for transportation purposes after extended periods of storage is of substantial concern as to whether or not the integrity of the cask can be maintained. In addition to the concern about the effects of thermal impact, we would be concerned about the effects of handling, moving, and shifting that might lead to breach of the container. We also question whether or not this cask could withstand a transportation accident with only minimal, or preferably no, loss of material. It would appear that the amount or level of deterioration of the concrete due to age would significantly increase the possibility of loss of containment and potentially damage the spent fuel in a transportation accident. This could result in substantial radiation exposure to first responders and substantial contamination of the accident area, and would require considerable effort and expense to clean up the site. The amount of harm to the public would depend on the severity of the accident.

301 CENTENNIAL MALL SOUTH P.O. BOX 95007, LINCOLN, NEBRASKA 68509-5007 AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

45-2

Charles Head Page Two 23 November 1988

3. Since there appears to be more than one method for handling and loading the casks with the spent fuel, the possibility of an accident increases significantly in relationship to the number of times the material is handled.

In conclusion, I believe that there is sufficient concern about the thermal, transportation and handling effects to indicate that use of this type of container may be premature. The fact that storage in concrete casks has not yet been licensed by the NRC at any site and the review of the topical safety analysis report on this technology also indicate that it may be premature.

A study should be made on how to minimize and reduce the number of times the spent fuel and casks need to be handled. This would decrease the possibility of an accident. Decreasing the handling times would also make sense from the health physics perspective of maintaining as low an exposure as can reasonably be achieved.

Further information or questions would be welcomed by our Division of Radiological Health; Harold Borchert is the division director.

Sincerely,

Gregg F. Wricht, M.D., M.Ed.

Director of Health

GFW/1b

cc: Governor Orr
Harold Borchert