MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

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Alex Radin
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December 22, 1989

The Honorable John B. Breaux
Chairman
Subcommittee on Nuclear Regulation
Committee on Environment and Public Works
United States Senate
Washington, D.C. 20510-6175

Dear Senator Breaux:

Enclosed are the responses of the Monitored Retrievable Storage Review Commission to the questions posed by the Subcommittee in a letter dated December 5, 1989 in followup to our final report to Congress.

Unfortunately, we were not able to do all of the analyses you requested because under the law, the Commission will cease to exist on December 31, 1989, and there was insufficient time to generate the data files necessary to do some of the computer runs. As we indicate in our answers to the questions, you might ask the Department of Energy to perform some of the analyses since they will have copies of the models we developed and access to the data files necessary to perform the analyses.

If the Subcommittee Members or Subcommittee staff have any questions concerning the material we have submitted, they may contact any of the individual Commissioners.

We thank you for this opportunity to serve the Congress.

Sincerely,

Alex Radin

Alex Radin
Chairman

cc: D. Klein
F. Parker
J. Axelrad

ATTACHMENT

QUESTION 1. What is the basis for the Commission's assumption that most, if not all, reactors will be shut down upon the expiration of the initial term of their licenses?

RESPONSE: The Commission recognized that some reactors may obtain license extensions while others may shut down before their licenses expire. It is impossible at this time to predict how many will fall in either category. It therefore seemed reasonable to assume for purposes of our analysis that the early shutdowns and the life extensions would offset each other and, therefore, we assumed an average 40 year life for all reactors.

QUESTION 3: A survey conducted by the Institute for Nuclear Power Operations has determined that 70-80% of licensed facilities will seek to have their licenses extended. Would you please project the economic feasibility of an MRS if one-third (and three-fourths) of the reactors extend their licenses for five years (and ten years)?

RESPONSE: All the modeling done for the report used the No New Orders discharge file created by the Department of Energy. To perform the analysis requested in the question, our models would require new discharge files to be created by DOE corresponding to the assumptions of the question. Unfortunately, there is insufficient time for us to obtain the files, run the simulations, and analyze the results before the Commission's term ends. The Commission ceases business, according to law, on December 31, 1989. To effect an orderly close down, and taking into account the Federal holidays, we have already begun to remove books, furniture, and equipment. However, we are planning to transfer our computer models to the Department of Energy and we suggest you ask DOE to run the simulations.

QUESTION 4: The report appears to assume that transshipment will not occur. Isn't it already occurring? How does this fact affect the conclusions in the report concerning available onsite storage capacity and life-cycle costs of a no-MRS system?

RESPONSE: Transshipment has been used to alleviate spent fuel storage needs at a few reactors. However, as discussed on page 23 of our report, widespread intrautility transshipment has not occurred and there have been no interutility transshipments. In assessing the comparative risks of MRS and No-MRS systems, the Commission considered the situation in which intrautility transshipment would continue to be used (see Tables 4.5 and 5.5 in our report). No significant differences were found. Although such transshipment could provide temporary relief for a small number of reactors which are running short of storage space in their spent fuel pools, it cannot provide a long-term solution to the problem if the repository start date continues to be delayed since transshipment does not increase the total at-reactor pool storage capability. Transshipment would not reduce total system life-cycle costs since it merely shifts the costs of at-reactor storage from one location to another, and the reactor site to which the fuel is shipped itself runs out of in-pool storage space in a shorter period of time.

QUESTION 5. Did the Commission consider the possibility of the federal government taking title to waste that remains stored onsite in order to satisfy federal commitments to take title to waste by 1998? If not, why?

RESPONSE: The Commission chose not to examine whether the Department of Energy had a legal obligation to begin to accept spent fuel in 1998 or whether taking title to the spent fuel would satisfy any statutory obligation that may exist. This is a very complex legal issue that will ultimately resolved by the courts after the issue has been fully litigated. The Commission felt its charge would be better served by concentrating on the many complex technical and public policy issues before it and leaving resolution of this legal issue to the legal process. Furthermore, the Commission did not believe that the costs or risks of on-site storage of the spent fuel would be significantly different if DOE took title to the spent fuel on-site than they would be if the utilities retained title to the spent fuel, since the costs and risks are more closely related to the type and duration of the storage than they are to the entity providing this function.

QUESTION 6: Is the present value of an unlinked MRS system higher than that of the linked-MRS system?

RESPONSE: For the three principal scenarios used in the Commission's report (the repository opening in 2003, 2013 and 2023) the present value of the total-system life-cycle costs for the linked and unlinked MRS systems were approximately the same if the repository were assumed to open in 2003 or 2013 and the linked system was $100 million less expensive than the unlinked system if the repository were assumed to open in 2023. (See Table 6.8) At-reactor storage costs increase in the linked system when the repository is delayed, but this increase is offset by the fact that the expenditures to build the MRS are incurred further in the future, which results in a significant reduction in costs when costs are calculated as present values. In the unlinked MRS case, at-reactor storage costs are significantly lower, for comparable cases, but the costs of building and operating an MRS are incurred earlier (thus discounting has less effect). In addition, the MRS facility is operated for a longer period of time which increases operating costs.

QUESTION 7: Is the value of a linked versus unlinked MRS system speculative when compared to the savings of a no-MRS system?

RESPONSE: The value of a linked versus unlinked MRS system is no more or less speculative than the savings of a No-MRS system. The costs of each of the systems are dependent upon many factors which are uncertain at this time, such as the date when a repository will become available; the number of reactors that will obtain license extensions and those that will shut down early; and the availability of alternative storage technologies such as dual-purpose casks.

QUESTION 8: Why will it be easier for DOE and NRC to insure system compatibility with an MRS rather than for an onsite system?

RESPONSE: The Commission assumed that DOE would adopt a standardized storage system at the MRS. Unless a standardized storage form or package would be required by DOE or NRC, utilities would respond to their at-reactor storage needs on an individual, cost-effective basis. Some may consolidate; others may opt for dry storage using a variety of available technologies. If an MRS of unlimited capacity could be available early, before many reactors must consider alternative on-site storage methods, then the spent fuel would be stored either in spent fuel pools or at the MRS. The amount of consolidated spent fuel and the number of types of packages would be less in a system with an MRS than in a No-MRS system in which each utility would make its own decision on the form and type of storage it would use until the repository is available. In this way, an MRS would enhance system compatibility.

QUESTION 9: The Commission emphasizes the fact that it will be institutionally difficult for DOE to site and license both an MRS and a permanent repository at approximately the same time under the linked-MRS scenario. This is, doubtless, true. But while this argument is used to favor an unlinked storage facility over the linked MRS, it is not used to favor the no-MRS over the MRS scenario. Doesn't this argument apply in both cases?

RESPONSE: It is true that the No-MRS scenario does not require the institutionally difficult siting and licensing processes that any MRS scenario requires. The Commission recognized this as a disadvantage of the MRS system in its summary of the advantages and disadvantages of an MRS on page 97 of its report. However, with an unlinked MRS, DOE would not be required to site and license an MRS at the same time it would be siting and licensing the repository. It is likely the MRS could be sited and licensed substantially in advance of the repository, particularly under the current repository schedule of 2010 and the disadvantages would be less than they would be with a linked MRS. It should be noted that there may be licensing difficulties associated with obtaining license amendments for on-site storage. However, these would be borne by the utilities.

QUESTION 10: Many of the factors listed in support of some type of unlinked MRS system over the no-MRS system appear to be either speculative or repetitive.

A. Could the first factor, emergency storage, be taken care of by extending the current FIS program?

RESPONSE: The current FIS program is different in several significant respects from a facility to take care of emergencies. First, the current FIS requires utilities to anticipate storage need in advance and apply for storage space at the FIS facility by a date certain. Emergencies are unpredictable and utilities cannot be expected to anticipate such needs in advance. Second, the existing FIS does not provide the option of storage for emergencies. It is designed to prevent the shutdown of otherwise satisfactorily operating nuclear power plants. To use the FIS, utilities must make a showing that they are pursuing but have been unable to obtain a license for on-site storage. A shutdown reactor needing space in the pool for decontamination or to store debris would not likely be able to make the showing required under the current FIS provisions. Third, the existing FIS is user-funded whereas the Commission concluded that having a facility to take care of emergencies is in the interest of all utilities and should be funded from the Nuclear Waste Fund to which all utilities contribute.

QUESTION 10.B. Is the second factor speculative, since not a single case involving a plant that cannot expand onsite storage or transship spent fuel in the next few years is mentioned?

RESPONSE: The need for a facility to prevent the shutdown of otherwise satisfactorily operating nuclear power plants is uncertain. Congress recognized that some plants might face this situation and provided in the Nuclear Waste Policy Act for an FIS facility to accommodate such a situation. No utility has come forward and identified the need to use the FIS. However, as the repository is delayed further into the future, the amount of waste to be stored increases and at many reactors it starts to exceed the capacity of the reracked pools (see Table 8.1 in the Commission's report). Therefore, the possibility that such a situation might arise increases. Considering that the cost of acquiring replacement power for a 1000 MWe nuclear reactor assumed to operate at a 65 percent capacity factor is currently about $300,000 per day or about $110 million per year, it seems prudent to provide for this contingency.

QUESTION 10.C. If no facility is likely to be in this situation very soon, is there any reason to hurry to build an MRS or UFIS now?

RESPONSE: The number of reactors exceeding their reracked pool capacity for certain repository delay scenarios is shown in Table 8.1 of the Commission's report. The number of reactors ending their currently licensed lifetimes each year is shown in Figure 4.3. It is not possible to know a priori how many will have difficulty getting a license extension for on-site storage. Therefore, the Commission is unable to estimate whether or when a facility is likely to encounter this situation. Given the costs of replacement power described in response to Question 10.B, it seems prudent to provide for such a contingency.

QUESTION 10.D. Will the third factor, storage for previously shut down reactors, be important within the next twenty years or so?

RESPONSE: If we assume that reactors will not shut down before their licenses expire, storage of spent fuel at shutdown reactors will not become significant until about 2013 when there will be a sharp increase in the number of nuclear power plants whose current licenses are to expire, unless they receive license extensions. However, several plants at sites with no other operating nuclear plants have already shut down before their licenses were due to expire. These include the Lacrosse plant near Lacrosse, Wisconsin, the Rancho Seco plant in Sacramento, California, and the Shoreham plant in New York whose status is uncertain. It is likely that other plants may shut down prematurely. Therefore, storage of spent fuel from shutdown reactors is still a factor which favors an unlinked MRS.

QUESTION 10.E. Concerning the fourth factor, economies in the waste management system, isn't it more economical to have no MRS than an MRS, whether linked or unlinked?

RESPONSE: On a present value basis, our calculations show it to be more economical to have a No-MRS system than an MRS system. However, the differences in the total-system life-cycle costs between the two types of systems decrease over time, particularly if the repository is significantly delayed. In addition, the cost estimates are based on assumptions that may or may not prove to be accurate over the long time period for which the predictions are made, although the relative differences should remain the same unless components of cost for each do not change in a parallel fashion.

QUESTION 10.F. Is the fifth factor, greater redundancy in the event of unforeseen circumstances, repetitive with emergency, lack of onsite capacity, or shutdown?

RESPONSE: The fifth factor is not repetitive with these other factors. Emergencies was explained in terms of problems with the reactors. Here, we include disruptions in other parts of the national nuclear waste management system.

In addition, lack of on-site storage capacity or shutdown of reactors at the end of their licensed operating lifetimes are circumstances that can be predicted. However, not all situations are predictable. For example, natural disasters or other occurrences could disrupt the operation of a repository after it begins to accept waste. A transportation accident could disrupt shipping campaigns. The fifth factor is merely meant to take into account any unforeseen circumstances that could disrupt the national nuclear waste management system.

QUESTION 10.G. Is the sixth factor, surge capacity, offset by the "bottleneck potential" argument?

RESPONSE: In Chapter Eight of our report, on pages 96 and 97, we list the advantages and disadvantages of an MRS. Surge capacity is listed as an advantage and the "bottleneck potential" is listed as a disadvantage. In Chapter Nine, we listed in the referenced section all of the potential advantages of an MRS but stated that no single factor would cause the MRS alternative to be chosen in preference to the No-MRS alternative. However, after balancing the potential advantages and disadvantages collectively, the Commission recommended two smaller, more limited facilities.

QUESTION 11: How do you establish a funding mechanism for the recommended UFIS? How do you deal with "two-phase" payments and the risk of state PUC's disallowing costs?

RESPONSE: Section Three of Appendix I in the Commission's report describes two approaches to creating a user-funding mechanism for a UFIS, a cost approach and an auction approach. Both would employ a two-phase payment mechanism in which an initial payment would be designed to cover the construction and licensing costs and the second to recover the operating expenses. If a State Public Utility Commission were to disallow either payment, it would be recovered from the utility's stockholders rather than from its ratepayers.

QUESTION 12: Would the UFIS be sited through the efforts of the negotiator or by DOE?

RESPONSE: The Commission would recommend that the negotiator be involved in attempting to site the UFIS but would not preclude siting by DOE.

QUESTION 13: Isn't the UFIS more expensive than a no-MRS system?

RESPONSE: Tables 1a and 1b contain estimates of the total-system life-cycle costs for ten cases:

- two cases that do not include an MRS, one with the repository opening in 2003 and a second with the repository opening in 2013 (I-A and IIA);
- two cases with an MRS linked to the repository as specified in NWPA with the repository starting in 2003 (case I-B, which approximates the schedule envisioned by the NWPA) and 2013 (case II-B, which represents a more realistic schedule);
- four cases with a User-Funded Interim Storage Facility (UFIS) with a 5,000 MTU inventory cap, two beginning operation in 1998 and 2000 with the repository opening in 2003 (I-C and I-D), and two with the repository opening in 2013 (II-C and II-D);[1]

[1] The cost estimates do not include the cost of the Federal Emergency Storage (FES) facility recommended by the Commission. The capital cost of this facility is estimated to be about $250 million with a licensing cost of about $50 million if it were built as a separate, stand-alone facility. If it were co-located with a UFIS, the incremental capital cost is estimated to be about $100 million with no additional licensing cost being incurred. The operating costs were estimated to be about $25 million per year for a stand-alone FES and about $15 million per year for a co-located facility. Since the FES is intended to provide storage in the event of an emergency and emergencies, by definition, are impossible to predict, no attempt was made to integrate the costs of the FES into the cases reported in the table. If it is assumed that the FES would be co-located with the UFIS, the relative magnitudes are such that the results would not be affected significantly. These estimates are based on an analysis of the costs of these facilities that was prepared after the Commission's report was published and are slightly lower than those presented in Appendix I of the Commission's report. The estimates of the costs of the UFIS and FES facilities were made after the

-- a case with a UFIS without an inventory cap (but the same, 750 MTU/year acceptance rate used in the previous cases) opening in the year 2000 and the repository opening in the year 2013 (II-E); and,

-- a case with an MRS opening in the year 2000 without an inventory cap and the repository opening in the year 2013 (II-F).

Table 1a shows the estimates in constant 1989 dollars (or in nominal values) and Table 1b shows the same estimates in constant 1989 dollars discounted at an annual rate of four per cent (or in present values).

Comparing the cases in which the repository is assumed to open in 2003 shows:

-- Using nominal values or undiscounted dollars, the No-MRS system is $2.1 billion less expensive than the MRS system and the two UFIS cases are $1.6 billion less expensive than the MRS system.

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report was issued by modifying the cost accounts used to make the estimates of the MRS systems so that they could be used to estimate the costs of the considerably smaller UFIS/FES facilities. Each individual cost account was subdivided in a manner consistent with the basic engineering and technological requirements of the component in question. Thus, for example, the components of the MRS facility designed according to DOE specifications, which has an annual acceptance rate of 3,000 MTU per year, were scaled down to correspond to the annual acceptance rate of 750 MTU per year used for the UFIS. The receiving and handling facilities at an MRS designed to take 3,000 MTU annually include four, 750 MTU hot cells, for example, while the receiving facilities at the UFIS include one 750 MTU hot cell. A new cost data base was created with cost accounts scaled down in this manner for each relevant account.

-- If present values or discounted dollars are used, the No-MRS
system is $0.9 billion less expensive than the MRS system and the two UFIS systems are $0.7 billion less expensive.

Comparing cases in which the opening of the repository is delayed until 2013:

-- The No-MRS system is $1.3 billion less than the linked MRS system but only $0.1 billion less than the unlinked MRS system measured in nominal values.
-- If present values are used, as in Table 1b, both the linked and unlinked MRS systems are $0.5 billion more expensive than the No-MRS system.
-- The two UFIS cases, which are subject to a 5,000 MTU inventory cap, are about $0.9 billion less expensive than the linked MRS, but about $0.3 billion more expensive than the unlinked MRS, measured in nominal values.
-- In present value terms, however, the capped UFIS systems are $0.2 billion cheaper than both the linked and unlinked MRS systems.

The UFIS proposal was made in the context of a recommendation for a Congressional reevaluation of the need for an interim storage alternative in the year 2000. If it were determined that the repository were to be delayed, one option would be to lift the inventory cap on the UFIS. This case is shown in case II-E, which assumes that the repository would open in 2013 and that the UFIS would continue to accept spent fuel at the same 750 MTU annual acceptance rate used in the previous UFIS cases.

-- This case has considerably lower costs than the No-MRS case (0.7 billion), either the linked (2.0 billion) or unlinked MRS systems (0.8 billion), and either of the UFIS cases, measured in nominal values.

-- In present value terms, it has the same estimated cost as the No-MRS system, $9.2 billion, and is less expe sive than any of the other cases.

TABLE 1a - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES

(Billions of constant 1989 dollars)

Column	(1) At-Reactor	(2) D&E[2]	(3) Interim Storage Facility	(4) Transportation	(5) Repository	(6) Total[3]	(7) Inventory When Repository Opens (MTU)	(8) % of Dry Storage Needs Met When Repository Opens
I. Repository in 2003								
A. No-MRS	2.3	9.0	NA	3.7	9.7	24.8	0	0
B. MRS (NWPAA) 2000	1.2	9.8	2.5	3.7	9.7	26.9	4,400	72
C. UFIS (750/yr/5K cap) 1998	1.6	9.3	0.9	3.8	9.7	25.3	3,750	61
D. UFIS (750/yr/5K cap) 2000	1.7	9.3	0.9	3.7	9.7	25.3	2,250	37
II. Repository in 2013								
A. No-MRS	5.1	9.0	NA	3.3	9.2	26.6	0	0
B. MRS (NWPAA) 2010	3.7	9.7	2.1	3.3	9.2	27.9	4,400	24
C. UFIS (750/yr/5K cap) 1998	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
D. UFIS (750/yr/5K cap) 2000	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
E. UFIS (750/yr/no cap) 2000	2.8	9.3	1.3	3.3	9.2	25.9	9,750	54
F. MRS (3000/yr/no cap) 2000	1.1	9.8	3.2	3.3	9.2	26.7	36,100	200[4]

TABLE 1b - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES

(Billions of constant 1989 dollars, discounted at 4%)

Column	(1) At-Reactor	(2) D&E[2]	(3) Interim Storage Facility	(4) Transportation	(5) Repository	(6) Total[3]
I. Repository in 2003						
A. No-MRS	1.0	6.3	NA	1.0	3.2	11.6
B. MRS (NWPAA) 2000	0.6	6.6	0.9	1.1	3.2	12.5
C. UFIS (750/yr/5K cap) 1998	0.7	6.4	0.4	1.1	3.2	11.8
D. UFIS (750/yr/5K crp) 2000	0.7	6.4	0.3	1.1	3.2	11.8
II. Repository in 2013						
A. No-MRS	1.8	4.8	NA	0.6	2.0	9.2
B. MRS (NWPAA) 2010	1.5	5.0	0.6	0.6	2.0	9.7
C. UFIS (750/yr/5K cap) 1998	1.5	4.9	0.4	0.7	2.0	9.5
D. UFIS (750/yr/5K cap) 2000	1.5	4.9	0.3	0.7	2.0	9.5
E. UFIS (750/yr/no cap) 2000	1.1	4.9	0.5	0.7	2.0	9.2
F. MRS (3000/yr/no cap) 2000	0.6	5.1	1.2	0.8	2.0	9.7

NOTES

1. Total-system life-cycle costs include all the costs of the system (research, development, licensing, construction, operating and administration) over the entire duration of the development and operation of the system. The cost categories used, in general, follow those used by the Department of Energy in its annual Total-system Life-cycle Cost reports and in the MRS System Studies. The two principal differences between the cost definitions used in the Commission's report and those reported by DOE are: 1) the Commission includes the additional costs incurred for management and security at shutdown reactors as a part of at-reactor costs and DOE does not, and 2) the Commission keeps development and evaluation (D&E) costs constant at the levels estimated for 2003 scenarios in which the repository is delayed while DOE continues to escalate D&E costs. See the Commission's Report, Chapter Six and Appendix I for further discussion of the cost concepts in the tables.

2. D&E stands for development and evaluation.

3. Components may not add to total because of rounding.

4. The acceptance schedules, which indicate how much spent fuel will be shipped to an MRS or repository, that were used in the MRS cases shown in the table are the same as those used by DOE in its studies. In the unlimited MRS case, the amount of spent fuel that would be stored at the MRS, according to DOE acceptance schedules, is twice as large as the amount of dry storage at reactor sites that would be necessary if neither a repository nor any interim storage were available, i.e., they would unload the spent fuel pools since the MRS is available to the utilities at no additional cost (it is Waste Fund financed).

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DEC 20 1989

The Honorable J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510-6150

Dear Senator Johnston:

Enclosed are the responses of the Monitored Retrievable Storage Review Commission to the questions posed by Members of the Committee in a letter dated November 6, 1989 in followup to our testimony at the November 2, 1989 hearing. In response to questions asked during the hearing, the Commission also is submitting a paper on the need for an MRS for the long-term aging of spent fuel.

Senator McClure requested responses to his questions from each individual Commissioner. However, since the Commissioners have no differing views on the responses to the questions, individual responses are not provided.

If the Committee Members or Committee staff have any questions concerning the material we have submitted, they may contact any of the individual Commissioners.

The Commission will cease to exist on December 31, 1989. Again, we thank you for this opportunity to serve the Congress.

Sincerely,

Alex Radin

Alex Radin
Chairman

cc: D. Klein
F. Parker
J. Axelrad

ATTACHMENT 1

QUESTION 1. You have stated that "There are a number of advantages that would justify a central storage facility not limited in capacity nor linked to the repository schedule and operation." Why then did you not either recommend such a facility or recommend that the current linkage between an MRS and a permanent geologic repository be repealed? Was this a political or technical decision on your part?

RESPONSE:

The advantages attributed by the Commission to an unlinked MRS were contingent upon four important factors: (1) having an MRS available early; (2) a significant delay in the repository program; (3) no linkages in time between the MRS and the repository, and (4) no capacity limit on the MRS. Each of these factors is clouded at this time by a great deal of uncertainty.

For example, even if a decision were made today to have an MRS, the date when an MRS would be available is by no means certain. Legislation would have to be enacted to remove the linkages to the repository schedule, and it is uncertain how quickly Congress might complete such action. Assuming, however, that Congress approved the removal of the time linkages, an MRS might then be delayed because of difficulties in site selection, licensing or construction.

Because of uncertainties about the date an MRS is likely to be available and the long planning horizons of the utilities, many utilities would be forced to provide expanded on-site storage of spent fuel in any event. (See Table 8.1 of the Commission's Report, p. 88.)

With regard to the date of opening of the repository, the Commission found in its studies that if the repository were delayed beyond the year 2013, the need for an MRS would be greater because of the sharp increase in the

the building of a permanent geologic repository as expeditiously as possible, consistent with meeting necessary safety and other public interest considerations.

Because the realization of all of the advantages of an unlinked MRS was based upon factors that were so time dependent, the Commission did not believe it was necessary or desirable to make a commitment to an unlinked MRS at this time. The Commission focussed on the most urgent needs to be served by an MRS and recommended facilities to provide those needs. The Commission also recommended that Congress reexamine the need for an MRS in the year 2000 when more is likely to be known about several of the factors that affect the need for interim storage.

As the report indicated, the Commission, in response to its mandate to "evaluate the utility of an MRS facility from a technical perspective," found that there is no technical basis for the linkages. However, the Commission did not construe its mandate from the Congress to limit its recommendations to technical considerations. One of the charges by the Congress to the Commission was to "obtain comment and available data on monitored retrievable storage from affected parties, including States containing potentially acceptable sites." The views expressed included both technical and policy considerations and the Commission felt obliged to take both categories of views into account. The Commission's recommendations therefore reflect both technical and policy considerations.

QUESTION 2. You acknowledge that the conclusions you reached do not provide all the benefits that an MRS would have provided, especially with the regard to an integrated nuclear waste system from the point of the waste's generation until its ultimate permanent disposal. Why then did you recommend a combination of public and private facilities that provide fewer benefits than would be provided by an MRS?

RESPONSE:

For the reasons stated in the report (Conclusion 3, p. 100), the MRS Review Commission could have recommended at this time an unlinked MRS. However, such a recommendation would entail premature commitment of resources. In contrast, our recommendations would meet the storage needs as seen at present, and would leave the sytem open to changes as they occur. In the next ten years, more will be known about the suitability of the Yucca Mountain site, the availability of dual-purpose casks, and the advantages and disadvantages of rod consolidation. Congress will be in a position to make a more informed decision in the year 2000 about the need for interim storage. (See response to Question 9 for discussion of the comparative costs of interim storage options.)

QUESTION 3. If the three conditions stated in your letter of transmittal are met, if these conditions were satisfied, would you then recommend an MRS?

RESPONSE:

It is impossible to determine whether the Commission would support an MRS if the three conditions were met. The conditions are subject to so much uncertainty, as indicated in the response to Question No. 1, that the Commission did not have discussions as to what its recommendations would be if the three condjtions were met. Even if the three conditions were met, a decision on the need for an MRS would be made based upon what other options were available at the time (e.g., dual-purpose casks).

Faced with the many uncertainties that could affect its decision, the Commission felt that the most prudent course was to recommend more limited facilities to address the most urgent needs for spent fuel storage. At the same time, the Commission recommended a reexamination of the issue in the year 2000, when some of the uncertainties might be resolved and additional storage options might be available. Mid-course corrections are normal and highly desirable in comparison to setting a fixed course at this time for 40 to 50 years.

QUESTION 4. If the Negotiator in the NWPA were able to find a willing party and undertake negotiations for an MRS as envisioned in the NWPA, would you support its construction?

RESPONSE:

In its report, the Commission rejected an MRS linked as envisioned in the NWPAA and would not support its construction even if it were sited by a negotiator. The Commission believes it would be useful for a negotiator to assist in site selection for the Federal Emergency Storage and User Funded Interim Storage facilities recommended by the Commission. Decisions about expanding the capacity of those facilities should be left until Congress revisits the need for interim storage in the year 2000. It would be a premature commitment of resources to recommend an unlinked MRS at this time even if one were to be sited by the Negotiator.

QUESTION 5. What capability does the Commission see for expansion of the on-site storage capability at existing nuclear power plants?

RESPONSE:

The Commission believes there is quite a large capability to expand the on-site storage capacity at existing nuclear power plants. Our contractor studies and preliminary findings from the Department of Energy's Facility Interface Capability Assessment (FICA) study show that most, if not all utilities, have already reracked with high-density racks to increase the amount of in-pool storage. In addition, the referenced studies show that most, if not all, utilities could expand on-site storage using dry storage technologies already in use at some sites. If further developments in dual-purpose casks and rod consolidation take place, this could increase the utilities' options for on-site storage. The NRC has said that spent fuel can be safely stored on-site for up to 100 years.

To be sure, a few utilities, for technical reasons, may be unable to expand their on-site storage facilities and others may encounter public opposition to expansion of on-site storage. The User Funded Interim Storage facility recommended by the Commission should provide capacity for those utilities that cannot provide on-site storage until Congress revisits the issue in the year 2000.

QUESTION 6. You recommend that the need for an MRS should be reexamined in the year 2000. Reference is made to the uncertainty in the date for operation of a permanent repository. If this date is your principal concern, why not immediately reexamine the date, rather than delay as you suggest. Would you comment?

RESPONSE:

The Commission did not feel that it had either the mandate or the capability to examine the date when the repository might become operational. As indicated in our Recommendation No. 3, we would need further information about the status of the repository which can only be forthcoming when additional surface and at-depth studies are made at the repository site. However, the Commission did do sensitivity studies to determine the effects of repository delay. Furthermore, past events have shown that even with the best of intentions, unforeseen events can cause schedule slippages.

In any event, the uncertainty in the date of operation of a permanent repository was only one of the uncertainties that affects the decision whether to have an MRS. On the other side of the equation, as Question 5 recognizes, is the availability of alternative means of storing spent fuel until the repository becomes available. If spent fuel could be stored at reactor sites safely and at a lower total system cost than at an MRS, then there would be little justification for the facility on the basis of safety and cost. By the year 2000, Congress will be in a better position to judge how much of a delay is likely in the repository program, and the availability of alternative means of storing spent fuel. At that time, a more informed decision on the need for interim storage can be made.

QUESTION 7. What is the basis for the capacity limits that you recommend for the Federal Emergency Storage (FES) and the User-Funded Interim Storage (UFIS) facilities?

RESPONSE:

The basis for the capacity limits for the FES and the UFIS facilities is described in Appendix I to our report. A copy of the pertinent section is attached.

Appendix I

The Commission's Recommendations: Cost, Capacity, and Financing

Section One: Costs

The Commission's recommendations to create the Federal Emergency Storage (FES) and User-Funded Interim Storage (UFIS) facilities do not rest on the expectation that they would reduce the cost of the spent fuel management and disposal system. The FES is intended to provide resilience to the system by insuring that spent fuel can be removed expeditiously from a reactor pool in an emergency and to provide storage for reactors that would have to shut down because they were unable to build at-reactor dry storage facilities. The UFIS will provide an alternative to on-site dry storage for utilities that choose to use it, at their own expense. The UFIS may reduce the share of the total cost that comes from the Nuclear Waste Fund, but it is unlikely to reduce overall system cost.

The annual Federal Interim Storage Fee Study[1] estimates the cost of storage facilities for a number of alternative types, sizes, and locations. In the 1988 report, the capital costs for a 1,900 MTU facility ranged from a low of $140 million for a facility located at a site where transfer facilities and hot cell facilities were already in existence and made use of a field drywell storage system to a high of $220 million for a facility located at a site without transfer or hot cell facilities using dry cask storage.

The Commission also asked Golder Associates Inc., who developed the cost data base and simulation model described in Chapter Six, to provide some preliminary cost estimates. These estimates were based on the encoded cost data base described in Chapter Six, which explicitly incorporates uncertainty about the future escalation of such costs. Thus, they are higher than today's engineering estimates of what it would cost to build and operate such facilities. As emphasized in their report, these estimates were "very preliminary, order of magnitude only."[2] Golder estimated that the capital cost of a 2,000 MTU capacity facility built at a site with existing hot cell and transfer facilities using dry casks for storage would be $330 million. The capital cost of the same facility built at a site without these facilities was estimated to be $370 million.

For a 5,000 MTU facility using dry cask storage, Golder estimated the capital cost to be $530 million if built at a site with transfer facilities and hot cells and $570 million if built at a site without such facilities.

Section Two: Capacity

The recommended capacities of the FES and UFIS are not intended to provide for all storage needs over the life cycle of the national spent fuel management system. The Commission's objective is to provide a prudent degree of resiliency and redundancy in the system over the next 10 to 15 years. The recommendations assume that, as outlined in Recommendation No. 3 in Chapter Nine, the Congress will reconsider the subject of interim storage by the year 2000; the recommendations also reflect the concerns that have been expressed about such facilities becoming a de facto repository.

The FES facility's principal purpose is to provide a place for spent fuel should there be an emergency at a reactor, which would make it desirable to remove all of the fuel stored in the pool. As indicated in Chapter Nine, about 1,000 MTU of capacity would be required to empty a large, full pool at an operating reactor and would always be reserved for that purpose. The remaining 1,000 MTU of capacity would be available for use by utilities that would have to shut down before the end of their designed operating life because they were unable to provide on-site dry storage if the UFIS were not available.

Until the Facility Interface Capability Assessment (FICA) survey being conducted by DOE on reactor capabilities is completed, it will not be possible to ascertain how many, if any, reactors will be unable to accommodate at their sites all of the spent fuel they will discharge. However, if neither a repository nor an MRS were available, in 20 years about 13,900 MTU of dry storage capacity would be needed at reactor sites. Assuming that utilities plan at least five years ahead, provision has already been made for about 1,300 MTU of dry storage. Thus, even if as many as 10 percent of the reactors were to find it impossible to store additional discharges of spent fuel on-site, the provision of 1,000 MTU of capacity for this purpose seems reasonable and conservative over the 10- to 15-year planning horizon the Commission has used.

Reserving 1,000 MTU for emergency purposes also appears to be a reasonable and conservative assumption. Emergencies at nuclear power plants that would require the reactor to shut down or a pool to be emptied are rare events. The frequency of rare events is difficult to predict. However, some calculations that provide rough estimates are available. The *Reactor Safety Study*, commonly referred to as WASH-1400 or the Rasmussen Report, which was published by the NRC in 1975, estimated that the probability of a serious accident involving a core meltdown, in the current generation of reactors, was 1/20,000 per reactor year.[3] Assuming 100 reactors will be operating over the next 20 years, there would be 2,000 reactor years. Using the WASH-1400 probability estimate of a core meltdown as the probability of a serious accident would mean that the probability of a serious accident occurring during that time period would be equal to 2,000 x 1/20,000 or 10 percent.

The risk estimates in WASH-1400 have been criticized from a number of perspectives.[4] The Lewis Report[5] concluded that the estimates may be off by one order of magnitude in either direction, which would mean that over the time period in question, the probability of a serious accident would range from a low of 1 percent to a high of 100 percent. In any event, the Commission believes the probability that a serious accident may occur is not negligible, thus, it would be prudent to maintain a capability to deal expeditiously with the possible need to remove the spent fuel from the pool. A reasonable estimate of the capacity required to accomplish this appears to be 1,000 MTU.

Section Three: Financing

In its submission to the Congress of the MRS Program Plan, DOE presented a funding plan calling for the MRS to be financed through the Nuclear Waste Fund. It said it did not consider user funding for an MRS because:

> [A]n approach that imposes a surcharge on only the generators and owners of spent fuel that passes through the MRS facility would be inconsistent with the integral nature of the MRS facility. The decision of which fuel will pass through the MRS facility rests on overall system considerations and not on the preferences of individual utilities. Hence, this approach is not considered further.[6]

As DOE's proposed MRS has evolved from a comprehensive packaging, consolidation, storage, and logistical facility into a simpler "basic" facility providing only storage and logistics, this logic has become less persuasive, particularly if the facility is constrained by an inventory limit.

As explained in Chapter Seven, the smaller the MRS, the more limited its services, and the fewer the number of utilities that make use of it, the weaker the case for general, industry-wide financing on both equity and economic efficiency grounds. Thus, the Commission recommends that its UFIS, a 5,000 MTU, optional, off-line, centralized interim storage facility, be user funded.

There are two basic ways to design user-fee systems: a cost approach and an auction approach.

The *cost approach* is illustrated in considerable detail in the annual Federal Interim Storage Fee studies, which have been prepared by E.R. Johnson Associates, Inc., for the Department of Energy since 1983.[7]

The cost approach is normally utilized when the demand for the facility is expected to be smaller than its potential capacity. In the case of an FIS, E.R. Johnson Associates has identified 13 utility sites as prospective FIS users. By 1995, they estimate, these sites will have a combined demand of only 1,286 MTU compared to an authorized FIS capacity of 1,900 MTU. Since none of the sites has applied to use the FIS and the report assumes an MRS will open in 1998 followed by a repository in 2003, the expectation that the demand for an FIS would be less than its authorized 1,900 MTU limit appears quite conservative. If the demand for the facility were expected to exceed its capacity, a lottery or some sort of "needs" criteria for making an administrative determination would have to be used to decide who would get the available capacity and who would not.

The *auction system* is the second approach to designing a user-fee system. It is based on price rather than cost. It is best suited to a situation in which the demand for the facility is uncertain or is expected to be greater than the capacity of the facility. If there is more storage needed than the facility is able or permitted to provide, letting potential users bid for it helps insure that the use will go to those who "need" or value it most (in the sense that they are willing to pay the highest price to acquire it).

Similarly, if it is not clear that there are enough interested users to justify building a facility, holding an auction provides a mechanism for ascertaining how much storage is desired and whether potential users are willing to pay enough to enable the government to provide the service. If the proceeds from the auction were not sufficient to cover the cost of building the facility, it simply would not be built. Subsequent auctions could be held, however, to ascertain if conditions or expectations had changed sufficiently to warrant building the facility.

The design criterion underlying the *cost approach* is to insure that the fees cover all capital and operating costs of the facility. This is done with a two-fee system. As outlined in the annual FIS report prepared by E.R. Johnson Associates, an "initial" fee, paid when the contract is signed, covers all construction and licensing expenses expected to be incurred before the facility opens. Then a "final" fee is determined which covers: (1) transportation costs to the FIS, (2) estimated operating and decommissioning costs, and (3) an adjustment for any over or under estimates that may have been made in establishing the "initial" fee. The final fee is paid when the fuel is delivered to the FIS. Since the report assumes a repository will be available in 2003 and the fuel from the FIS will have to be transferred within three years as specified by the NWPA, there is little (assumed) uncertainty about how long the spent fuel will be stored at the facility. In the case of a UFIS, there might be considerably more uncertainty and, thus, it would probably be prudent to make the operating expenses an annual fee, payable as long as the fuel remained at the facility, rather than part of a "final" fee.

Under the *auction approach*, an auction would be held at which prospective users would bid for the available storage capacity with the highest bidders winning the right to store spent fuel at the facility. In order to assure that the fees collected cover all costs of the facility, a variation of the two-fee system described in the cost approach above could be used. The initial fee would be set on the basis of bids received at auction and paid when construction was initiated. The final fee and annual operating charge would be set as described above so as to insure all costs were fully compensated.

The principal problem in implementing this approach is the uncertainty as to the cost of licensing the facility. The financial risk associated with a commitment to license an inherently controversial nuclear facility of this sort may be too great to permit a two-fee, auction-implemented, user-funded mechanism to function. Further, potential users would need some assurance that a centralized facility would be available by a specific date, if they are to be able to efficiently compare the centralized storage alternative with at-reactor storage. Therefore, prior to the auction of storage rights, DOE, with the advice and assistance of NRC, should provide a realistic estimate of the licensing costs and a guarantee that licensing costs in excess of this amount would be paid for from contingency funds.

Under a *cost system*, eligibility criteria would probably be needed to insure: (1) the demand for storage could be anticipated with enough certainty to make a reasonable estimate of costs, and (2) the demand for the facility would not exceed the desired capacity limit.

If the *auction system* were used, it would be important to make the auction as competitive as possible. Effective competition usually requires a large enough number of bidders to make collusion among them difficult to arrange or enforce. In the case of utilities, the number of potential bidders is probably large enough, at least for storage in the late 1990's and beyond.[8] Under either a cost or an auction system, efficiency would be enhanced if the rights (or contracts) to store spent fuel could be bought and sold. This would allow all utilities to compare the cost of on-site storage options with the cost of centralized storage and make adjustments if warranted. It would also encourage utilities to bid in an auction system since they could sell rights at a later date if their need for storage were to change or if an increase in the price of the rights were to make it more advantageous to sell rather than use them.

Appendix I Notes

1. E.R. Johnson Associates, Inc., for Pacific Northwest Laboratory, "1988 Federal Interim Storage Fee Study: A Technical and Economic Analysis," PNL-6727/UC-85, November 1988 (Hereafter cited as FIS Study/PNL-6727), p. 4-4. Costs rounded in text.

2. Golder Associates Inc., "Interim Storage Facility Cost Estimates," October 2, 1989. Costs rounded in text.

3. Nuclear Regulatory Commission, "The Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," (Rasmussen Report) WASH-1400, NUREG-75/014, October 1975.

4. See Nuclear Energy Policy Study Group, *Nuclear Power Issues and Choices*, Cambridge, Massachusetts: Ballinger Publishing Company, 1977, pp. 221–233, and Wood, William C., *Nuclear Safety Risks and Regulation*, Washington, D.C.: American Enterprise Institute, 1983, pp. 41-43, for a discussion of the WASH-1400 estimates.

5. H.W. Lewis et al., "Risk Assessment Review Group: Report to the U.S. Nuclear Regulatory Commission," NUREG/CR-0400, September 1978.

6. Department of Energy, "Monitored Retrievable Storage Submission to Congress," DOE/RW-0035/1, Rev. 1, March 1987, Vol. III, pp. 5.1-5.3.

7. FIS Study, PNL-6727, November 1988, and previous years.

8. The number of sites projected to require dry storage if an MRS or a repository is not available increases from 12 in 1995, to 32 in 2000, to 44 in 2005.

QUESTION 8. How long do you think it would take to bring into operation either the FES or the UFIS facilities you recommend? If these schedules cannot be met, what would you propose?

RESPONSE:

Once authorizing legislation was passed, the Commission estimates it would take between two to five years to bring the FES facility into operation. This estimate is based upon the Department of Energy's estimates for bringing a Federal Interim Storage (FIS) facility into operation. These estimates are contained in its annual "Implementation Plan for Deployment of Federal Interim Storage Facilities for Commercial Spent Fuel," DOE/RW-0218, January 1989. As Chapter Nine of our report indicates, the proposed FES is similar in size to the FIS facility currently authorized under the Nuclear Waste Policy Act and the Commission recommended that the siting and licensing provisions currently in that act apply to the proposed FES as well. Therefore, the schedule estimates for the FES should be similar.

DOE estimates the time to site, license and construct an MRS to be about 8 to 10 years. It is the Commission's hope that it would be easier to site and license the UFIS than an MRS because it would be smaller in capacity and user funded and may, therefore, generate less opposition.

If these schedules for the FES and UFIS cannot be met, then spent fuel can continue to be safely stored at reactor sites although there may be some sites where out of pool storage will not be possible. If the smaller, more limited FES and UFIS facilities cannot be built expeditiously, it is likely an unlinked MRS would encounter substantially greater delays.

QUESTION 9. a. Would you provide for the record a comparative economic analysis of the costs of No-MRS, No-MRS but your proposal, an MRS on the schedule envisioned by the NWPA (without delay of the repository), and an MRS on a realistic schedule (but tied to the repository)?

RESPONSE: Tables 1a and 1b contain estimates of the total-system life-cycle costs for ten cases:

-- two cases that do not include an MRS, one with the repository opening in 2003 and a second with the repository opening in 2013 (I-A and IIA);
-- two cases with an MRS linked to the repository as specified in NWPA with the repository starting in 2003 (case I-B, which approximates the schedule envisioned by the NWPA) and 2013 (case II-B, which represents a more realistic schedule);
-- a case with a User-Funded Interim Storage Facility (UFIS) without an inventory cap (but the same, 750 MTU/year acceptance rate used in the previous cases) opening in the year 2000 and the repository opening in the year 2013 (II-E); and,
-- four cases with a UFIS with a 5,000 MTU inventory cap, two beginning operation in 1998 and 2000 with the repository opening in 2003 (I-C and I-D), and two beginning operation in 1998 and 2000 with the repository opening in 2013 (II-C

and II-D);[4]

-- a case with an MRS opening in the year 2000 without an inventory cap and the repository opening in the year 2013 (II-F).

Table 1a shows the estimates in constant 1989 dollars (or in nominal values) and Table 1b shows the same estimates in constant 1989 dollars discounted at an annual rate of four per cent (or in present values).

Comparing the cases in which the repository is assumed to open in 2003 shows:

-- Using nominal values or undiscounted dollars, the No-MRS system is $2.1 billion less expensive than the MRS system and the two UFIS cases are $1.6 billion less expensive than the MRS system.

-- If present values or discounted dollars are used, the No-MRS system is $0.9 billion less expensive than the MRS system

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[4] The cost estimates do not include the cost of the Federal Emergency Storage (FES) facility recommended by the Commission. The capital cost of this facility is estimated to be about $250 million with a licensing cost of about $50 million if it were built as a separate, stand-alone facility. If it were co-located with a UFIS, the incremental capital cost is estimated to be about $100 million with no additional licensing cost being incurred. The operating costs were estimated to be about $25 million per year for a stand-alone FES and about $15 million per year for a co-located facility. Since the FES is intended to provide storage in the event of an emergency and emergencies, by definition, are impossible to predict, no attempt was made to integrate the costs of the FES into the cases reported in the table. If it is assumed that the FES would be co-located with the UFIS, the relative magnitudes are such that the results would not be affected significantly. These estimates are based on an analysis of the costs of these facilities that was prepared after the Commission's report was published and are slightly lower than those presented in Appendix I of the Commission's report. For further information on this point, see response to Question 9b.

and the two UFIS systems are $0.7 billion less expensive than the MRS.

Comparing cases in which the opening of the repository is delayed until 2013:

-- The No-MRS system is $1.3 billion less than the linked MRS system but only $0.1 billion less than the unlinked MRS system measured in nominal values.

-- If present values are used, as in Table 1b, both the linked and unlinked MRS systems are $0.5 billion more expensive than the No-MRS system.

-- The two UFIS cases, which are subject to a 5,000 MTU inventory cap, are about $0.9 billion less expensive than the linked MRS, but about $0.3 billion more expensive than the unlinked MRS, measured in nominal values.

-- In present value terms, however, the capped UFIS systems are $0.2 billion cheaper than both the linked and unlinked MRS systems.

The UFIS proposal was made in the context of a recommendation for a Congressional reevaluation of the need for an interim storage alternative in the year 2000. If it were determined that the repository were to be delayed, one option would be to lift the inventory cap on the UFIS. This case is shown in case II-E, which assumes that the repository would open in 2013 and that the UFIS would continue to accept spent fuel at the same 750 MTU annual acceptance rate used in the previous UFIS cases.

-- This case has considerably lower costs than the No-MRS case ($0.7 billion), either the linked MRS ($2.0 billion) or unlinked MRS systems ($0.8 billion), and either of the UFIS cases, measured in nominal values.

-- In present value terms it has the same estimated cost as the No-MRS system, $9.2 billion, and is less expensive than any of the other cases.

The last two columns in Table 1a relate the cases to the "need" for dry storage.[5] The first (column 7) shows the magnitude of the inventory, measured in metric tons of uranium, at the interim storage facility when the repository opens. The next column expresses that magnitude as a percentage of the total dry storage need that would exist without any interim storage facilities. To illustrate:

-- A linked MRS opening in the year 2000, when the repository opened in 2003, would have an inventory of 4,400 MTU which amounts to 72 per cent of the estimated 6,100 MTU which would have to be put into dry storage if no interim storage facility or repository were available by that date.

-- In the 2013 case, because the date at which an MRS can accept spent fuel would be delayed on a day-for-day, month-for-month basis if the repository were delayed, the linked

[5] The "need" for dry storage refers to the total amount of spent fuel which the WACUM simulation model shows could not be accommodated in pools even if all pools were fully reracked. Some utilities have testified before the Commission that they plan to provide dry storage at the reactor sites and other utilities may make the same choice.

MRS would not be able to accept fuel until the year 2010. As a consequence it would not be able to accept as much spent fuel as any of the UFIS systems.

-- The UFIS without an inventory cap would be able to accept more than twice as much fuel as the linked MRS and would be $2.0 billion less expensive.

-- If the Congress were to remove the linkages and an unlinked MRS were to open in 2000, it would have an inventory of 36,100 MTU in the year 2013, which is twice as large as the estimated need for dry storage. (This assumes DOE accepts spent fuel at the MRS at the currently predicted rate of 3,000 MTU per year after a short ramp up period. Fuel would be unloaded from the spent fuel pools since the MRS would be available to the utilities at no additional cost because it would be Waste Fund financed.)

-- The UFIS shown in II-E would be able to meet 54 percent of the need for dry storage and only have an inventory of 9,750 in 2013.

When considering the costs of a system without an MRS, or the costs of any system which because of linkages or inventory caps may not be able to accept spent fuel, it is importa[illegible] to recognize that the costs included in the estimates of total-system life-cycle costs shown in the tables do not include estimates of the costs that would be incurred if otherwise satisfactorily operating reactors were to have to shut down because they could not store spent fuel at the reactor sites or could not obtain the license amendments necessary to do so in a timely fashion. The cost of acquiring replacement power for a 1000 MWe nuclear reactor assumed to operate at a 65 percent capacity factor is currently about $300,000 per day or about $110 million per year.

A final relevant attribute of the cost comparisons involves the "voluntary" nature of the costs under user-funding and the mandatory nature of the costs if the facilities are paid for from the Nuclear Waste Fund. Under a user-funded system, the decision to use the UFIS rather than to store spent fuel at the reactor is made by the utility. Therefore, if the utility chooses to use the UFIS, it either expects the cost of using the UFIS to be less than on-site storage or it expects the additional benefits it will derive from the UFIS to outweigh the additional costs.

QUESTION 9.b. Would you provide an analysis of the full costs of your no-MRS recommendation?

RESPONSE:

The costs of our recommendations were provided in response to Question 9a. The methods used to estimate the costs of the MRS and No-MRS cases, and the Commission's recommendations, are shown in Tables 1a and 1b and are described in Chapter Six and Appendix I of our report. Briefly, a panel of experts with experience in the estimation of the costs of spent fuel management and disposal systems met as a group and developed probability distributions for a comprehensive set of cost accounts corresponding to various functions to be performed by the spent fuel management and disposal system. The cost accounts were then integrated into a simulation model which was used to estimate costs under different assumptions as to the start date for the repository and the schedules, nature, and location of the other components of the system. Some differences in the definition and measurement of costs between our estimates and those made by the Department of Energy exist and are discussed in the report, but, in general, the pattern of cost differences between MRS and No-MRS alternatives is consistent, or reconcilable, between the two sets of cost estimates.

The estimates of the costs of the UFIS and FES facilities were made by modifying the cost accounts used to make the estimates of the MRS systems so that they could be used to estimate the costs of the considerably smaller UFIS/FES facilities. Each individual cost account was subdivided in a manner consistent with the basic engineering and technological requirements of the component in question. Thus, for example, the components of the MRS facility designed according to DOE specifications, which has an annual acceptance rate of 3,000 MTU per year, were scaled down to correspond to the annual acceptance rate of 750 MTU per year used for the UFIS. The receiving and handling facilities at an MRS designed to take 3,000 MTU annually include four, 750 MTU hot cells, for example, while the receiving facilities at the UFIS include one 750 MTU hot cell. A new cost data base was created with cost accounts scaled down in this manner for each relevant account.

When looking at costs twenty years into the future, one also must be cautious about the uncertainties in the predictions. The cost estimates are based on assumptions that may or may not prove to be accurate over the long time period for which the predictions are made, although the relative differences should remain the same unless components of cost for each do not change in a parallel fashion.

TABLE 1a - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES
(Billions of constant 1989 dollars)

Column	(1) At-Reactor	(2) D&E[2]	(3) Interim Storage Facility	(4) Transportation	(5) Repository	(6) Total[3]	(7) Inventory When Repository Opens (MTU)	(8) % of Dry Storage Needs Met When Repository Opens
I. Repository in 2003								
A. No-MRS	2.3	9.0	NA	3.7	9.7	24.8	0	0
B. MRS (NWPAA) 2000	1.2	9.8	2.5	3.7	9.7	26.9	4,400	72
C. UFIS (750/yr/5K cap) 1998	1.6	9.3	0.9	3.8	9.7	25.3	3,750	61
D. UFIS (750/yr/5K cap) 2000	1.7	9.3	0.9	3.7	9.7	25.3	2,250	37
II. Repository in 2013								
A. No-MRS	5.1	9.0	NA	3.3	9.2	26.6	0	0
B. MRS (NWPAA) 2010	3.7	9.7	2.1	3.3	9.2	27.9	4,400	24
C. UFIS (750/yr/5K cap) 1998	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
D. UFIS (750/yr/5K cap) 2000	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
E. UFIS (750/yr/no cap) 2000	2.8	9.3	1.3	3.3	9.2	25.9	9,750	54
F. MRS (3000/yr/no cap) 2000	1.1	9.8	3.2	3.3	9.2	26.7	36,100	200[4]

TABLE 1b - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES

(Billions of constant 1989 dollars, discounted at 4%)

Column	(1) At-Reactor	(2) D&E[2]	(3) Interim Storage Facility	(4) Transportation	(5) Repository	(6) Total[3]
I. Repository in 2003						
A. No-MRS	1.0	6.3	NA	1.0	3.2	11.6
B. MRS (NWPAA) 2000	0.6	6.6	0.9	1.1	3.2	12.5
C. UFIS (750/yr/5K cap) 1998	0.7	6.4	0.4	1.1	3.2	11.8
D. UFIS (750/yr/5K cap) 2000	0.7	6.4	0.3	1.1	2	11.8
II. Repository in 2013						
A. No-MRS	1.8	4.8	NA	0.6	2.0	9.2
B. MRS (NWPAA) 2010	1.5	5.0	0.6	0.6	2.0	9.7
C. UFIS (750/yr/5K cap) 1998	1.5	4.9	0.4	0.7	2.0	9.5
D. UFIS (750/yr/5K cap) 2000	1.5	4.9	0.3	0.7	2.0	9.5
E. UFIS (750/yr/no cap) 2000	1.1	4.9	0.5	0.7	2.0	9.2
F. MRS (3000/yr/no cap) 2000	0.6	5.1	1.2	0.8	2.0	9.7

NOTES

1. Total-system life-cycle costs include all the costs of the system (research, development, licensing, construction, operating and administration) over the entire duration of the development and operation of the system. The cost categories used, in general, follow those used by the Department of Energy in its annual Total-system Life-cycle Cost reports and in the MRS System Studies. The two principal differences between the cost definitions used in the Commission's report and those reported by DOE are: 1) the Commission includes the additional costs incurred for management and security at shutdown reactors as a part of at-reactor costs and DOE does not, and 2) the Commission keeps development and evaluation (D&E) costs constant at the levels estimated for 2003 scenarios in which the repository is delayed while DOE continues to escalate D&E costs. See the Commission's Report, Chapter Six and Appendix I for further discussion of the cost concepts in the tables.

2. D&E stands for development and evaluation.

3. Components may not add to total because of rounding.

4. The acceptance schedules, which indicate how much spent fuel will be shipped to an MRS or repository, that were used in the MRS cases shown in the table are the same as those used by DOE in its studies. In the unlimited MRS case, the amount of spent fuel that would be stored at the MRS, according to DOE acceptance schedules, is twice as large as the amount of dry storage at reactor sites that would be necessary if neither a repository nor any interim storage were available, i.e., they unload the spent fuel pools since the MRS is available to the utilities at no additional cost (it is Waste Fund financed).

QUESTION 10. You recommend that the issue of interim storage should be reexamined in the year 2000. What should be the basis for that reexamination? Are you recommending that the capacity limit or the need for interim storage should be reexamined?

RESPONSE:

The factors which would provide the basis for that reexamination, as described in Chapter 9, are:

a. Status of the repository;

b. Status of nuclear power plants, i.e., number that shut down early, license extensions, utilization of extended burnup, etc.;

c. Availability of at-reactor storage;

d. Utilization and adequacy of the 2,000 MTU Federal Emergency Storage facility;

e. Utilization and adequacy of the 5,000 MTU User-Funded Interim Storage facility;

f. Status of rod consolidation, dual-purpose casks, and other technological developments in spent fuel storage;

g. System optimization; and

h. The fee schedule established for the user-funded facility.

As these factors suggest, the Commission has explicitly recommended that the capacity limit and need for interim storage facilities should be reexamined in the year 2000.

QUESTION 11. Current law imposes several conditions on an MRS, such as State veto, congressional override, and impact compensation.

a. **Should similar conditions apply to the facilities you propose?**

b. **How would you propose to avoid similar limitations?**

RESPONSE:

Similar conditions should apply to the facilities proposed by the Commission.

QUESTION 12. On page 101 of your report, you state that "consistent with the NWPA provisions, an NRC license will not be required if the FES is located at an existing Federal site." What is the basis for that statement?

RESPONSE:

Taken in the context of the surrounding discussion, this statement was intended as the Commission's recommendation that an NRC license not be required for an FES located at an existing Federal site. The Nuclear Waste Policy Act of 1982 (NWPA) exempts from NRC licensing a Federal Interim Storage (FIS) facility located at an existing Federal site, but requires a finding from NRC that an FIS at a Federal site would adequately protect public health and safety. The FES recommended by the Commission is similar in size to the FIS authorized in the NWPA. Therefore, the Commission believes the same provisions with regard to licensing should be applied to the FES.

QUESTION 13. Could the FES and UFIS be used as staging facilities for shipments to the repository? If not, where would you propose to provide this capability?

RESPONSE:

While the Commission's studies did not demonstrate the need for a staging facility for shipments to the repository, studies now under way indicate there may be some advantages to tailoring the receipt of spent fuel to provide levelized energy deposition over the areal and temporal extent of the repository. However, spent fuel can be stored at the reactor sites and selectively shipped directly to the repository to provide the necessary mix of spent fuel.

With regard to the need for staging for transportation purposes, the Commission determined that the radiological and non-radiological transportation risks associated with both the No-MRS and MRS alternatives were small and are not discriminating in the determination of the need for an MRS.

Therefore, the Commission did not recommend the FES and the UFIS be used as staging facilities for shipments to the repository.

If there were a n ed for staging, there is no reason the UFIS could not be used for this purpose. It would not be expected that the FES would be used as a staging area since its primary mission is for emergencies. However, if the FES and UFIS were co-located, either one could serve as a staging area consistent with any capacity limitation, and consistent with the reservation of 1000 MTU of capacity for emergencies.

QUESTION 14. Your report recommends that the Federal Emergency Storage facility be located at an existing Federal site. What would be the recommended criteria for selecting that site and when would you expect the FES to be operational?

RESPONSE:

The Commission did not address the criteria for selecting sites for either of the facilities it recommended. According to the NWPA, as amended, the responsibility for site selection rests with the Department of Energy. The schedule for operation of the FES is addressed in response to Question 8.

QUESTION 15. The interim storage facility proposed by the Commission will seem to many people to be an unlinked mini-MRS. Mr. Radin, could you tell me how this recommended interim facility would be different?

RESPONSE:

The interim storage facility proposed by the Commission is different from the unlinked MRS in that it would be more limited in capacity (5,000 MTU versus 15,000 MTU); it would be user funded; and it would be an off-line facility--not all of the spent fuel in the nation's waste management system would pass through the facility.

QUESTION 16. What criteria would you recommend for selecting the location for the interim facility?

RESPONSE:

As indicated in response to Question 14, the Commission was not responsible for siting an interim storage facility and did not address siting criteria.

ATTACHMENT 2
December 20, 1989

LONG-TERM AGING OF SPENT FUEL

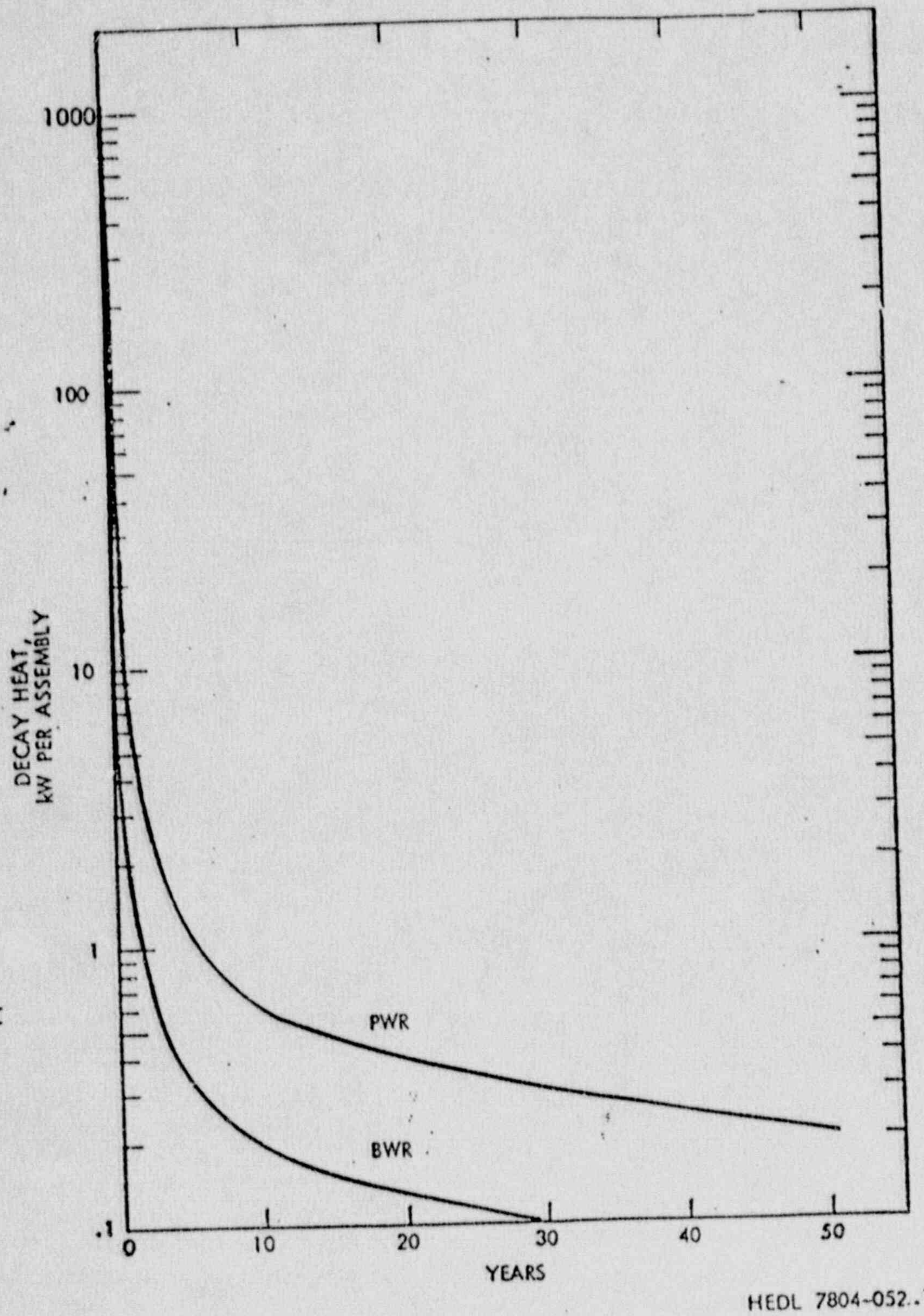
INTRODUCTION

At the November 2, 1989 hearings before the Senate Committee on Energy and Natural Resources on the final report of the Monitored Retrievable Storage Review Commission, Senator Johnston asked a number of questions concerning the need for long-term aging of spent fuel before it is emplaced in a geologic repository and the role of a monitored retrievable storage facility (MRS) if such aging is necessary or desirable. This report was written to address these questions.

Aging of spent fuel prior to emplacement in a repository is an important part of prudent spent fuel management. It allows time for decay of the shorter lived fission products in the fuel and reduces the thermal output (decay heat) of the fuel (see Figure 1). This could allow emplacement of more spent fuel per acre in a geologic repository, thus reducing the area to be excavated and the resulting repository costs, or it could reduce the technical uncertainties about thermal effect on the waste package and the emplacement medium if the same spent fuel spacing were maintained. The reduced thermal output would reduce the temperature of the host rock which would substantially reduce the scientific uncertainties in analysis of the interactions of the rock, ground water, backfill, overpack, canister material, and the waste.

As can be seen from Figure 1, the rate of decrease in decay heat decreases substantially after the first 10 years. However, the thermal output does continue to decrease. For example, for pressurized water reactor (PWR) fuel, the thermal output decreases from 1.1 kW/assembly at five years to 0.6

FIGURE 1 - Typical PWR and BWR Fuel Assemblies' Decay Heat Curves.



Hanford Engineering Development Laboratory "Spent Fuel Data for Waste Storage Programs" HEDL-TME-- 79-20, September 1980, pg 45 kW/assembly at 10 years to 0.4 kW/assembly at 20 years to 0.2 kW/assembly at 50 years. The proportional decrease is the same for boiling water reactor (BWR) fuel. These numbers are for an average fuel element irradiated at nominal conditions (33,000 MWd/MT for a PWR and 27,000 MWd/MT for a BWR).[1]

As Senator Johnston observed and the Commission recognized in its report, other countries have chosen to age their high-level waste for long periods (in some cases up to 40 or 50 years) before emplacement in a repository to reduce the temperature in the repository host rock.[2] The reduction in thermal output of the waste is expected to result in peak host rock temperatures of about 100°C. The schedules of other countries for development of a geologic repository are protracted, in part because of the decision to cool the waste for long periods before disposal.

In contrast, the United States' program has placed its emphasis on moving as quickly as possible to develop a geologic repository and to begin to dispose of the waste. DOE has determined that geologic repositories for the disposal of spent fuel can be designed to dispose of 10 year old fuel safely in any of three media (i.e. tuff, salt, and basalt) and is designing its repository for acceptance of 10 year old fuel. The current DOE designs call for a peak temperature of about 200-250°C in the host rock.

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[1] In reality, spent fuel from a commercial nuclear power plant will have a spectrum of energy output at different ages depending on its initial enrichment, whether it was used in a BWR or PWR, and its burnup history in the reactor. For this general discussion, we shall use average conditions.

[2] Most European countries with nuclear power plants reprocess their spent fuel. (See Table D1--Summary Table: Spent Fuel and HLW Storage in Eight Countries in Appendix D of the Commission's report for a list of those countries that reprocess.) If the spent fuel is reprocessed, the resultant high-level waste is expected to be stored 20 to 50 years prior to disposal in a geologic repository.

Assuming a 2003 repository start-up date, DOE estimated that the average age of spent fuel received at the repository would be about 20 years.[3] If the repository start date were delayed until 2013 (which is reasonably close to the 2010 start date now being projected by DOE), the average age of the spent fuel would increase to about 30 years with the youngest fuel emplaced being about 20 years old. This aging of the fuel would occur regardless of whether there was an MRS in the system and the scenarios examined by the Commission encompassed this type of long-term storage. The question is whether aging of spent fuel for even longer periods would be beneficial and whether the benefits would outweigh the costs.

BENEFITS

Aging of spent fuel for additional periods of time (e.g. requiring that the youngest emplaced fuel be 30 years old prior to emplacement in a repository) could provide additional advantages in repository design (e.g. even more spent fuel could be emplaced in a given excavated area) or further reduce uncertainties about the potential adverse effects on the repository of thermal output from the spent fuel. However, an accurate determination of temperature decreases in the host rock associated with additional aging of the spent fuel cannot be ascertained without conducting a complex analysis for a given spent fuel package design emplaced in a particular array in a specific host rock at a specific site, and considering the relative merits of many available design tradeoffs. This is best done after a repository site has been characterized.

The thermal effects of spent fuel in a repository are complicated and

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[3] DOE Response to Questions from the Senate Committee on Energy and Natural Resources, July 16, 1987, Question 1d.

have a temporal as well as a spatial component. Repository design is dependent not only on the thermal output of the fuel at the time of emplacement but also on the integrated heat load over the life of the repository. In the short term, thermal output can affect the mechanical stability of the emplacement area both during the emplacement period and during the 50 year period following emplacement when it is necessary to maintain a capability to retrieve the fuel. In the long-term, the thermal output from the spent fuel can affect the integrity of the emplacement package (which by regulation must continue to function as a barrier to radionuclide release for at least 300 years), and the characteristics of the geologic/hydrologic environment (e.g. rock permeability, fluid flow, and chemical solute transport and reactions) which must be relied on to isolate the radionuclides in the spent fuel from the accessible environment for thousands of years.

The long-term thermal effects of spent fuel depend not only on the thermal output at the time of emplacement, but on the decrease of the thermal output over time. Both depend on the fuel's burnup history in the reactor, its age, and its original enrichment. In addition, thermal effects and their consequences will depend on the geologic/hydrologic setting (i.e. the emplacement medium, the moisture content of the emplacement medium, and the nature of the surrounding geology); the repository design (i.e. repository size and shape, emplacement depth, waste package spacing, and the total amount of fuel emplaced); the design of the emplacement canister (i.e. the size, shape, material of construction, and type of overpack); and the configuration of the spent fuel itself (i.e. consolidated or unconsolidated). When all of these factors are taken together, it is possible that for a specific site it could be advantageous to maintain a higher temperature than at other sites. Preliminary studies have shown this may be the case at Yucca Mountain.

Figure 2 shows the temperature history of waste package components and host rock expected over the first 1000 years at the Yucca Mountain site based on preliminary DOE studies and assuming burial of 10 year old fuel.[4] As can be seen, the temperature of the host rock one meter from the bore hole in which the package has been emplaced will be above 100°C for the entire 1000 year period. There is an advantage to maintaining the temperature above 97°C (the vaporization temperature of the unconfined and unbound pore fluid in the host rock) to maintain a dehydration zone around the waste package. This decreases the possibility of package degradation and migration of the radionuclides in the spent fuel to the accessible environment. Therefore, extended cooling of the spent fuel may, in fact, be disadvantageous for the repository at Yucca Mountain.[5]

It also appears that, in terms of its effect on long-term far-field phenomena, long-term aging of spent fuel prior to emplacement may be of limited value. For example, thermomechanical and thermohydrologic

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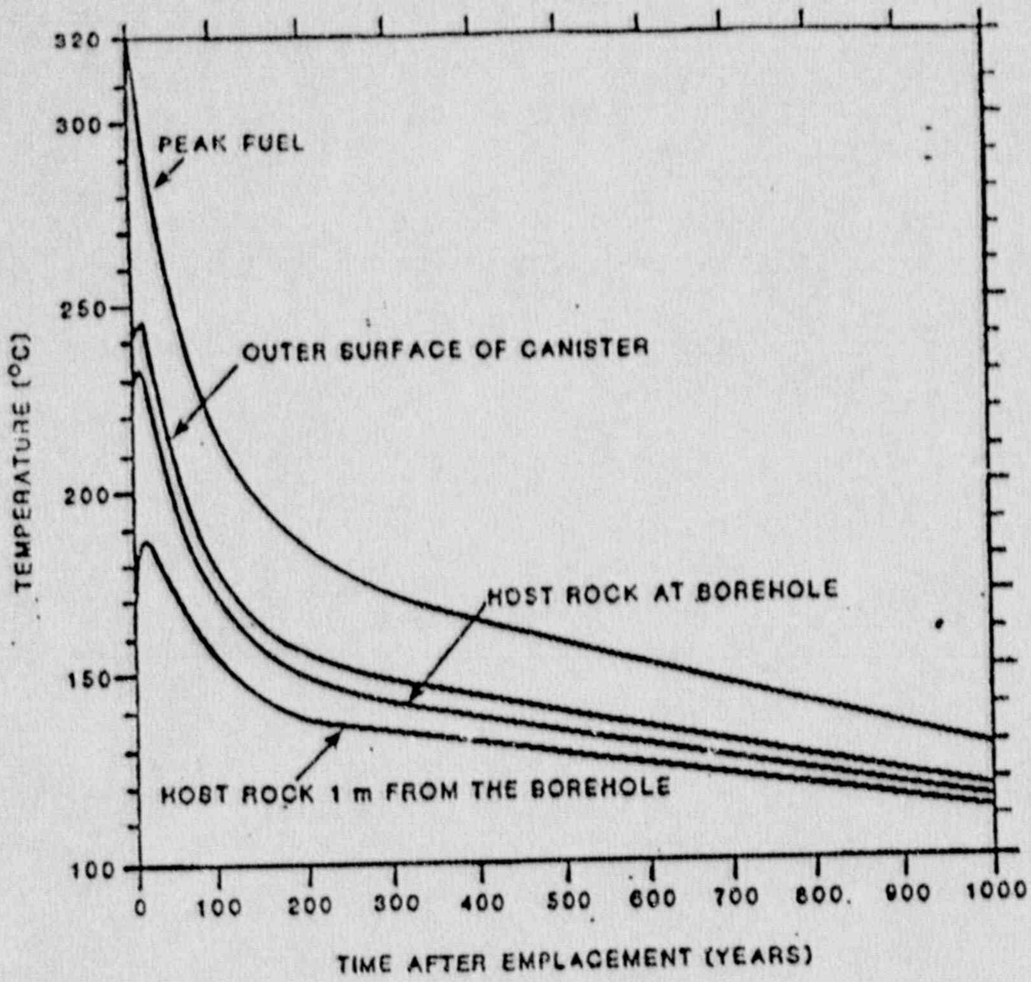
[4] Department of Energy, "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," December 1988, pg. 7-41.

[5] The potential benefit from maintaining a relatively high temperature in the vicinity of the canister only applies for unsaturated systems similar to those existing at Yucca Mountain. In a saturated system, water bound to minerals or trapped in small pockets or inclusions in the host rock can be released by heating and under some circumstances can migrate up the temperature gradient toward the waste package. This can result in a convective cell in which hot fluid is continually drawn into contact with the waste package and, depending on the chemical composition of the fluid, could result in corrosion of the waste canister. Therefore, if the repository were to be located at a site where the host rock were saturated, there could be additional incentive to reduce the heat output from the spent fuel prior to emplacement in the repository.

Figure 2 - Example Temperature Histories of Package Components and Host Rock for 10 Year Old Spent Fuel Emplaced in Tuff at the Yucca Mountain Site



INITIAL CONDITIONS

WASTE FORM	SPENT FUEL
LOCAL POWER DENSITY	57.0 kW/acre
AREAL POWER DENSITY	46.4
AVERAGE 10-YR POWER	3.3 kW
CONTAINER DIAMETER	0.7 m
DISTANCE BETWEEN CONTAINERS	5 m
DISTANCE BETWEEN DRIFTS	47 m

Source: W.C. O'Neal et al, "Preclosure Analysis of Conceptual Waste Package Designs for a Nuclear Waste Repository in Tuff", UCRL 53595., Nov. 1984, pg. 36

perturbations (e.g. surface uplift and subsidence) in the host rock formation depend on heat buildup in the entire formation over hundreds or thousands of years. These effects are dependent on the long-term integrated heat load from the spent fuel. However, the more important thermal effects are expected to be near-field effects which are quite sensitive to the thermal output of the fuel, and thus its age, at the time of emplacement. A 1983 study performed for the Nuclear Regulatory Commission by Lawrence Berkeley Laboratory[6] reached the following conclusions about the advantages and disadvantages of surface cooling:

"- Surface cooling allows more concentrated waste emplacement and lower thermal loading. The quantitative changes depend sensitively on the waste type and on the thermal criteria used in determining optimal loading.

- For the region in the vicinity of the waste package and the repository room-and-pillar, the lower thermal loadings associated with older wastes could reduce the short term temperature rise and the thermomechanical instability.

- Reductions in the near-field thermomechanical perturbations are significant for older wastes in salt and especially in hard rocks. If the near-field criteria determine the waste loadings, the creep analyses for salt and the thermoelastic analyses for hard rocks should be carefully evaluated to determine the optimal waste-loading densities for older wastes.

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[6] Lawrence Berkeley Laboratory "Thermal Impact of Waste Emplacement and Surface Cooling Associated with Geologic Disposal of Nuclear Waste," NUREG/CR-2910, March 1983, pg. 3.

- If far-field criteria are used, the extension of surface cooling periods will allow only a modest increase in waste density for spent fuel. The balance between a modest reduction in repository spatial requirements and the additional expense of the maintenance of surface storage facilities will be the determining factor in optimizing the duration of surface cooling."

COSTS

Aging of spent fuel, if desired, could be carried out at the reactor, at an MRS or UFIS, or at a surface facility located at the repository site. All are technically feasible, and the costs would differ with a number of factors such as the location of the storage, the size of the storage facility, and the status of the reactors at the sites, among others.

The Commission has not attempted to model the costs of extended aging, but the magnitude of some of the cost effects can be approximated by comparing the cost estimates prepared for the Commission's report. In Chapter Six of the report, the costs of delaying the repository until 2023 were estimated. As noted above, delaying the repository until 2023 would increase the average age of spent fuel received at the repository to 40 years and the age of the youngest fuel to about 30 years. For a system without an MRS, a delay in opening the repository from 2013 until 2023 would increase at-reactor storage costs by about $1.5 billion. At-reactor storage costs for a system with a linked MRS would increase by about $1.2 billion and the at-reactor costs for a system with an unlinked MRS would increase by about $0.3 billion for the same 2013 to 2023 delay.

If the unlinked MRS were used to age spent fuel, the reduction in at-reactor storage costs would be offset by the additional operating and capital costs for the MRS. A ten-year extension of the period during which an unlinked MRS would operate before a repository opens would add about $150 million to total MRS capital costs (because larger facilities would be required to store additional spent fuel) and over $40 million per year in MRS operating costs. Ascertaining the actual increase in MRS costs or the cost savings to the repository which increased aging would permit is beyond the scope of the Commission's models and time does not permit us to modify the models to obtain accurate estimates of the total system life-cycle costs of increased aging.

CONCLUSIONS

After careful reassessment, the Commission sees no compelling reason to alter its original position on this issue by recommending extended spent fuel cooling periods, especially since, with the announced delay in repository opening and assuming oldest fuel first emplacement, almost all of the spent fuel will automatically be aged at least 20 years (see Figure 3).[7] However, since it is not possible at this time to allocate a meaningful dollar value to decreased scientific uncertainty resulting from emplacement of more aged fuel and we do not have the data available to calculate the savings in repository design and construction aging might permit or the overall costs to the waste management system of extended aging, we were not able to do the customary

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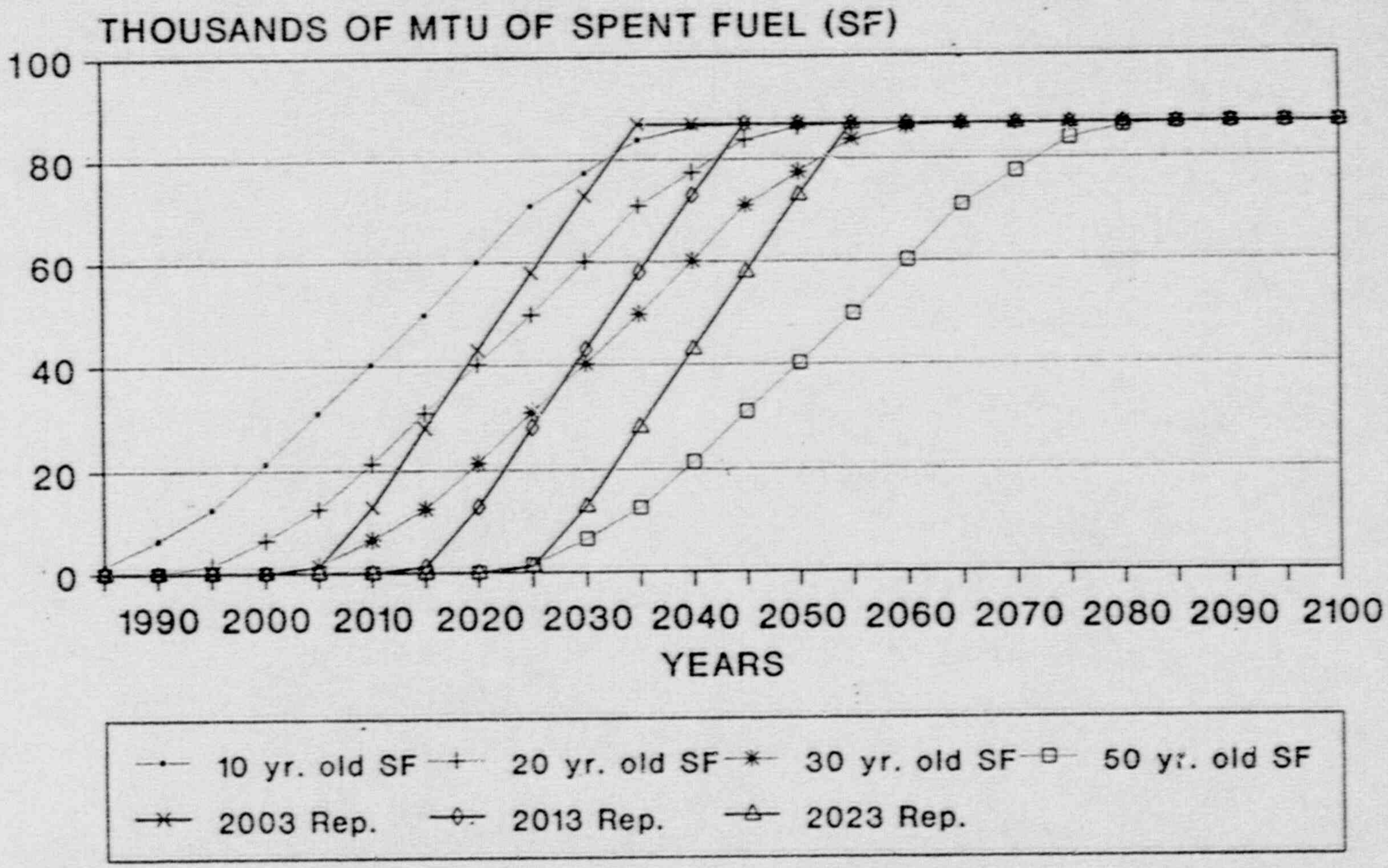
[7] If the repository were to begin operation in 2003 as DOE originally planned, and spent fuel were to be accepted at the repository at the rate proposed by DOE, the fuel emplaced in the repository would have an average age of about 20 years and the youngest fuel emplaced would be about 10 years old. If the repository were to begin operation in 2013 (which is close to the present DOE projected date of 2010), the average age of the emplaced fuel would be about 30 years with the youngest emplaced fuel being about 20 years old. If the repository opening were to be delayed until 2023, the average age of the emplaced fuel would be about 40 years and the youngest emplaced fuel would be about 30 years old.

FIGURE 3 - AGED SPENT FUEL AVAILABLE FOR SHIPMENT TO THE REPOSITORY*



* It is assumed that the repository accepts spent fuel at the rate proposed by DOE in appendix E of the MRS System Study Summary Report [Department of Energy, "MRS System Study Summary Report", DOE/RW-0235, June 1989], and is used to dispose of all 87,000 MTU of spent fuel generated by commercial nuclear power plants.

benefit-cost analysis for lower repository temperatures resulting from extended fuel aging. We note, however, that every other country designing geological repositories, all of which are in the saturated zone, has opted to limit peak rock temperatures to 100°C.

At this time a commitment to even longer spent fuel storage does not appear warranted. However, in the Congressional review in the year 2000, when more details about the repository and waste package may be available, the temperature rises in the repository host rock could be more accurately calculated and the issue could be reexamined with no loss in any of the advantages perceived at this time.