A STRATEGY FOR FULFILLING A UTILITY'S RESPONSIBILITY FOR STORING SPENT FUEL

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ABSTRACT

The Nuclear Waste Policy Act assigned owners and generators of spent fuel the responsibility of storing this fuel until accepted by the Federal government for disposal. The earliest that DOE plans to begin accepting fuel for disposal is January 31, 1998.

Elements of a process to develop a strategy to meet this responsibility are outlined. The process recognizes that there are a number of uncertainties regarding the date of fuel acceptance, the rate of acceptance, and the quantities of fuel that will be generated. Therefore, the strategy developed must consider contingency actions should the DOE acceptance schedule be delayed.

INTRODUCTION

The primary responsibility of a utility utilizing nuclear power is to insure that the health and safety of the general public and its employees are protected. Storage of spent fuel is possibly the most benign aspect of the nuclear fuel cycle. Existing regulations and procedures with respect to spent fuel are adequate to assure that this responsibility is and will continue to be met.

Secondly, utility management has the responsibility to act as caretakers of ratepayers' funds required to manage and dispose of the spent fuel. This requires not only the development of optimum, strategies of managing the spent fuel until delivered to the U.S. Government but also attempting to assure that the Federal disposal program is effective, cost efficient and conducted on schedule.

Thirdly, utility management has the responsibility to maintain the productive capacity of the stockholders' investment in plant and equipment. Spent fuel jeopardizes this responsibility when it may force the shutdown of the plant because of a lack of the ability to discharge depleted fuel.

These responsibilities have not changed over the twenty-five year history of nuclear power, however, the environmental constraints within which these responsibilities are exercised have changed considerably.

HISTORICAL PERSPECTIVE

On April 7, 1977, President Carter announced that civilian reprocessing of spent fuel would be deferred indefinitely. This position was initiated because of the Administration's concern that reprocessing might contribute to the potential for the proliferation of nuclear weapons. Since the Administration's position was motivated by national security considerations, the Department of Energy announced on October 18, 1977, that the Federal Government proposed to accept and take title to used, or spent reactor fuel from utilities on payment of a one-time storage fee. At that time it was expected that spent fuel storage would be required only for the interim until 1988 when a Federal repository would be in operation.

On February 12, 1980, President Carter presented his comprehensive National Radioactive Waste Management Program based on the report of the Interagency Review Group on Nuclear Waste Management. This program stated that interim storage of spent fuel would continue to be the responsibility of the generators or owners of spent fuel until a permanent geologic repository was in existence. The Administration indicated its intention to press for legislation to build or acquire limited spent fuel storage capacity at one or more away-from-reactor (AFR) facilities for those utilities unable to expand their storage capacity and for limited amounts of foreign spent fuel the storage of which would foster objectives of U.S. nonproliferation policy. This plan also set 1995 as the target date for operation of the first full-scale terminal waste repository.

Thirteen months later, in March 1981, the government announced that it did not intend to build AFR's and the date for operation of the first full-scale repository had slipped ten years to 2005.

On October 8, 1981, President Reagan released a long awaited policy statement on nuclear power. Among its provisions was a lifting of the ban on commercial reprocessing. He instructed the DOE to work with industry and state governments to proceed swiftly towards creation of means of storing and disposing of commercial spent fuel and high level radioactive waste.

In the months that followed, six and sometimes more committees in both Houses of Congress labored on bills to deal with the nuclear waste issue. These efforts eventually culminated in the passage of the Nuclear Waste Policy Act of 1982 (Public Law 97-425) which was signed by President Reagan on January 7, 1983.

One of the principal findings of the Nuclear Waste Policy Act is that "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 the act" (Section 111.a.5).

Although the Act establishes schedules and processes for the siting, construction and operation of repositories, no guarantees are provided as to when specific quantities of spent fuel may be transferred to the Secretary of the DOE.

The closest approach to a performance specification appears in Article II of the standard Contract For Disposal Of Spent Fuel And/Or High Level Waste[1] which was signed by all owners or generators of spent fuel prior to July 1, 1983. This article states, "the services to be provided by DOE under this contract shall begin, after commencement of facility operations, not later than January 31, 1998 and shall continue until all spent fuel is disposed of". The Contract does not provide specified acceptance quantities nor penalties if the DOE does not begin accepting spent fuel by January 31, 1998.

DEVELOPING A UTILITY STRATEGY

If anything, the historical review of nuclear waste management policies convinces one that this is an area of change. Therefore, utilities should develop a spent fuel storage strategy which recognizes uncertainty and the high probability of change. It is this uncertainty factor in terms of schedules, technical issues, licensing and public acceptance that require that the strategy be conservative and flexible.

Figure 1 shows a simplified decision tree listing the steps involved in the development of a spent fuel storage strategy.

Determination of Storage Requirements

The ability to store spent fuel on an interim basis until such time as reprocessing and/or terminal waste storage facilities are available depends, to a large extent, on the time frame for which the interim storage is required. As recently as four years ago it was expected that interim storage would only be required to 1988. Now it would appear that interim storage may be required for the next twenty-five years. This change in time horizon can have a significant effect not only on the quantities of storage required but also on the preferred institutional and technical approaches which represent an optimum for the situation.

The first step is to establish a target date on which one assumes the DOE will begin to accept spent fuel. The most optimistic approach is to assume that the National Waste Management Program is completely successful and that fuel is accepted starting in January 1998 at the rates specified in the Mission Plan. The Disposal Contract specifies that the oldest fuel or waste will have the highest priority for acceptance except for emergency deliveries allowed by prior written approval from DOE. Criteria for what constitutes an emergency are not specified although drafts of the contract mentioned accepting fuel from decommissioned reactors. Based on this, one can estimate the earliest date for accepting specific fuel assemblies as shown in Table I. In most cases there will be a twenty year delay from the time the fuel is discharged until the earliest date for acceptance.

Another approach is to use a Delphi evaluation in which a number of knowledgeable people are asked to estimate when they believe the DOE will begin accepting fuel, the acceptance rates and the degree of confidence they attach to the estimates. These data are plotted and a probability distribution fitted to the data points. An acceptable level of uncertainty is then selected to yield a target date.[5]

I would recommend a more conservative approach in which it is assumed that all the fuel generated during the units' lifetime must be accommodated. Since this, hopefully, is too conservative it is suggested that the implementation of the resulting strategy be divided into several phases with a determination of the necessity of proceeding to the next phase based on a reevaluation of the date and rate at which the DOE will accept spent fuel.

The next step is to determine how much spent fuel must be accommodated up to the date when it is expected that DOE will begin accepting more spent fuel than the units generate per year. For a plant with substantial operating experience, there will be a basis to estimate average cycle lengths, capacity factors and reference fuel management plans. For a new plant, the experience of other plants of the same size and from the same manufacturer should be reviewed. Long outage perods to overcome generic problems should be removed from the data base if the particular cause of the outage has been corrected in the specific plant.

Based on the various estimates of the DOE acceptance dates and of spent fuel discharge rates, total quantities of fuel that must be accommodated can be established. Comparison of these values with available on-site storage capabilities will establish the magnitude of the problem.

Reduction In Spent Fuel Generation

The next step in determining a strategy is to evaluate if the number of assemblies that must be accommodated can be reduced. The spent fuel discharge rate is dependent on the plant power

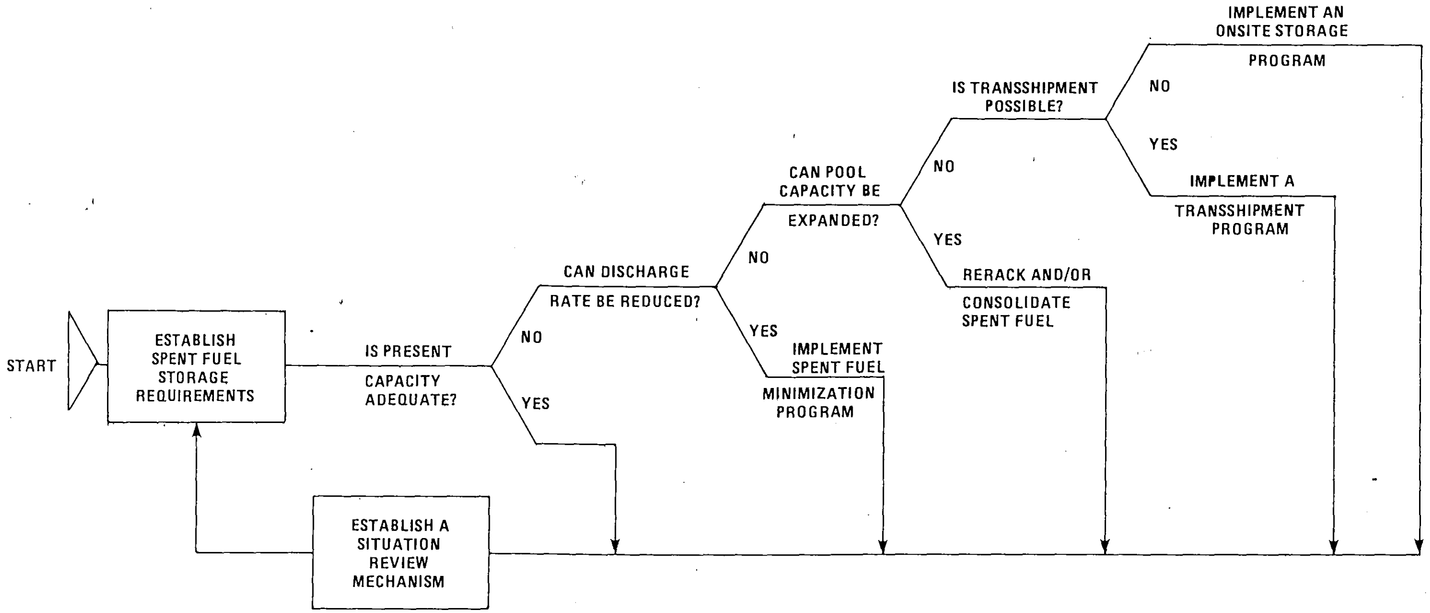

FIGURE 1
SPENT FUEL STORAGE DECISION TREE

output, the capacity factor, and the achievable fuel assembly burnup. For economic reasons, it is beneficial to maximize the power output and capacity factor of the plant; therefore, these parameters generally cannot be reduced to decrease the amount of storage requirements. Thus, the discharge rate is mainly dependent on the average burnup or energy extraction from the fuel.

The primary reason for extending assembly burnup is for fuel cycle economics although a secondary benefit is the reduction of storage requirements. For example, at today's prices, increasing average burnup from 36,000 MWD/MT to 44,000 MWD/MT in PWR, would decrease fuel cycle costs by 2% to 4%.

Assuming moderate increases in average assembly burnup are possible (20% to 40%), the net affect on near term storage requirements is small because it takes a number of years to begin to realize the effects of the higher burnup. The effect on storage requirements for the life-of the plant may be substantial depending on how long the plant has operated to date.

Spent Fuel Pool Capacity Expansions

Since most pools originally contained storage racks to accomodate only one and one-third cores of fuel, it is possible to obtain substantial increases in pool capacity by installing new racks with higher fuel densities.

During the last several years numerous rack manufacturers have come up with creative designs incorporating poison plates, preferential moderation channels and different geometrical designs all for the same purpose, i.e., controlling criticality while storing spent fuel at higher densities[6]. It should be possible to increase the number of fuel assemblies that can be stored by a factor of six or seven over the initial design of one and one-third cores with any of these designs plus consolidation of fuel rods. Reracking can generally be accomplished within about two years using an accepted rack design and with minimum licensing exposure. Some utilities have reracked two or more times.

One problem which limits the amount of increase possible in existing pools, is the allowable pool floor loading criteria established in order to meet seismic criteria. Many pools are located relatively high in the power plant structure where their seismic response becomes limiting (mainly BWR's). Quite frequently, however, overly conservative analysis of the pool floor loading capacity leads utilities to conclude that in-pool expansion is not feasible. The use of non-linear, finite mesh, structural analysis generally will justify increases in capacity by factors of two or three over pre-1978 analysis.

The objective of the rod consolidation programs is to increase the fuel storage density in the geometric envelope of existent racks by a factor of 1.8. This factor includes the assumption that the fuel assembly hardware is returned to the spent fuel pool.

Consolidation appears to be feasible but the process has not been performed on a licensed basis. Equipment to perform fuel rod consolidation is currently under development by a number of vendors. Demonstration programs and submittal of topical reports to the NRC are also planned by several vendors. One four-bundle, hot demonstration has been performed by Duke Power Co. at the Oconee station. TVA plans to consolidate 12 BWR bundles at the Browns Ferry station this year. A third program is being conducted by Northeast Utilities at Millstone Unit 2 with the objective of performing a 12 bundle, hot demonstration of consolidation. This project, jointly sponsored by Northeast Utilities, Baltimore Gas and Electric, the DOE, and EPRI, is scheduled for 1985.

Transshipment of Spent Fuel

If the preceeding steps are not sufficient to provide the storage capacity required, the next most cost effective means to investigate is shipment of fuel from one unit to another, either on the same site or to another site at which excess storage capacity exists.

Transfer of spent from one unit to another on the same site can and has been accomplished relatively easily. Transshipment of spent fuel between two licensed sites, while in theory not difficult, has developed some complications[7]. Among these complications are restrictive state and local laws, physical security during transit, and conflicting regulations.

Spent fuel can be transported by truck, rail or barge. Of the three available transport modes, truck and rail are the more feasible alternatives, while the barge option is, for most applications, precluded based on cost, licensing uncertainties, lack of domestic experience, and port availability. An analysis of economic and licensing issues indicates that the truck transport mode is generally superior to rail especially when overweight truck shipments are possible. This is based on the advantages which the truck mode has over rail in the areas of route flexibility, industry experience, cask availability, and transportation cost.

Transshipment should be considered as an option only after all relatively easy methods of on-site expansion have been exhausted. One utility is currently planning on-site dry storage capacity at a facility because a local ordinance has blocked them from shipping fuel to a new nuclear plan which has additional capacity[8].

Establishing Additional On-site Storage Capacity

In the event that sufficient additional storage capacity cannot be obtained from the previous steps the remaining alternative is to provide additional capacity in new facilities either on-site or at a remote location.

On-site facilities are generally the least expensive providing there is additional land available for construction. The cost will be a function of how many existing reactor facilities can be used jointly. This varies depending on the proximity of the new facilities to the existing site. There is an economic vs. risk trade-off here. If the new storage facility is closely allied with an operating unit there is a greater risk that the latter's operating license will be in jeopardy during construction either from NRC or intervenor activity.

In general, recent evaluations have indicated that either a new pool facility or a dry cask facility are the most economical for sizes less than 1,000 MT[9,10]. For capacities greater than 1,000 MT it is possible that drywell, silo, canyon, or Modrex storage may also be economical. The choice between a new pool and dry cask storage is a function of the quantity of storage required, cash flow requirements, and whether present loading facilities can accomodate the weight of the typical storage cask.

The selection of the least-cost storage alternate is an individual decision based on specific site characteristics.

Situation Review

The optimum strategy for a utility generally will be a phased approach using a combination of one or more of the techniques discussed. In developing a strategic plan in the presence of uncertainties in licensing, discharge rates and repository availability, scheduled hold points should be established for review of the strategy and its assumptions.

The Nuclear Waste Policy Act makes a provision for up to 1,900 MT of Federal Interim Storage to provide continued operation of existing plants. This alternative is specifically designed as a stop-gap measure where a utility is faced with shutting down a facility until additional storage can be provided. NRC certification of the necessity of federal storage and the relatively high costs[11] make this truly an emergency choice.

UTILITY OVERSIGHT OF THE FEDERAL RADIOACTIVE WASTE MANAGEMENT PROGRAM

Under the terms of the Waste Disposal Contract, the DOE is not obligated to begin accepting fuel before 1998. By that time, utilities will have paid more than $9 billion into the *Nuclear Waste Fund* without actual performance[12]. If acceptance of fuel is delayed beyond that time, the cost of additional storage is very likely to be the responsibility of the utility.

As a minimum, a utility has responsibility to the consumer to help ensure that Federal program plans and expenditures are timely, reasonable and appropriate. For these reasons, utilities have responsibility to review the Federal program and provide constructive input to the DOE.

Utilities individually and collectively are engaged in various activities to fulfill this responsibility. The Utility Nuclear Waste Management Group (UNWMG) is a specific activity that is funded by forty-two utilities with nuclear programs with the sole objective of assisting in the resolution of spent fuel storage and nuclear waste disposal issues. The UNWMG has been very effective in providing constructive comments and support to the Radioactive Waste Program.

REFERENCES

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3. "Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980", DOE/NE 0017, September 1981,

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Table I

Estimated Repository Acceptance Schedules

Year Transferred To DOE	One Operational Repository (Fuel discharged prior to date shown)	Two Operational Repositories (Fuel discharged prior to date shown)
1998	6/76	6/76
1999	6/78	6/78
2000	9/79	9/79
2001	10/80	10/80
2002	11/81	11/81
2003	6/83	6/84
2004	12/84	6/86
2005	3/86	3/88
2006	3/87	6/89
2007	3/88	6/90

Assumptions

(1) Fuel discharge rates prior to 1980 from reference 2. Fuel discharge rates in 1980 and later from reference 3.

(2) Repository receipt rates less fuel from decommissioned reactors as shown in reference 4.

NB A five (5) year delay in the initial fuel receipt will result in 1,155 MT of fuel from decommissioned reactors which will have receipt priority. A ten (10) year delay in initial fuel receipt will result in 4,880 MT of fuel from decommissioned reactors which will have receipt priority.