AT-REACTOR STORAGE: A PROGRESS REPORT

R. W. Lambert
Electric Power Research Institute
Palo Alto, California

R. K. Kunita
Carolina Power & Light Co.
Raleigh, North Carolina

M. L. Smith
Virginia Power Co.
Richmond, Virginia

ABSTRACT

In spite of the current uncertainties associated with meeting the schedule prescribed in the Nuclear Waste Policy Act, utilities must select methods to increase their on-site fuel storage capacity. The demonstration programs now under way are building a strong technical base to make available a range of licensable, cost-effective storage concepts that can meet the growing utility need. Dry storage and in-pool rod consolidation are expected to be early chosen concepts.

BACKGROUND AND OVERVIEW

To the casual observer it may appear that enactment of the Nuclear Waste Policy Act of 1982 (NWPA) made the task of the utility planner a simple exercise. Utilities had only to provide for spent fuel storage until 1998 and thereafter fuel would be removed from the utility site by the DOE. Unfortunately, the real world does not present such a narrow range of scenario options and today's spent fuel planner is forced to deal with a complex set of variables, many of which contain high degrees of uncertainty. Despite this environment of uncertainty, prudent management dictates that definitive plans must be made and these plans executed in order to assure sufficient on-site storage to keep reactors operating.

To provide perspective on the uncertainty facing utility planners, the following questions illustrate the type of issues that must be addressed as part of a utility's spent fuel storage decision making process.

- When will a repository (or MRS) be on-line, what will be its realistic receiving capacity, and how will my fuel fit into the queuing priority?
- If I am forced to store fuel past 1998, will it be at my expense or to DOE's account?
- If I now provide long-term storage capability, would I be penalized in the DOE fuel removal process because I no longer would have an acute need?
- How will the DOE choice of a back-end scenario (MRS, dual purpose casks, etc.) effect the economics of my chosen storage mode?
- Should I minimize near-term costs or try to pick a strategy that better serves a long-range system optimization strategy?
- Will transportation issues emerge as a major factor that could perturb my storage strategy?

Without belaboring the point, it should be apparent that it is easier to ask the questions than provide the answers and that planners must face the fact that, in the near term, uncertainty will continue to dominate the spent fuel storage scene.

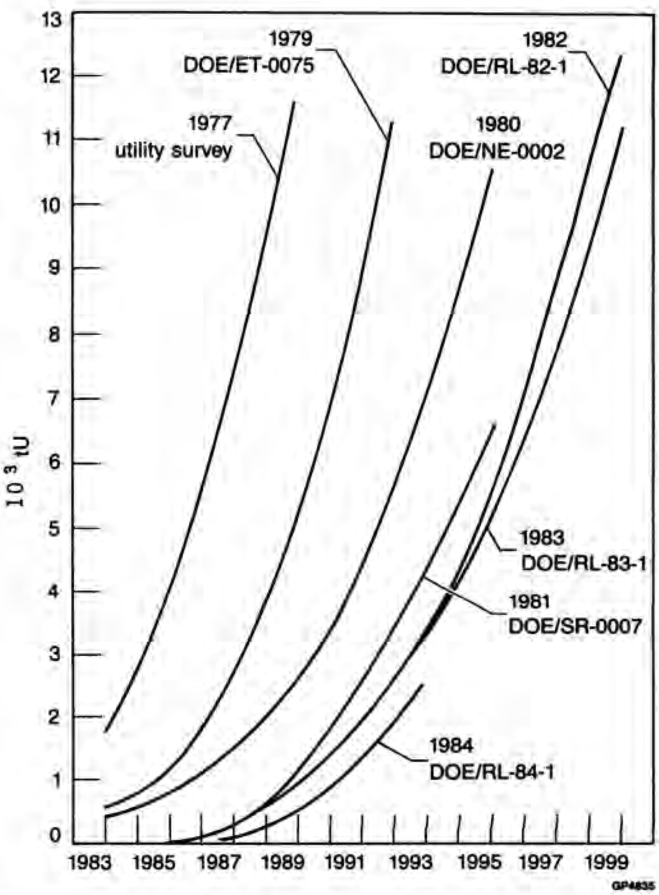

Fig. 1. Changing utility estimates of additional storage requirements.

Changing Utility Needs

On the brighter side, an examination of utility projections for *additional* on-site storage requirements reveals an encouraging trend as shown in Fig. 1. These data are all plotted for the so-called reference case which assumes (1) utilities rerack their pools to their maximum capacities, (2) no transshipments occur except where already licensed, and (3) plants retain full core reserve. The plots include data from the first informal utility survey that was made in 1977 as well as the six official DOE surveys that have been conducted annually beginning in 1979. The 1985 DOE requirements report has not yet been published.

The dramatic reduction in the timing and size of out-of-pool storage capacity can be attributed to a variety of factors. The principal reason for the changing forecasts was the adoption by utilities of advanced rack technologies, incorporating neutron poison materials, that achieved significantly higher pool storage densities and therefore delayed the time when additional on-site storage was needed. Also, utilities tended to make their projections based on bounding-type fuel cycle assumptions rather than on the most likely expected conditions. Therefore, if fuel exposures exceeded targets or if plant capacity factors fell below target, the actual amount of fuel discharged fell below the larger amount that had been projected.

This slippage in the projected level of storage requirements has been a major factor in keeping operating plants out of serious storage problems. Unfortunately, with rerack opportunities nearly exhausted, it appears that the storage demand curve is now stabilizing and that further significant slippage will occur only from actions such as utilities adopting rod consolidation technologies or continuing to increase average fuel burnups. In any case, developing alternate licensable on-site storage capacity is no longer just a long-range planning exercise but rather an immediate high priority action item.

THE ROLE OF POOL STORAGE

Before looking at the newer on-site technologies now being developed and demonstrated, it is important to keep the role of pool storage in proper perspective. As of today, 100% of the more than 11,000 metric tons of fuel in storage resides in water-filled pools. Pool storage is also the only storage mode currently licensed in the U.S. By 1993, it is expected that at least 93% of the cumulative fuel discharged will still be in pool storage.

In order to further build a strong technical base that validates pool storage as a safe long-term storage technique, EPRI is continuing the effort begun by DOE to conduct and document a pool storage surveillance program. The most recently published report [1] documents recent pool operating experience and identifies those fuel assemblies now in storage that can serve as lead test assemblies for parameters such as longest storage time, highest burnup, highest internal pressure, highest hoop stress, etc. The current surveillance project is focusing on the long-term integrity of pool structural components such as rack materials, pool liners, piping, etc.

EMERGING ON-SITE TECHNOLOGIES

While existing pools will continue to accommodate the major fraction of future discharge fuel, by the year 2000 it is expected that greater than 10,000 tons of spent fuel will have to be stored using advanced storage technologies. In theory, 1900 tons of this fuel could be stored away from the reactors under the Federal Interim Storage (FIS) program authorized by the NWPA. As a practical matter, however, the financial and procedural constraints associated with FIS storage virtually assures that it will not be used by utilities.

The storage concepts that are expected to be used to meet the added on-site storage needs fall into two basic categories: in-pool rod consolidation and on-site dry storage.

Rod Consolidation

Rod consolidation is the process of disassembling fuel bundles and then close packing the fuel rods into a canister in a manner that achieves maximum storage density. An increase by a factor of between 1.7 and 2.0 in storage density can be achieved by applying this technology. Other papers in this conference will deal with the mechanics of rod consolidation and this discussion will only address the utilities' perception of consolidation and their plans to implement the technology.

Rod consolidation has the potential for benefiting many elements of the fuel disposition process including wet and dry storage, transportation, and final repository disposal. In the near term, however, utilities are generally motivated to consider rod consolidation because it provides a practical and low-cost way to increase their existing pool storage capacity. Several utilities have now adopted rod consolidation as their reference strategy for increasing on-site storage.

There are, however, certain constraints and uncertainties that limit the application of rod consolidation technology. The heavier weight loadings may result in excessive seismic and structural loads for some plants, particularly those with elevated pools. It now appears, however, that for certain reactor pools even these constraints can be overcome by performing more sophisticated structural analyses.

Another area of utility concern is the handling, processing, and disposition of the bundle scrap hardware that is left over from the consolidation process. The degree to which this material can be compacted has a major impact on the net storage gain that can be realized in the storage pool. The scenario for eventual packaging and DOE disposal of this scrap is not well-defined and thus injects added uncertainty into the decision-making process. Other areas of uncertainty include questions such as: (1) what are the total system costs of consolidation, (2) what licensing risks will be associated with consolidation, (3) what are the safeguards implications of consolidation, and (4) how will consolidation interface with downstream DOE fuel disposal scenarios?

The answers to some of these questions should be found during the next year as the Northeast Utility rod consolidation demonstration program is concluded. This project; a cooperative effort involving Northeast Utilities, EPRI, Baltimore Gas and Electric, and Combustion Engineering; has the objective of designing and demonstrating a state-of-the-art rod consolidation system. Additionally, the project includes submitting a license application to the NRC for maximum density rod consolidation in the entire Millstone 2 fuel storage pool.

The Northeast Utility project, along with the 1982 unlicensed demonstration by Westinghouse at Duke's Oconee station and a planned limited demonstration by TVA and DOE at Browns Ferry, will constitute the near-term hot demonstration data base for rod consolidation activities. Other consolidation activities, such as dry consolidation or the MRS program, may provide useful data but are not expected to have a major impact on utilities' efforts to expand on-site pool storage.

Dry Storage Technologies

Dry storage concepts have gained broad support in recent years because they are perceived to be a more passive form of storage and ones which can be implemented at nearly any reactor site. Of the three general dry storage concepts: vaults/silos, drywells, and casks; the concept that is the current leading contender for near-term application is the metal storage cask.

The advantages of metal casks include (1) they are the most modular of all dry concepts, (2) they appears to be the most mature technology, (3) significant off-shore experience is available to assist in licensing, and (4) the overall storage system costs appear to be competitive. Drawbacks associated with metal casks include the uncertainties relative to: (1) long-term monitoring requirements and (2) the rehandling and inspection procedures that may be required prior to transfer of fuel to DOE for disposition.

Utilities must also assess the overall financial and operational incentives that may accrue to a utility should a dual purpose (storage and transportation) cask concept become a viable option. Unfortunately, most utilities will have to commit to an on-site storage strategy long before the issues associated with dual purpose casks or final waste package designs are resolved.

Dry vault storage concepts have not gained wide spread support from U.S. utilities because they are perceived to be best suited for a central store rather than the smaller scale at-reactor-type facility. The economics are not thought to be attractive given the need for substantial up-front capital expenditures in order to meet a future storage need of uncertain amount or duration.

Modular concrete casks or silos appear to be attractive in certain situations. For example, they have been used for storage of CANDU reactor fuel which has relatively low shielding and heat dissipation requirements. Concrete casks have also been demonstrated using PWR fuel at the EMAD site and have recently been chosen as the reference storage design for the U.S. MRS program.

Additionally, Carolina Power and Light (CP&L) has chosen a unique derivative of the concrete silo to demonstrate in its cooperative program with the DOE. This concept, to be discussed later in this paper, is expected to offer attractive operational features and favorable economics.

A potential drawback of concrete modular packages is a reduced probability that they can be converted into an efficient dual purpose transport and storage package because, in general, they are bulkier and heavier than packages made of higher density materials.

STATUS OF DRY STORAGE DEMONSTRATIONS IN THE U.S.

In recent years, the pace of dry storage demonstrations in the U.S. has accelerated significantly. Smaller scale programs started by the DOE in the late 1970s have now been complemented by joint DOE and utility demonstrations as authorized by the NWPA. While dry cask storage can now be licensed by the NRC for certain applications, the utility-DOE cooperative agreement programs are aimed at gathering confirmatory storage data for both intact and consolidated fuel and developing experimental data to validate the analytical codes used in heat transfer and shielding calculations.

The earlier DOE programs have included single bundle tests at the Nevada EMAD site starting in 1977 and large-scale cask thermal tests using a DOE procured REA 2023 cask at Morris in 1984. This large REA storage cask is now scheduled to go to TVA where it will be used to demonstrate licensed on-site storage. TVA is also currently proceeding with an additional on-site cask storage demonstration using a GNS supplied Caster IC nodular cast iron cask from Germany. Other DOE-related programs involve the shipment of fuel from the West Valley facility to the Idaho test site in a new cask designed by Transnuclear. After transport, the fuel will continue to be stored in the cask at the Idaho site.

The two cooperative dry demonstration programs being conducted under terms of the NWPA have Virginia Power and CP&L as the lead utilities and these programs will be separately described.

Virginia Power Demonstration

This program is a cooperative effort involving Virginia Power, EPRI, and DOE. The major objective is to demonstrate metal cask storage technology and the program has two distinct elements. The first is a testing program to be conducted at the TAN federal test site located at the Idaho National Engineering Laboratories (INEL). These tests are to include the following specific objectives and activities:

- o Test and demonstrate dry storage using a range of cask designs and materials
- o Test and demonstrate storage of both intact and consolidated fuel
- o Test storage over a range of conditions including internal cask environments of air, helium, and vacuum

The second element is a licensed storage demonstration to be conducted at the Surry reactor site. Virginia Power has applied to the NRC for a license to store up to 84 casks, each holding about 10 metric tons of intact fuel, at the site.

This cooperative program, which was initiated early in 1984, has already achieved the following key milestones:

- o One Castor V/21 nodular cast iron cask has been ordered from GNS. It was delivered to Idaho in December 1984.
- o One Westinghouse forged carbon steel cask has been ordered for use at the Idaho site with delivery set for early 1986.
- o A second Castor V/21 has been ordered for use at the Surry site.

- o Licensing topical reports have been submitted by both GNS and Westinghouse and the Surry license application has been submitted by Virginia Power.

- o Fuel characterization has been completed at the Surry plant on fuel to be used in the program.

Additional near-term milestones include beginning shipping of fuel to Idaho in the summer of 1985 followed by early placement of fuel in the Castor V/21 cask. NRC approvals of the GNS topical and the Surry site license application are also expected by mid-year 1985.

Figure 2 presents a picture of the Castor V/21 cask that will be first tested at the Idaho site.

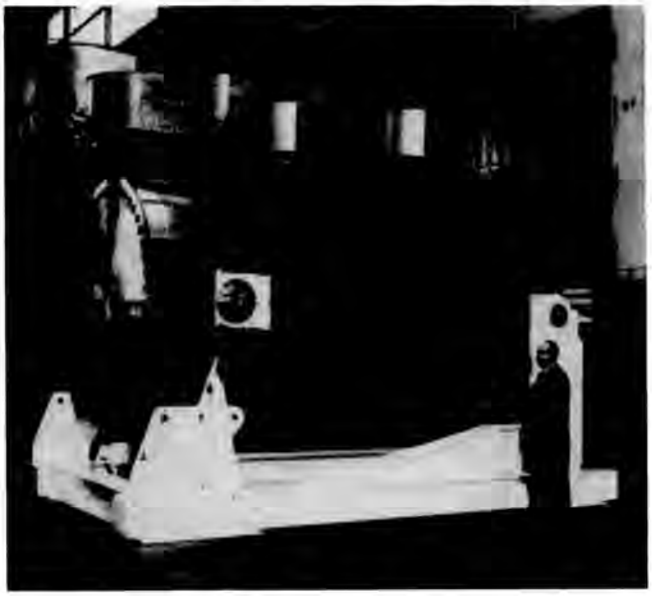

Fig. 2. GNS castor V/21 cask.

CP&L Demonstration

This program is a cooperative effort involving CP&L, EPRI, DOE, and NUTECH. The major objective is to demonstrate a licensed horizontal concrete silo storage system. This system, conceived by NUTECH and called NUHOMS, consists of a sealed inner metal canister holding seven PWR bundles that is stored horizontally in a low-cost concrete shielding module. The canisters will be transported from the reactor to the storage modules in the IF-300 transport cask currently owned by CP&L. The overall concept is illustrated in Fig. 3.

The NUHOMS concept has the following potential advantages.

- o Lower costs than other dry storage concepts

- o Can be easily integrated with future shipping systems

- o Is totally modular in design and offers the opportunity for on-site construction of major components

- o Can facilitate final disposition because of the sealed canister design

The CP&L program plans to license and demonstrate three storage modules at the H. B. Robinson plant. The program is on schedule with the NUHOMS topical report having been submitted in November 1984 and the CP&L site-specific license application having been submitted in February 1985. Fuel is expected to be loaded in late 1986.

SUMMARY AND CONCLUSIONS

Utilities still face a difficult task in assuring adequate on-site capacity for storing spent fuel, but recent activities suggest that with prudent planning, the needs can be met. The current status can be summarized as follows:

- o Great uncertainty will continue to exist in NWPA scenario selection and the date when utility fuel will actually be transferred to DOE.

- o Future projections of added on-site storage are expected to stabilize and utilities will be shifting from a planning mode to a build-and-construct mode.

- o Spent fuel storage demonstrations now under way are expected to provide a range of licensable, practical alternatives that will enable utilities to meet their on-site storage needs.

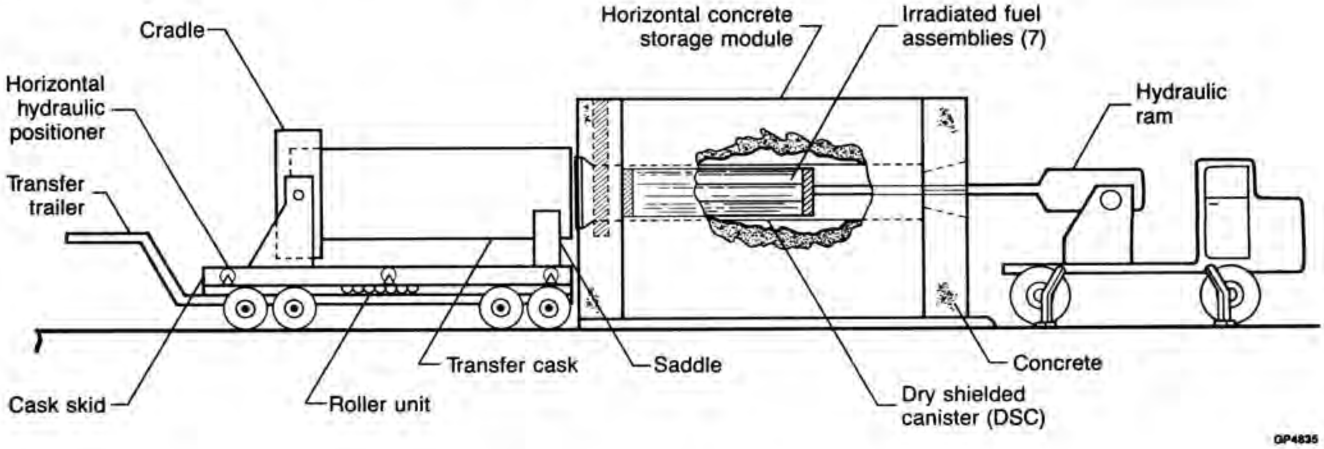

Fig. 3. NUHOMS storage system.

- Metal storage casks and in-pool rod consolidation appear to be the technologies that will obtain the earliest NRC approval for large-scale expansion of on-site storage capacity.

REFERENCES

1. W. J. Bailey and A. B. Johnson, Jr., "Surveillance of LWR Spent Fuel in Wet Storage," EPRI NP-3765, October 1984.