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ON-SITE INTERIM STORAGE OF SPENT NUCLEAR FUEL: EMERGING PUBLIC ISSUES

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ABSTRACT

Failure to consummate plans for a permanent repository or above-ground interim Monitored Retrievable Storage (MRS) facility for spent nuclear fuel has spurred innovative efforts to ensure at-reactor storage in an environmentally safe and secure manner. This article examines the institutional and socioeconomic impacts of Dry Cask Storage Technology (DCST)—an approach to spent fuel management that is emerging as the preferred method of on-site interim spent fuel storage by utilities that exhaust existing storage capacity.

INTRODUCTION

This paper posits that DCST exemplifies the politics of "institutional rational choice" (IRC) in national nuclear waste policy. IRC predicates that in situations where policy choices generate conflicts over values, perceived benefits and costs, and uncertain risks, decision makers select policies on the basis of two principal constraints: (1) the influence of stakeholders who stand to gain or lose from a policy, and (2) the "decisional context" (the setting within which rules are made for any given decision). This context provides legal and political legitimacy for a policy.

Consistent with IRC decision making, I predicate that DCST is a rational response to impasse over plans to permanently dispose of spent nuclear fuel for three reasons. First, when a utility opts for DCST, policy debate on expansion of spent fuel storage is confined to a relative handful of potential stakeholders. The principal participants in DCST decisions are generally utilities, NRC regulators, and, at times, interested parties in the immediate community surrounding a plant responsible for licensing construction activities. This small number of participants has hastened rapid adoption of DCST.

Second, like pool storage, DCST has been shown to be safe, secure, and environmentally stable, and thus, legally acceptable to regulators. In other words, it does not compromise the goals of the "decisional context" mandated by the NRC which, among other things, is designed to ensure that spent nuclear fuel can be safely stored at-reactor for at least 30 years beyond the licensed life of operation of a nuclear power plant (which includes the 20 year period encompassed by a renewed license).

Third, DCST has thus far engendered little public controversy at utilities where it has been introduced. In short, it has succeeded in narrowing the field of relevant stakeholders while fully complying with existing regulations—all the while hastening relatively rapid implementation of plans to supplement at-reactor pool storage facilities.

While safe and environmentally secure, however, DCST merely defers the need for permanent disposal—it is not an environmentally or politically appropriate substitute for permanent geological disposal of HLW provided for by law, because: (1) under the Nuclear Waste Policy Act of 1982, as amended, DOE is charged with developing a permanent repository—it is Congresses' intent that this method be used for permanent disposal of spent fuel; (2) nuclear power plant sites were licensed to host nuclear power plants; not to serve as repositories for spent nuclear fuel; and (3) safe disposal of spent nuclear fuel requires isolation from the environment for longer periods of time than are feasible through interim storage at-reactor.

WHY INTERIM STORAGE?

The U. S. Department of Energy is responsible for taking possession of spent fuel from nuclear power plants in 1998 for interim storage in an MRS followed by permanent disposal in an underground repository (The Nuclear Waste Policy Act of 1982, P. L. 97-425; Nuclear Waste Amendments to the NWPA of 1982, P. L. 100-123, 1987; Gerstberger, 1987; U. S. DOE, 1989; Parker, 1989; Bartlett, 1990). DOE estimates that site selection for an MRS could occur as early as 1992 with subsequent acquisition of spent fuel from utilities in 1998 (Bartlett, 1990). If an MRS or spent fuel repository become available, plants that have exhausted their spent fuel pools and are unable to ship spent fuel to other plants can use this facility

Prospects for timely disposal of spent fuel are problematic for three reasons. First, the current candidate site for a high level repository, Yucca Mountain, Nevada, is limited by law to 70,000 metric tons of spent fuel. Assuming most nuclear plants currently in operation are relicensed for an additional 20 years, continued on-site storage for upwards of 50,000 metric tons of spent fuel will be necessary until a second repository is built—which may take several decades (Pub. L. 97-425, U. S. NRC, 1991a).

Second, efforts to identify a host-site for an MRS are unlikely to provide for a completed interim spent fuel storage facility by 1998 due to the need for engineering studies, environmental assessments, and even host-community compensation packages (U. S. GAO, 1991).

Finally, many plants have limited spent fuel storage capacity and are turning to pool expansion, re-racking of spent fuel (i.e., bringing spent fuel bundles closer together or "dense racking"), longer fuel burnup to delay spent fuel unloading, and above-ground dry storage due to deferral of an MRS or permanent repository (Gilbert, Bailey, and Johnson, 1988; U. S. DOE, 1991).

SEARCH FOR AN OPTIMAL SPENT FUEL POLICY: A DCST PRIMER

Since the mid-1980s, DCST has emerged as the technology of choice for on-site interim spent fuel management for three reasons: (1) like pool storage, it is safe and environmentally secure—however, it offers greater worker protection by minimizing the possibility of handling accidents or occupational exposure; (2) it is more economical than continued pool storage since it offers a stable, semi-permanent medium for spent fuel that can be expanded as needed; and, (3) it provides an environment for spent fuel storage that is simpler and easier for utilities to maintain than pool storage and that permits retention of a flexible capacity for spent fuel in a plant's fuel storage pool (U. S. NRC, 1985).

From the standpoint of national waste management policy, the greatest advantages of DCST are that it: (1) defers the need to site and build an MRS and/or permanent repository; (2) permits more time for policy makers to consider alternative disposal options and techniques, including fuel re-reprocessing (should this again prove to become a viable option) or even transmutation or actinide burning (McCabe and Colglazier, 1991); (3) uses little land area at the reactor site; and (4) can be accomplished with minimal adverse environmental, safety, and health impacts—except where mitigation is required due to DCST construction placing sensitive ecological resources at risk (U. S. NRC, 1985; U. S. NRC, 1988).

Moreover, at the three sites where DCST has been undertaken, anecdotal evidence suggests that it is an acceptable (or, at least comparatively less unacceptable) option to the public. At every nuclear plant site where DCST has been undertaken, environmental assessments have been prepared accompanied by findings of no significant impact (FONSI). Obtaining local construction permits has been relatively easy, and public comments have been remarkably few in number (U. S. NRC, 1985).

In Finland, Germany, Switzerland, Sweden , and Canada—where DCST has been used the longest—the technology has been a safe, economical method of spent fuel storage (Roberts, 1987: Johnson, 1989). Fuel rods under dry-storage conditions appear to be environmentally secure for long periods of time (Bailey, et. al., 1984). DCSTs are also simpler and more readily maintained than spent fuel pools. Monitoring of occupational exposure in dry-rod consolidation pilot studies indicates that doses received by workers are consistent with those of normal fuel movement, in-service inspection and repair activities due to reliance upon remote manipulation techniques (Gerstberger, 1987; Zacha, 1988; Johnson, 1989).

Dry cask storage technologies developed in the United States, Canada and Western Europe have been pursued in conjunction with dry rod consolidation experiments designed to prove that, once removed from water, cooled spent fuel can be stored in a stable, closely packed environment (Gilbert, Bailey, and Johnson, 1988; U. S. DOE, 1989). Specific methods of dry cask storage vary widely from country-to-country—with spent fuel rods variously stored in concrete and steel casks, underground silos, dry wells, or vaults (Bailey, et. al., 1984). The common thread in all of these approaches is removal of the spent fuel from pools by remote-handling and its placement into a containerized medium that can be stored at-reactor indefinitely, easily transported, and possibly, even disposed in a repository (Mitchell, Schneider, Lakey, 1990).

Perhaps the greatest appeal of DCST, however, is the potential for providing an integrated waste management system for spent fuel disposal. In Western Europe and Canada, where DCST has been used the longest, plans are underway to develop bi-modal (i.e., dual purpose storage and transport) and even tri-modal (storage, transport, and disposal) cask systems. Germany and Switzerland are using the former, while Germany and Canada are undertaking research into the feasibility of the latter (Mitchell, Schneider, Lakey, 1990; Shelor and Whittington, 1988). While U. S. utilities are poised to adopt DCST en masse, as shall be seen, such bi-modal or tri-modal plans appear far too ambitious to be included in current efforts.

DCST AS INSTITUTIONAL RATIONAL CHOICE

U. S. nuclear utilities are turning to DCST because nuclear utility executives believe that a durable, innovative alternative for on-site storage is needed. I predicate that the motivation for DCST turns on the notion of "institutional rational choice" (IRC). IRC means a policy is selected on the basis of the constraints and opportunities afforded by: (1) the stakeholders who stand to gain or lose from a policy, and (2) the "decisional context" (the setting within which rules are made for any given decision) (Kaiser and Ostrom, 1982; Jenkins-Smith, 1991). IRC theorists would argue that this interpretation of decision making applies to nearly all policies involving highly controversial choices among alternatives.

According to IRC theorists, under conditions of policy gridlock, institutions seek optimal interim solutions that: (1) buy additional time before policy makers must commit to permanent policies; and (2) offer modest change in the policy status quo, i.e., a slight discontinuity from previous policy. These two criteria ensure that a policy meets with relatively little resistance from stakeholders and will be fairly durable. An institutionally rational policy is one that limits stakeholder interaction and conflict, "localizes" decision making to the extent feasible (in this case, by transforming nuclear waste storage into a site-specific rather than a national "solve the problem forever, now" issue), yet still meets the essential institutional constraints of legitimate policy (e.g., it is legally defensible and publicly acceptable).

DCST is an institutionally rational policy for the disposition of high level nuclear waste because it narrows the body of relevant stakeholders to the NRC and a given utility needing to augment spent fuel storage, and it meets all regulatory requirements for safe, secure, and stable storage. Moreover, DCST is merely a procedural change in current storage practice (spent fuel pools at-reactor), and thus entails no significant change in the status quo of on-site storage (which is done through storage of spent fuel rods in special pools). As a result, DCST has not, at least until fairly recently, aroused large scale public concern.

Trends in DCST

In 1990, with the assistance of the Nuclear Management and Resources Council (NUMARC), Oak Ridge National Laboratory administered a survey of U. S. nuclear utilities with the objective of gathering information on the environmental impacts of commercial nuclear power plant relicensing. Under the topic of waste management, a principal goal was to determine present and anticipated spent fuel management strategies by nuclear utilities.

To determine how utilities intend to manage spent nuclear fuel in lieu of implemented plans for permanent disposal, plants were queried about what measures they currently rely upon for spent fuel management under their original 40 year licenses. In addition, they were asked to project the methods they expect to utilize during the period encompassed by an additional 20 years of operation (assuming they will apply for relicensing) in lieu of a permanent repository and/or MRS. The results are depicted in Table 1.

Method	Current (%)	Future (%)
Re-racking	90.6	34.4
Dry Storage	4.7	73.4
Longer burnup	43.8	40.6
Other	7.8	37.4

Table 1. Spent Fuel Management by U. S. Nuclear Utilities: Current and Anticipated Trends[1]

Although pool storage is by far the most widespread current method of spent fuel management, dry storage and extended burnup are actively under development. The former is expected to eclipse pool storage in the future. The most important findings of this survey, however, are that longer fuel burnup and re-racking of spent fuel rods—methods that may conserve pool storage space—are expected to reach a plateau; utilities do not believe they can markedly increase storage space through these methods. As a result, re-racking is expected to decline and dry storage is expected to increase 15-fold. Finally, a number of utilities responded that they are actively looking at DCST for the future and intend to decide on its use, possibly in conjunction with expanded pool storage, within the next 15-20 years.

Full-scale demonstrations of NRC licensed DCST at two nuclear plants (Surry in Virginia and Robinson-2 in South Carolina) provide insight into potential impacts and sources of public concern. More importantly, they highlight the conformance of DCST's emergence with the theory of institutional rational choice.

A Tale of Two Utilities

Virginia Power Company and Carolina Power and Light turned to DCST in the mid-1980s. NRC-licensed DCST facilities at these respective utilities' Surry and Robinson-2 nuclear plants provide insight into DCST as institutional rational choice.

Surry's above ground dry storage facility entered operation in October, 1986. This effort was the culmination of an experiment involving U. S. DOE, the Electric Power Research Institute, and Virginia Power Company.

While the first two participants were seeking volunteers to test the efficacy of DCST technologies under controlled conditions (the first placement of spent fuel in casks took place at Idaho National Engineering Laboratory where it was monitored and tested), Virginia Power sought a substitute, licensable system for spent fuel pool storage given the likelihood of exhausting its at-reactor pool capacity by 1986 (Godlewski, 1987). Pressure to quickly introduce an alternative system, economic pressures, and the ability of all experiment participants to conjointly mobilize an efficient, concerted research and development effort an institutionally

[1]64 nuclear utilities (>90%) responded to the survey. Column percentages exceed 100% due to multiple methods in use by utilities. "Other" includes trans-shipment of spent fuel to other plants owned by the same utility, rod consolidation within the spent fuel pool (bringing the rods closer together), and, in some instances, a combination of high-enriched fuel, smaller reload batches, and rod consolidation.

expedient solution to the problem possible. Moreover, the ultimate design of the system built upon this institutionally rational base, is shown below.

The cask storage system, manufactured and assembled by a contractor, consists of a series of stainless steel modules filled with spent fuel and placed in an Independent Spent Fuel Storage Installation (ISFSI) (Gertsberger, 1987). Before the casks are placed onto the ISFSI, they are filled with water and submerged in the fuel pool for loading with spent fuel assemblies (Godlewski, 1987). This procedure limits occupational exposure since the water acts as a radiation barrier. Since the filling operation takes place within the pool, contact with ground or surface water and other resources is also prevented. After filling, the casks are fastened with lids, water is pumped out, and they are backfilled with helium to prevent corrosion.

The current ISFSI will be filled by 2010, necessitating consideration of other options during the remainder of Surry's current license, including longer fuel burnup (the plant currently operates on an 18 month cycle), and possible construction of two additional storage pads. ISFSIs use little land area, taking up approximately 7400 square feet for 28 casks.

H. B. Robinson's use of DCST also exemplifies IRC decision making for DCST. Carolina Power and Light has resorted to several methods of augmenting spent fuel storage at-reactor, including trans-shipment of fuel to another plant licensed to the same utility—Shearon Harris, longer fuel burnup, and a complete rerack of the spent fuel pool to augment storage capacity.

Robinson currently uses DCST for 5-year cooled fuel assemblies. The plant uses a modularized concrete and stainless-steel canister system which has been shown to minimize occupational and population exposure. The canisters are placed horizontally into a vault to minimize contact with the environment (Godlewski, 1987).

Other utilities are contemplating adoption of DCST. At Indian Point 2 (New York), current plans dictate that after 2013, dry storage, rod consolidation and longer burnup will be considered. Limerick (Pennsylvania) intends to rerack its fuel storage pool to permit storage until 2011 at unit 2 and until 2012 at unit 1. If dry storage is undertaken, as current plans contemplate, economics favor the use of concrete casks at Limerick. If no repository is available after 2011, Limerick will employ a combination of dry storage and rod consolidation.

Finally, at D. C. Cook (Michigan), dry storage may be pursued after 2009 if no permanent repository is available and pool storage at-reactor is exhausted. In short, of the utilities responding to the ORNL survey on spent fuel management who reported they are contemplating using DCST at some future point (nearly 3/4 of them), virtually all are doing so after exhausting other options and in response to concerns over the future status of a permanent spent fuel repository.

DCST AND EMERGING PUBLIC ISSUES: PANACEA OR PANOPLY?

Interim storage needs vary among U. S. plants with older units more likely to lose pool storage capacity sooner than newer ones. In those instances where insufficient space is available, shipment of spent fuel to other plants has occurred. The greatest at-reactor impact of spent fuel storage is occupational exposure from handling, moving, and reracking spent fuel rods within pools or from pools to dry-storage facilities. These impacts vary because of different remote handling techniques for fuel rod consolidation and movement.

Although annual spent fuel discharges are expected to decline for boiling water and pressurized water reactors (BWRs and PWRs) early in the next century, spent fuel volumes will more than triple between 1990 and 2020 due to the probable relicensing of nuclear power plants. During this period, 62% of all nuclear plants will be operating under original licenses (U. S. NRC, 1989). Thus, continued storage of spent fuel onsite will be an issue for utilities—particularly those that renew their NRC operating licenses.

Dry storage is not a panacea. There are economic limits to the viability of indefinite expansions of dry storage facilities and over the very long term time horizons (greater than 100 years, after reactor sites are closed and decommissioned), other options for spent fuel management must be considered.

On a practical level, DCST has technical limits as well. The current dry storage facility at Surry, for example, will be filled by 2010, necessitating consideration of other options during the remainder of Surry's current license, including longer fuel burnup (the plant currently operates on an 18 month cycle), and possible construction of two additional DCST storage pads.

Finally, at some plant sites, public concerns toward DCST are growing. There is an emerging recognition that DCST may transform nuclear plants into "de facto" MRSs, thereby prohibiting actual closure of nuclear plant sites and converting them into semi-permanent or permanent high level radioactive waste sites. At one plant contemplating introduction of DCST (Prairie Island in Minnesota), the state Department of Public Service has recommended to their commission to limit the number of casks stored by the operating utility in response to concerns that without such limits, the plant site would become an MRS (U. S. NRC, 1991b).

CONCLUSION

DCST projects are currently in operation at Virginia Power Company (Surry), Carolina Power and Light (Robinson), Duke Power (Oconee), and the decommissioned Ft. St Vrain Nuclear Plant (Colorado Public Service Co.) Industry wide, over 70% of all nuclear utilities are studying or planning to use DCST as a means for storing spent fuel on-site once fuel pools become exhausted.

While environmental assessments undertaken by utilities for all current DCST facilities conclude that they pose no significant adverse environmental impact to worker health and safety, public dose exposure, or sensitive ecological resources, public concerns over dry storage techniques have not been completely allayed. Concerns over DCST becoming "de facto" MRSs are growing and are likely to increase as more utilities adopt the technology. Some state officials who have spoken about long-term storage of spent fuel at-reactor hypothesize that the public will oppose violation of an implicit "social contract" under NRC licenses based on the assumption that spent fuel would be removed from plants (U. S. NRC, 1991b). In addition, the interminable presence of DCST facilities in nuclear plant communities long after plants are decommissioned—assuming no permanent disposal facilities are available by that time—is certain to become an issue.

Adoption of DCST by many utilities may occur given the lack of movement toward permanent disposal of spent nuclear fuel, delays in siting an MRS, and the likelihood of spent fuel pools becoming filled—especially if plant operating licenses are renewed.

Despite the efficacy of the technology, attention must be paid to these public concerns if DCST is to attain its maximum potential for alleviating short term fuel storage problems. Any attempt to stretch the technology beyond this purpose not only goes beyond "institutionally rational" policy, but threatens public confidence and trust in HLW management as well.

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