Spent Fuel Storage in a Post-Fukushima World

By Nancy J. Zacha

A look at the status of spent nuclear fuel storage in the United States in the wake of the accident at the Fukushima Daiichi nuclear power plant in Japan and the recommendations of the Blue Ribbon Commission on America's Nuclear Future.

Who can forget those days in March 2011, when the world watched the slowly unfolding disaster at the Fukushima Daiichi nuclear power plant in Japan? Hit first by an enormous earthquake (which, in retrospect, did little or no damage to the plant—although the devastation it left behind meant that in the early days of the disaster, it was nearly impossible to get personnel or equipment to the Fukushima site) and then in close succession by the earthquake-generated tsunami, which caused a great deal of damage, the staff at the Japanese plant worked valiantly to get cooling to the fuel in the units. And soon the world became concerned not just with the fuel in the reactor cores, but with the fuel in the plant's spent fuel pools as well. Was the fuel still covered? Could it go critical? Could it possibly melt—as the fuel in the cores most certainly had?

At this writing, with the Fukushima plants in cold shutdown and the initial drama settled into the everyday work of stabilizing the situation, the world remains concerned about spent (or used) nuclear fuel stored in spent fuel pools—not just at Fukushima, but at nuclear power plants around the world.

Indeed, potential spent fuel pool breaches have been on the radar of many regulatory agencies for years but certainly since the terrorist attacks in New York City and Washington, D.C., on September 11, 2001. The U.S. Nuclear Regulatory Commission has expressed its concern about possible sudden loss of cooling water in spent fuel pools and has been studying the situation. Nonetheless, it has stated that the current program of spent fuel storage in the United States, both wet storage in pools and dry storage in concrete casks, is safe—at least for some 120 years.

Spent fuel storage has also come under increased scrutiny because of the collapse of the Yucca Mountain spent fuel/high-level waste repository program. With spent fuel now certain to be stored at nuclear power plant sites for many additional decades, given that there will be no repository to receive the fuel, both pool storage and dry cask storage are being examined critically as never before.

Dry Versus Wet Storage

Since 9/11, certain segments of the antinuclear lobby have been pushing for the removal from spent fuel pools of all spent fuel aged longer than five years, with that fuel to be transferred into dry storage casks at all the nuclear plants in the country.

But since the Fukushima accident, more voices have been added to the chorus of those pushing for immediate dry storage at all U.S. nuclear plants. Bills have been introduced in Congress to mandate such a move, although in the current climate of partisan paralysis in the legislature, the bills have received little attention. But the question arises: *Is* dry storage really safer than pool storage?

It is in this climate that the Electric Power Research Institute (EPRI) organized a telephone media briefing on Used Fuel in a Post-Fukushima World, held November 8, 2011. Speakers included Adam Levin, director of Used Fuel Management for Exelon Nuclear; Kurt Edsinger, director of materials with EPRI; and Doug True, president of ERIN Engineering and Research.

Levin pointed out that his company owns and operates 17 nuclear power plants in three states. About 80 percent of the spent fuel generated by the company resides in spent fuel pools at the plant sites. Eight sites have dry cask storage; a ninth site, Clinton, will have dry cask storage "in a couple of years;" and a tenth, Three Mile Island-1, will not be using dry cask storage until "the next decade." The utility moves just enough fuel to dry storage each year to keep space in the pool for the core.

Why doesn't Exelon move all its spent fuel into dry casks? Because, Levin pointed out, dry storage is expensive, costing the industry around $500 million since 1999 and costing individual plants between $5 million and $10 million each year. In addition, moving fuel into dry storage exposes personnel to added radiation doses.

Edsinger discussed EPRI research activities in the area of spent fuel storage. On the topic of spent fuel pools, EPRI has done research on long-term liner degradation and just finished a study in 2010 on the impacts of early fuel movement (the additional rad doses from such movements, he said, are not huge, but they are "measurable"). In the area of dry storage, EPRI has been studying long-term degradation of fuel cladding, of concrete, and of cask materials. It has also been looking at the economics of dry storage, including buying casks before they are needed. A real challenge, he said, is the cask infrastructure—specifically, the manufacturing and licensing of these casks.

True presented a discussion of risk analysis of pool storage. The risks of pool storage are extremely low, he said, due to the robustness of structures and design. In fact, he said, the earthquake at Fukushima did not damage the pools. And in the event of a loss of cooling water, there would be time in most instances to restore the cooling. In addition, he stated, in the wake of the Fukushima accident, site-specific and generic enhancements to ensure cooling at U.S. spent fuel pools have been added at U.S. plants, and the U.S. is the only country to have done this. So, U.S. plants would be considerably safer in the unlikely event that a Fukushima-type accident happened in this country. And, he added, there are still no definitive answers as to the amount of damage sustained at the Fukushima pools.

Besides, he noted, removing fuel to dry storage does not change the need for cooling in the pools, because newer fuel is the primary heat source and the biggest challenge in pool storage. In fact, he said, moving cool fuel only serves to make the pool hotter.

In response to questions about enhancements to spent fuel pools in the wake of the Fukushima accident, panelists noted that one enhancement identified to date is remote monitoring, and the industry is working to see how that could be done. (The information that would be monitored is, typically, water level and water temperature.) This would be important, Levin said, because officials at Fukushima had problems understanding the condition of the pools, having lost the ability to monitor those parameters.

Asked how long it would take a spent fuel pool to reach the boiling stage, Levin replied that it would depend how recently fuel had been discharged into the pool. If, say, you are looking at three months past the most recent fuel discharge into the pool, then the answer would be "days, not hours or minutes." There's a "tremendous amount" of water above the fuel, he pointed out. And "days" would give a plant time to respond to the threat. In addition, he continued, there are redundant systems capable of supplying water to a pool, most included in the original plant design but others added after 9/11.

As for dry storage, True noted that increased monitoring of the dry storage systems would provide valuable information. Asked what kind of monitoring, he suggested studying the differences, if any, between welded versus bolted canisters. When you talk about licensing dry storage for 60 years or more, he said, you would like to see what's going on inside the casks and canisters, perhaps with a camera inside the concrete overpack.

Ultimately, the industry would like to be able to take a canister to a hot cell after a certain storage period and pull out the fuel to assess its condition. However, as noted during a recent American Nuclear Society meeting, no such hot cell facility currently exists in the United States, although groups are studying the most logical place to locate one (see "Very Long Term Dry Fuel Storage . . . and Other Issues," *Radwaste Solutions,* September–October 2011, pp. 59–64).

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In summary, Levin noted that there is still an open question about any damage to spent fuel pools at Fukushima. Basing an opinion that dry storage is safer than pool storage on the Fukushima situation would be premature, he implied.

Consolidated Interim Storage

One issue addressed by the Blue Ribbon Commission on America's Nuclear Future (BRC) is consolidated interim storage of spent fuel, which would be particularly valuable for decommissioned plants (with their fuel sometimes referred to as "stranded fuel"), which must store their spent fuel onsite in dry storage casks, at a cost of up to $10 million annually to guard and monitor the fuel.

Centralized storage, however, is not a new concept. Indeed, in the original 1982 Nuclear Waste Policy Act (NWPA), the legislation made provision for a "monitored retrievable storage (MRS) facility" that could be located in any state *except* the state in which the final repository was to be located, but such a facility could exist only if a repository program were in active status. That is, an MRS facility program could not take the place of a repository program.

The BRC's draft report (see www.brc.gov) devotes 18 pages to spent fuel storage, recommending that "the United States proceed promptly to develop one or more consolidated interim storage facilities." Spent fuel storage in the United States, the BRC notes, has developed in an *ad hoc* fashion. Originally, nuclear power plants expected to store spent fuel for a limited amount of time, perhaps up to a decade or so, until the fuel would be moved out to a reprocessing plant or to a final repository. But the country eventually abandoned plans for reprocessing and early on ran into difficulties with developing a final repository. A 1970s plan to site a repository in a salt bed in Lyons, Kans., was hastily proposed and, after problems with the site were showcased, just as hastily abandoned.

In the early 1980s, many nuclear power plants feared that they would have to shut down because they would soon be running out of space in the spent fuel pool. Fuel reracking technologies bought utilities some time, until

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Regardless of its *ad hoc* beginnings, spent fuel storage can have some positive benefits, the BRC notes. As the report points out, "extended interim storage preserves options and enhances flexibility while other elements of a comprehensive waste management system—including options for the final disposition of [high-level waste] and [spent fuel]—are developed and tested. The United States may ultimately dispose of spent fuel or make use of reprocess and recycle technologies if closing the fuel cycle becomes advantageous in the future. Storage preserves the option of going in either direction. If the ultimate disposition path for spent fuel involves permanent disposal in a geological repository, allowing the fuel to cool through a period of interim storage reduces the siting challenge for a disposal facility and/or increases the disposal capacity of a given facility."

These benefits apply whether interim storage is provided at a centralized facility or at reactor sites, the report observes, but for maximum operational efficiencies at a system level, consolidated interim storage is a preferable option.

The BRC report lists six benefits of consolidated interim storage:

- *Consolidated storage would allow for the removal of stranded spent fuel from shutdown reactor sites.* This would enable the former reactor sites to be reclaimed for economically productive or otherwise desirable uses. In addition, most of these shutdown reactors no longer have the capability to remove spent fuel from the storage canisters for inspection if long-term degradation problems emerge that might affect the ability to transport the canisters. Consolidated storage sites can be developed to provide these capabilities.
- *Consolidated storage would enable the federal government to begin meeting waste acceptance obligations.* The federal liability for failure to take possession of spent fuel is estimated at between $500 million and $1 billion.
- *Consolidated storage would provide flexibility to respond to lessons learned from Fukushima.* The BRC notes that no determination has been made that current at-reactor storage arrangements in the United States are not adequately safe. However, access to consolidated storage would be very helpful if, for example, the decision were made to reduce inventories of spent fuel in reactor pools, which might simplify the management of a postaccident situation at a reactor by removing an important potential source of risk, freeing up pool space for other purposes, and reducing the number of issues plant operators and emergency responders would have to attend to.
- *Consolidated storage would support the repository program.* Experienced gained by siting, testing, licensing, and operating a consolidated storage facility would benefit repository development and operation. At the same site, a storage facility would act as a buffer and as valuable redundancy for a repository system as a whole.
- *Consolidated storage offers technical opportunities for the waste management system.* Such a facility could support valuable activities that benefit the waste management system, including long-term monitoring and periodic inspection of dry storage systems, instrumentation development, and work on improved storage methods.
- *Consolidated storage would provide options for increased flexibility and efficiency in storage and future waste handling functions.* For example, a planned, deliberate, and reliable process for moving spent fuel from shutdown reactor sites to a central facility can be initiated before any issues arise and where problems can be dealt with more easily and cost-effectively than at multiple shutdown sites. And if fuel currently in dry storage needs repackaging prior to final disposal, such work could be done at a centralized site, because individual sites may no longer have this capability.

What about HOSS?

Hardened On-Site Storage, or HOSS, is a concept developed after the 9/11 terrorist attacks to provide enhanced safety and security to dry storage systems. As described by its proponents, the HOSS concept adds berms and reinforced concrete vaults and overstructures to conventional dry storage systems, ostensibly to add greater resistance to potential terrorist attacks using aircraft or conventional weapons. HOSS is generally included in the calls for removal of all spent fuel more than five years old

from spent fuel pools and into dry storage casks.

The recommendation to use HOSS at reactor sites, instead of conventional dry storage technology, is being considered as part of the NRC rulemaking that is currently under way to update nuclear plant security requirements. Utilities and the nuclear power industry have generally not supported the HOSS approach, saying that the currently used system of tiered security forces, active and passive response systems, and conservative and robust technology designs ensures that dry cask storage facilities remain safe and secure.

What's Next?

The BRC's legal analysis of its recommendations noted that work "toward a consolidated storage facility can begin *immediately* [emphasis added] under the existing provisions of the NWPA, which authorize the federal government to site and design an MRS facility and obtain construction authorization. Further legislative action would not be required until prior to designation of a MRS facility site (and potentially not until the construction phase), at which time Congress would need to amend the NWPA to allow DOE to go forward independent of the status of a permanent repository."

The Nuclear Energy Institute maintains that there are several communities that would welcome a consolidated storage facility. Various experts have stated that if work began immediately, such a facility could be up and running in about a decade. (See "ARRA, the BRC, and Radium Girls in the Spotlight at ANS Meeting," this issue, page 102.)

However, some people forget that the NRC has already licensed an interim dry cask storage facility that could serve as consolidated storage for the country. Private Fuel Storage LLC (PFS) received a license in February 2006 to operate a 40 000 metric ton storage facility on Skull Valley Band of Goshute Indians Tribal land in Utah. (PFS is a consortium of eight nuclear utilities.) In a preemptive strike, a month earlier the state of Utah, which opposes the facility, declared the land surrounding the site as part of the Cedar Mountain Wilderness Area, which would preclude PFS from building a railroad spur to the site.

The NRC license for the facility was contingent on a positive ruling by the Bureau of Indian Affairs (BIA) on a couple of issues, including approval of a land lease. When the BIA disapproved the lease, PFS filed suit and charged that political interests, not the best interests of the Skull Valley Tribe and its members, had influenced the BIA decision. Initial rulings have sided with PFS and against the BIA. In the meantime, a PFS facility exists on the books but not on the ground.

Whether PFS can ever build and operate a facility will seem to depend on whether the federal government decides to get into the spent fuel storage business itself. A consolidated interim storage facility in operation within a decade would most likely have a capacity larger than 40 000 metric tons and would remove the need for the smaller facility. But can a federal government that cannot even get legislative consensus to raise the debt ceiling really come together to agree to build an interim storage facility and to amend the NWPA when necessary?

The original NWPA was a near masterpiece of bipartisan legislation, passed at a time when Republicans held the White House and the Senate, while Democrats held the House of Representatives. Since that time, the NWPA has itself become a partisan issue, with Democrats conveniently forgetting their initial support for the legislation and Republicans standing behind it. An attempt to bring the legislation up for amendment would most likely bring out Republican calls instead for a resumption of work on Yucca Mountain, even though the program has been essentially eviscerated and all infrastructure, contracts, and personnel associated with the project have been dismantled, closed out, and reassigned.

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Indeed, the House Energy and Water Appropriations bill for 2012 included funding to restart the Yucca Mountain program (the Senate bill did not), and Sen. Mark Kirk (R-Ill.) and some 30 other Republicans have introduced a bill urging Senate and House appropriators to restart the Yucca Mountain program as part of the fiscal 2012 appropriations process. The bill was debated briefly in November then set aside, but debate could resume at a later date. Still, it's a pretty safe bet that as long as Sen. Harry Reid (D-Nev., and a long-time opponent of the Yucca Mountain project) is the Senate's majority leader, a bill to restart the project is highly unlikely to pass the Senate.

Whether Congress will choose to stand behind the BRC's final report (due out in late January 2012) or not is anybody's guess. But to put things colloquially, congressional Republicans "have no dog in this hunt." The BRC was a creation of a Democratic president and energy secretary, and Republicans have no political or practical reasons to endorse its findings. So, with Democrats pushing for a new direction and Republicans pushing equally hard for a dismantled old program, it is likely that any movement toward consolidated spent fuel storage will remain a dream at least until the next election cycle. ■

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