Dry Cask Storage in Vermont

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Nelson A. Rockefeller Center for
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Dartmouth College
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prepared by

Amie Sugarman, Kathleen Schoener, Jill Harris, Madeline Hwang, Yuni Yang, Brian Hanley, Kailin Kroetz, Matt Lewis, and Becca Wehrly

Contact:
Nelson A. Rockefeller Center, 6082 Rockefeller Hall, Dartmouth College, Hanover, NH 03755
http://policyresearch.dartmouth.edu • Email: policy.research@Dartmouth.edu

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Nelson A. Rockefeller Center, 6082 Rockefeller Hall, Dartmouth College, Hanover, NH 03755
http://policyresearch.dartmouth.edu • Email: Policy.Research@Dartmouth.edu

DRY CASK STORAGE IN VERMONT

Vermont's nuclear waste storage facility is currently approaching capacity, compelling the Vermont Legislature to consider whether or not to approve the use of an alternative waste storage method called dry cask storage. This report weighs the advantages and risks of dry cask storage as an option in Vermont. The contents of this report are organized into the following sections:

- *What is Spent Nuclear Fuel?*
- *What is Dry Cask Storage?*
- *Why consider Dry Cask Storage?*
- *Advantages and Risks of Dry Cask Storage*
- *Other States and Dry Cask Storage*

WHAT IS SPENT NUCLEAR FUEL?

Spent nuclear fuel refers to the waste produced during the process of nuclear energy production. Nuclear reactors are fueled by bundles of enriched uranium pellets that are sealed within metal tubes.[1] These bundles remain in the reactors for three to four years, at which time approximately one-third of them are replaced.[2] Once they have been removed, the extracted fuel bundles are referred to as spent nuclear fuel; they are still radioactive and potentially dangerous.[2] For decades, spent nuclear fuel has been stored within steel-lined concrete pools of water, a method often referred to as "wet" storage.[3] However, there is insufficient wet pool storage space to handle the continued production of radioactive waste. This situation has lead nuclear power plants across the country to search for new methods to store spent fuel.

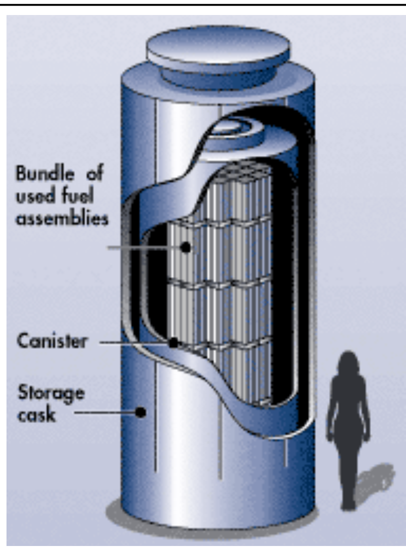

Figure 1. Vertical dry cask. Source: Nuclear Regulatory Commission, 2004.

WHAT IS DRY CASK STORAGE?

Dry cask storage is an alternative to wet storage that was first introduced in 1986. With this storage method, spent nuclear fuel is cooled in a pool for three to four years and then placed in 18-inch-thick steel casks.[2] The casks are filled with inert unreactive helium gas and surrounded by layers of steel and concrete to provide additional shielding against radiation leaks.[2] Each cask is then placed in specially designed storage containers to allow for proper ventilation and to keep the fuel cool. All cask designs, including those stored vertically (see Figure 1),[2] are constructed to prevent radiation from escaping and to resist a variety of stresses that can be caused by natural disasters. The Nuclear Regulatory Commission (NRC), which is responsible for all independent spent fuel storage installations (ISFSI), licenses and monitors them through inspections designed to evaluate public health, safety, environmental, and security criteria.[2] Based on these and other criteria, the practice, to date, has been deemed safe by the NRC.[2]

WHY CONSIDER DRY CASK STORAGE?

Located in Vernon, Vermont's only nuclear power plant Vermont Yankee provides approximately 73 percent of the electricity generated in the state.[4] Yankee's contribution amounts to approximately 35 percent of the state's energy requirements.[4] The plant is operated by the Entergy Nuclear Corporation and received its operating license in February 1973. Although the plant's license is set to expire in March 2012, the plant faces growing pressures to meet its storage needs in the short-term.[5] Yankee currently utilizes wet pool storage, but at the current rate of production, the plant will run out of pool storage capacity and be forced to shut down in 2008, four years prior to its license's expiration.[3]

When Vermont Yankee and other nuclear power plants were built in the 1960s and 1970s, the plants' designers did not intend to store the spent fuel on-site because the federal government planned on transporting the spent nuclear and high-level radioactive waste to the Yucca Mountain long-term storage facility in Nevada.[3] Although the Department of Energy (DOE) has deemed the Yucca Mountain site safe, technical, regulatory and political hurdles have kept the DOE from meeting the 1998 deadline for opening the facility.[6] The Yucca Mountain site is now scheduled to open in 2010, although the departing Energy Secretary admits the opening will likely be later than 2010.[7] Additionally, the opening of Yucca would not solve many emerging storage issues. For example, the Yucca Mountain facility is only designed to hold the amount of waste that will exist in 2011 and is not designed to accept additional waste created after this date.[8] Thus, to address the need for additional storage, states will still need to develop other options.

Using dry cask storage in Vermont would allow Vermont Yankee to deal with the pending 'storage crunch' created by the Yucca Mountain delay, while also enabling the plant to continue electricity generation. In September 2003, the Entergy Corporation submitted an application to the NRC to increase Yankee's maximum output by 20 percent.[5] Increased electricity production would cause the wet pool to fill up more quickly, causing Vermont Yankee to run out of storage room 18 months earlier than if production stays at the current rate.[5] Yet dry cask storage would allow Yankee to continue producing electricity, even after the wet pool fills to capacity.

Although the NRC has jurisdiction over all changes made to nuclear storage facilities in the U.S., several states have laws that require additional approval from the state's legislature. According to a 1977 law, the Vermont Legislature and state Public Service Board are required to review and approve any changes in wet and dry nuclear storage. Complicating the situation is a 1979 amendment to Vermont's radioactive waste storage law that granted an exemption to the Vermont Yankee Nuclear Power Corporation.[9] This amendment allowed Vermont Yankee's former owner to bypass legislative approval when it altered its waste storage methods, but the plant was purchased by Entergy Nuclear in 2002.[9] Entergy officials unsuccessfully lobbied the Vermont Legislature to alter the amendment to include Vermont Yankee Nuclear Power Corporation's successors in the exemption, thereby allowing Entergy to institute dry cask storage without legislative approval.[9] However, Vermont's Assistant State's Attorney Michael McShane issued an opinion in April that the Vermont Legislature does in fact retain the authority to approve all nuclear waste storage alterations made by Entergy, since Entergy is not included in the exemption.[9] Thus, the Legislature must approve Vermont Yankee's request, before Entergy can build the proposed 36 dry casks.[3]

A series of recent small mishaps at Vermont Yankee has prompted concern about the use of dry cask storage. For example, a transformer caught fire at the plant in June 2004 and during the ensuing emergency shutdown, reactor core water pumps malfunctioned.[10] Although approving dry cask storage would enable the plant to increase its electricity production and continue to function beyond its license expiration in 2012, there is concern that recent accidents foreshadow larger problems in the future. Given the age of the plant, some wonder whether a significantly lengthened period of operation would be safe.[10] Others worry that allowing Yankee to develop an on-site storage facility would lead to the production of a large amount of waste and ultimately require further intervention by the state, or that it will also become a repository for other states' nuclear waste.[3]

ADVANTAGES AND RISKS OF DRY CASK STORAGE

Advantages

When compared with the wet pool method, dry cask storage enjoys economic and safety advantages. Not only does it provide a temporary solution to the wet pool capacity problem, facilitating the continued operation of existing plants, but it is also considered a safer alternative because it poses fewer risks. First, unlike pool storage, dry cask storage requires no moving parts, and therefore does not rely on external power sources to ensure proper functioning of the storage apparatus. Second, this independence from outside power sources means it is not susceptible to risks associated with momentary losses of power, which could lead to the release of high levels of radiation through a waste fire.[11] Third, each dry cask contains less waste than a full waste pool; as a result, the smaller amounts of waste decrease the likelihood of overheating and potential ignition, and thus limit the corresponding environmental damage and threat of radiation poisoning to surrounding residents.[11] Also, for this reason, some experts believe dry cask storage is less susceptible to terrorism than wet storage, especially if the casks are geographically dispersed to reduce local concentration of stored nuclear material.[12] Dry cask storage also has been found to be environmentally secure, as a Harvard University study of various types of nuclear storage found that "there are very few scenarios that can be imagined that could provide the energy needed to break the cask and spread the radioactive material into the surrounding environment."[13]

Dry cask storage also can provide indirect economic advantages. For example, the method is less expensive than wet pool storage, which requires costly capital and construction investments[14] and subsequent 24-hour monitoring.[11] While the initial capital cost of casks is high, the maintenance costs are very low (Figure 2).[13,15] At a wholesale rate of 3.9 per kilowatt hour, Yankee is currently the cheapest source of electrical power in the state.[16] Maintaining this source of cost-effective energy contributes to Vermont's goal of a stable and affordable energy supply. At the same time, this source also raises concerns about potential environmental and public safety impacts.

Cost (millions of 1998 U.S. dollars)	**Pool storage**	**Cask storage**
Capital cost	1,220	1,024
Construction cost	1,036	82
Cask cost	78	934
Decommissioning and disposal cost	104	8
Operations cost	1,090	186
Transportation cost	32	47
Total	**2,342**	**1,256**

Figure 2. Breakdown of Estimated Storage Costs for 5,000-tonne Facility in Japan (Source: Bunn et al., 2001).

Potential Risks

While dry cask storage has many advantages, it also poses numerous potential risks to the public and to worker safety. Human error, such as dropping a cask, can damage plant safety equipment.[11] Technical aspects of dry cask storage also pose possible dangers. For example, the NRC noted delayed weld cracks in VSC-24's, a certain type of cask, at several nuclear facilities.

Welds seal shut the casks' shield lids, and if cracked, helium can escape from the casks, making the irradiated fuel vulnerable to contact with air.[11] Finally, the NRC recently acknowledged decreased oversight and day-to-day management of dry cask storage facilities, which increases the probability for potential problems.[17]

Transportation

Transportation is one of the most dangerous aspects of any nuclear waste storage, since it presents the maximum probability for both mechanical and human errors. Dry cask storage is especially risky, precisely because the spent fuel must be transported several times, often with concerns about proper ventilation. Because newly spent waste must be stored for several years in a pool before its level of radioactivity is safe enough to be stored in casks,[18] the waste must be transported twice during this phase. The waste initially is moved from the reactor to the pool and then from the pool to the cask. Some plants commonly fill wet pools to capacity before transferring spent fuel rods to casks, which some scientists describe as the riskiest method of transference because it creates the potential opportunities for a terrorist attacks (e.g., attacking containers).[19] Additionally, because the storage casks cannot actually be transported, the waste must be unloaded and put into separate transport casks. According to the NRC, workers' lack of experience unloading casks poses a potential source of human error in the process.[20]

In contrast to wet pool storage, dry cask storage does not have to occur at the same site as the nuclear reactor where the fuel is produced. Occasionally, other nuclear plants and storage facilities may be willing to store spent fuel in dry casks if space is limited or unavailable for storage at a given plant. However, this option means that spent fuel is transported by train from one nuclear plant to another, raising concerns about potential accidents. While this approach involves many inherent risks and costs, to date there have been no accidents that have resulted in the release of radiation.[21]

Radiation Exposure

Radiation from dry cask storage is another major risk to worker and public health because of the potential for it to leak into the atmosphere. The environmental impact statement for the Prairie Island nuclear power plant in Minnesota stated that the gamma radiation from the ISFSI would result in a lifetime risk of cancer of six incidences per 100,000 in surrounding residents. This risk exceeds the Minnesota Department of Health's maximum risk level of one per 100,000 residents from any single source.[22]

Natural Hazards - Floods

Potential flooding at dry cask storage sites presents a significant environmental risk. Many dry cask storage facilities are located in floodplains. For example, although the Prairie Island nuclear power plant is located on the Mississippi River's 500-year floodplain, the site actually has experienced major flooding twice in the past 40 years.[23] A radiation leak from dry casks above a floodplain during a flood could poison entire river ecosystems, including the water for millions of people who live downstream from the plants.[23]

The proposed dry cask storage site in Vernon, Vermont sits just above the elevation for the 100-year floodplain.[24] The river and the floodplain cut through Windham County less than 7 miles from where Vermont Yankee is located.[24] Additional concerns about this issue are driven by the possible inaccuracy of Vermont flood hazard maps. The U.S. Congress mandates that the director of the Federal Emergency Management Agency (FEMA) assess the need to update floodplain areas and flood risk zones every five years, including updates for ongoing development and construction.[25]

FEMA data and community responses to FEMA surveys regarding changes in local activities for the National Flood Insurance Program's Biennial Report were collected late last year in conjunction with the five-year Mapping Needs Assessment.[25] However, 87-percent of the state's flood maps are over ten years old.[25] This creates a potential false sense of security for Vermont's residents, especially in regard to dry cask storage. This concern is compounded by the fact that the small state of Vermont has received disaster declarations from FEMA for severe flooding nine times during the past ten years. Of these declarations, three in the past five years have included Windham County.[26] If a flood occurs during a cask malfunction, this could present the risk of contaminating the water, making effective public notification procedures a necessity with dry cask storage. The Vermont Yankee nuclear power plant has tried to ensure the safety of its surrounding residents by declaring the ten-mile radius surrounding the facility to be an Emergency Planning Zone that receives various types of warnings in the case of an emergency.[27] Yet, in October 2004, the NRC concluded that the power plant was not sufficiently maintaining the emergency warning systems.[28] This raises questions among some in the community about Vermont Yankee's ability to promptly and adequately notify and evacuate the surrounding population in the event of a dry cask emergency.

Incidences of Malfunction

Since the introduction of dry cask storage, several incidents around the country have illustrated the reality of the risks involved. For example, in 1996 a fully-loaded cask, containing 14 tons of spent nuclear fuel rods, exploded at the Point Beach nuclear facility in Wisconsin. This prompted the nation-wide suspension of further loading of VSC-24 casks, a particular type of dry storage cask.[29] The suspension failed to increase the safety of VSC-24 casks, though, as the next time they were used in the Palisades nuclear facility in 1999, they resulted in two "hydrogen ignition incidents."[11] Another malfunction took place in 2000, when the Surry nuclear power plant in Virginia noted six-inch-long cracks, loose bolts and helium leaks from its TN-32 cask.[11] Yet another problem at the Rancho Seco reactor in California illustrates the hazards of transporting spent fuel from pools into casks. When loading its first dry storage cask, Rancho Seco's irradiated fuel storage pool experienced an underwater air leak due to a faulty O-ring, which threatened to contaminate the site with radioactive pool water.[11]

OTHER STATES AND DRY CASK STORAGE

Currently, 34 nuclear sites in 25 states, including three in New England, utilize dry cask storage (Figure 3[2], Table 1). The first dry cask site was the Surry Power Plant in **Virginia**, which opened its dry cask storage facilities in 1986.[30]

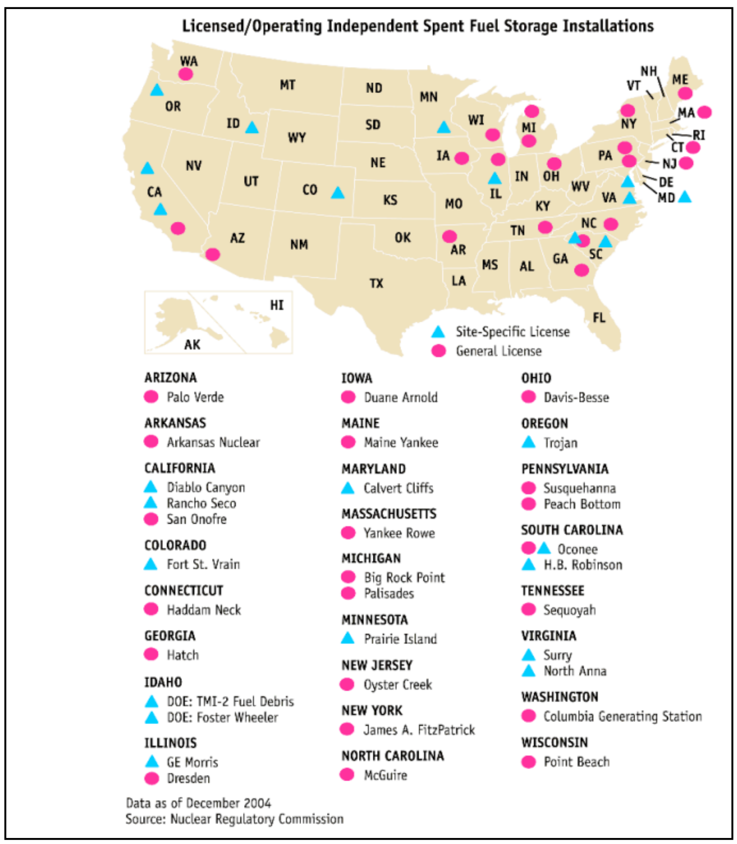

Figure 3. Source: Nuclear Regulatory Commission, 2004. Triangles represent site-specific licenses and circles represent general licenses

Dominion Resources, Inc., Surry's operator, recently received preliminary Table 1. State approvals needed for dry cask storage

State	Approval Agency	Process and Conditions Evaluated
Arizona[31]	NRC only	Must comply with state's other hazardous waste laws
California[32]	Public Utilities Commission, Coastal and Planning Commissions	Approval to authorize cask storage Approval to utilize the land
Colorado[33]	Department of Public Health	Approval to authorize waste storage facility
Connecticut[34]	Department of Environmental Protection, General Assembly	Approval of safety plans for facility Approval to authorize nuclear waste storage
Georgia[35]	Low-Level Waste Management Commission	Approval of waste storage
Idaho[36]	Pacific States Radioactive Materials Transportation Committee	Approval to authorize waste storage
Illinois[37]	NRC only	Must comply with federal regulations
Iowa[38]	NRC only	Must comply with federal regulations
Maine[39]	Maine Legislature, Department of Environmental Protection (Board of Environmental Protection)	Consent to construct waste storage facility Must comply with health and safety regulations
Maryland[40]	Department or Governor	Approval to authorize waste storage
Massachusetts[41]	Low-level Radioactive Waste Management Board, Department of Public Health	Approval and regulation of waste storage Regulate storage to ensure safety
Michigan[42]	NRC only	Approval to store spent fuel rods aboveground
Minnesota[56]	Environmental Quality Board, Public Utility Commission, State Legislature approval	Review environmental impact statement for adequate safety Approval of certificate for cask storage Approval of the use of dry cask storage
New Jersey[43]	Department of Environmental Protection, Commissioner of Northeast Interstate Low-Level Radioactive Waste Commission	Design and approval of nuclear waste storage facility Approval of nuclear waste storage facility
New York[44]	State Legislature and Governor, New York State Energy Research and Development Authority	Approval of nuclear waste storage facility Study and recommend approval of nuclear waste storage facility
North Carolina[45]	Governor or Radiation Protection Commission	Approval of license to store nuclear waste
Ohio[46]	Midwest Low-Level Radioactive Waste Commission, Department of Health	Approval of radioactive waste storage facility License and regulate radioactive waste storage facility
Oregon[47]	Energy Facility Siting Council, Additional state agencies	Approval of radioactive waste storage facility Enforce compliance with additional permits and licenses
Pennsylvania[48]	NRC only	Must comply with federal regulations
South Carolina[49]	Department of Health and Environmental Control	Regulation of licensing of radiation sources
Tennessee[50]	NRC only	Must comply with federal and interstate compact regulations
Virginia[51]	Coal and Energy Commission	Approval of storage and transportation of nuclear waste
Washington[52]	NRC only	Must comply with federal regulations
Wisconsin[53]	Public Service Commission	Approval to use dry cask storage

approval from the NRC to renew its permit for another 20 to 40 years. This approval would make it the first facility in the country to receive permit extension for on-site dry storage.[54] Unlike Vermont, Virginia does not require legislative approval for changes to nuclear storage facilities. Instead, Virginia law stipulates that the Coal and Energy Commission periodically address issues related to on-site temporary storage facilities.[55]

In **Minnesota**, any nuclear storage changes in the state must first be approved by the Minnesota Public Utilities Commission (PUC), then an environmental impact statement is prepared by the state's Environmental Quality Board, then the PUC reports to the House and Senate of the Minnesota State Legislature, who must then give final approval to the request.[56] The Legislature passed a bill in 2003 that granted the PUC and Legislature the final approval for changes to dry cask storage facilities.[56] Additionally, this bill allows the Prairie Island nuclear plant, which is run by Xcel Energy, to increase its number of dry casks from 17 to possibly 48. Xcel predicts that it will operate 12 new casks.[56] In the agreement, Xcel committed to contributing money to a renewable energy development account for all years that the plant is in operation.[56]

Also in the northeast, the Indian Point nuclear power plant in Buchanan, **New York** is preparing to transfer its spent fuel from pools to dry casks.[57] Like many other facilities, the plant was originally built with the expectation that significant amounts of nuclear waste would be transported to and stored at the Yucca Mountain facility. Given Yucca Mountain's delayed opening, the plant's wet pool units are filling toward capacity.[58] In light of the recent NRC approval of a 3.26-percent power uprate for the plant, the pools may fill even more rapidly.[59] The owner and operator of the Indian Point Plant, Entergy, possesses a general license from the NRC to utilize selected casks for dry storage, and thus no additional formal NRC approval is needed in order to proceed with the shift to dry cask storage.[57] Currently, various groups opposed to dry cask storage at Indian Point are presenting their cases to the United States Congress in hopes that Congress will increase mandatory security procedures for the plant.[60] The NRC has made clear that it takes responsibility for the protection of public health and safety, and it will be vigilant in the regulatory reviews and oversight of any facility before it is granted approval to operate.[57]

The Tennessee Valley Authority (TVA) recently began to utilize dry cask storage at its Sequoyah nuclear power plant in Chattanooga, **Tennessee**.[61] The TVA, owner and operator of the plant, states that Sequoyah is another example of a plant that has run out of room in its wet pools due to the Yucca Mountain delays.[61] To date, the TVA has spent $25 million transferring nuclear waste from its full pools into casks, but it recently won a U.S. Court of Federal Claims ruling that could lead to the recovery of millions of dollars in storage costs as a result of the DOE's breach of contract to dispose of TVA's waste beginning in 2002.[62] This award may prompt other states to follow suit by suing the DOE. The TVA is also enduring the NRC's 28-month schedule to grant approval of three dry cask storage units at its Browns Ferry nuclear plant in Alabama,[63] planned for 2005 through 2009.[19] The TVA has spent $22 million thus far building supplemental storage at Browns Ferry for its reactors.[64]

Some states continue to store spent fuel in dry casks from plants that have closed. Currently, the spent fuel from the permanently closed Connecticut and Maine Yankee nuclear power plants is stored in dry cask units in **Connecticut** and **Maine** respectively. These units will remain under heavy security until a permanent storage facility is completed and agrees to accept the transfer of this waste.[65]

CONCLUSION

The rapid pace with which the wet pool storage unit at Vermont Yankee is reaching capacity has led Entergy Energy, Inc. to explore alternative methods of spent nuclear fuel storage. Dry cask storage represents an option that has been successfully used by other power plants throughout the country. According to Vermont law, evaluating the advantages and risks of dry cask storage and determining whether this method should be used by Vermont Yankee falls to the Vermont Legislature.

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