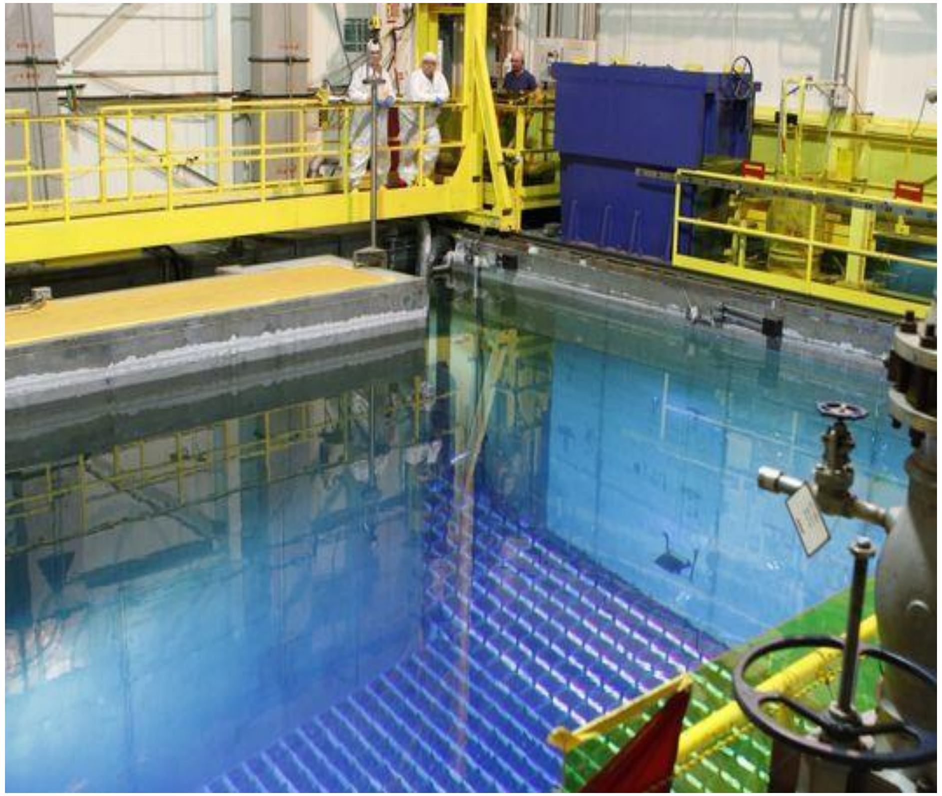
Spent Nuclear Fuel at the Indian Point Nuclear Power Station



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Why we should be concerned about spent power reactor fuel.

The U.S. Government Accountability Office informed the U.S. Congress in April 2017 that *"spent nuclear fuel can pose serious risks to humans and the environment ..and is a source of billions of dollars of financial liabilities for the U.S. government. According to the National Research Council and others, if not handled and stored properly, this material can spread contamination and cause long-term health concerns in humans or even death. "*

Because of these extraordinary hazards spent nuclear fuel is required under federal law (the Nuclear Waste Policy Act) to be disposed in a geological repository to prevent it from escaping into the human environment for tens-of-thousands of years. For these reasons, GAO concludes that spent power reactor fuel is *"considered one of the most hazardous substances on Earth…."*

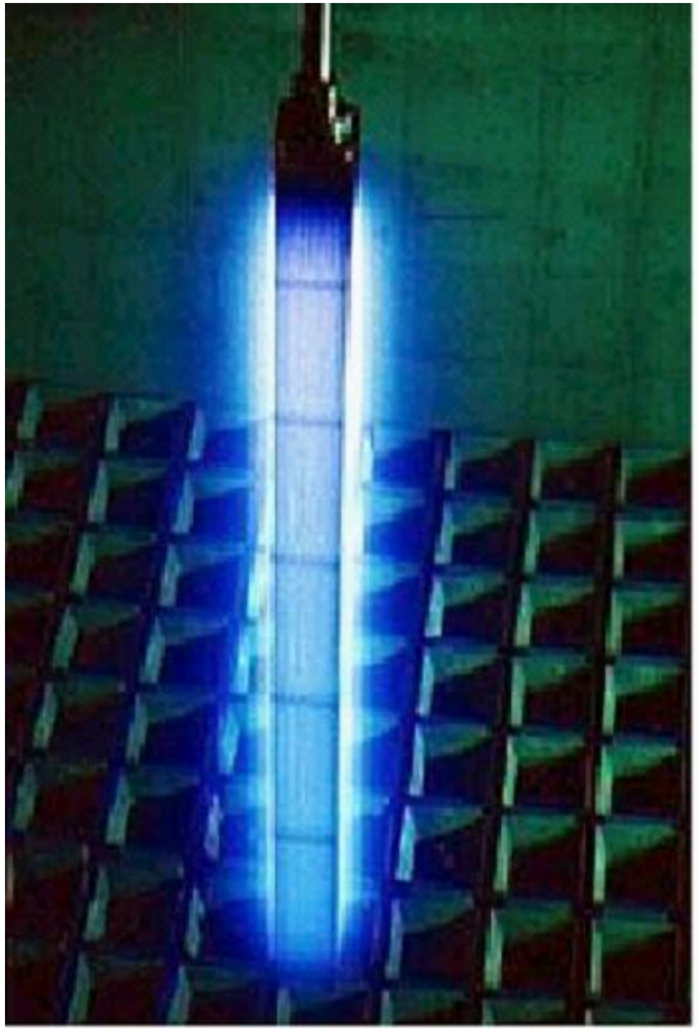
Sources: GAO- http://www.yuccamountain.org/pdf/gao-0517-684327.pdf, http://www.gao.gov/assets/660/653731.pdf

U.S. nuclear power plants that have retired or announced retirement

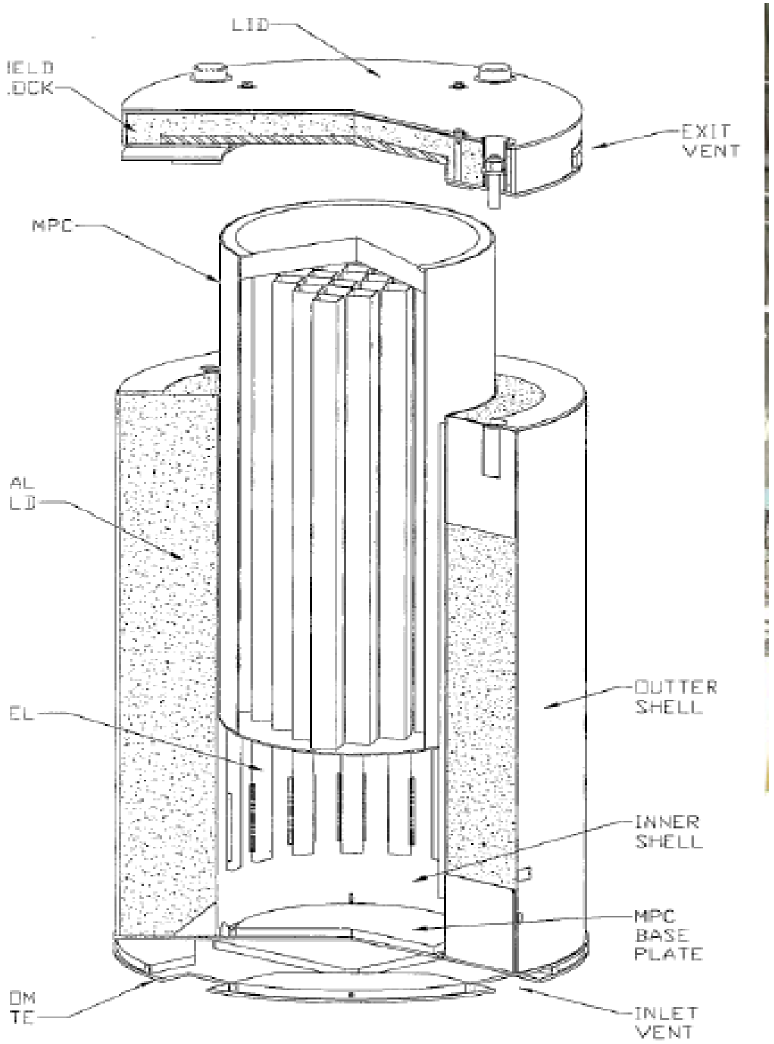
When it closes by 2021, the Indian Point Nuclear Station in Buchanan, New York is estimated to have generated about 4,242 spent nuclear fuel assemblies (~1,951mt) containing approximately 865,368 spent fuel rods. The rods contain about 208 million ceramic uranium fuel pellets.

After bombardment with neutrons in the reactor core, about 5 to 6 percent of the fuel is converted to a myriad of radioactive elements, with half-lives ranging from seconds to millions of years. The materials in spent nuclear fuel are radiotoxic meaning that that they create biological damage based on their radioactive properties alone.

The most immediate and severe form of harm is direct exposure to a spent nuclear fuel assembly at a near distance. For instance, a person standing within 3 feet of a spent nuclear fuel assembly would receive a lethal dose within minutes.   Long-term damage from lower doses includes cancers, other diseases, and genetic damage.



Typical vertical cask at grade



Holtec HI-STORM

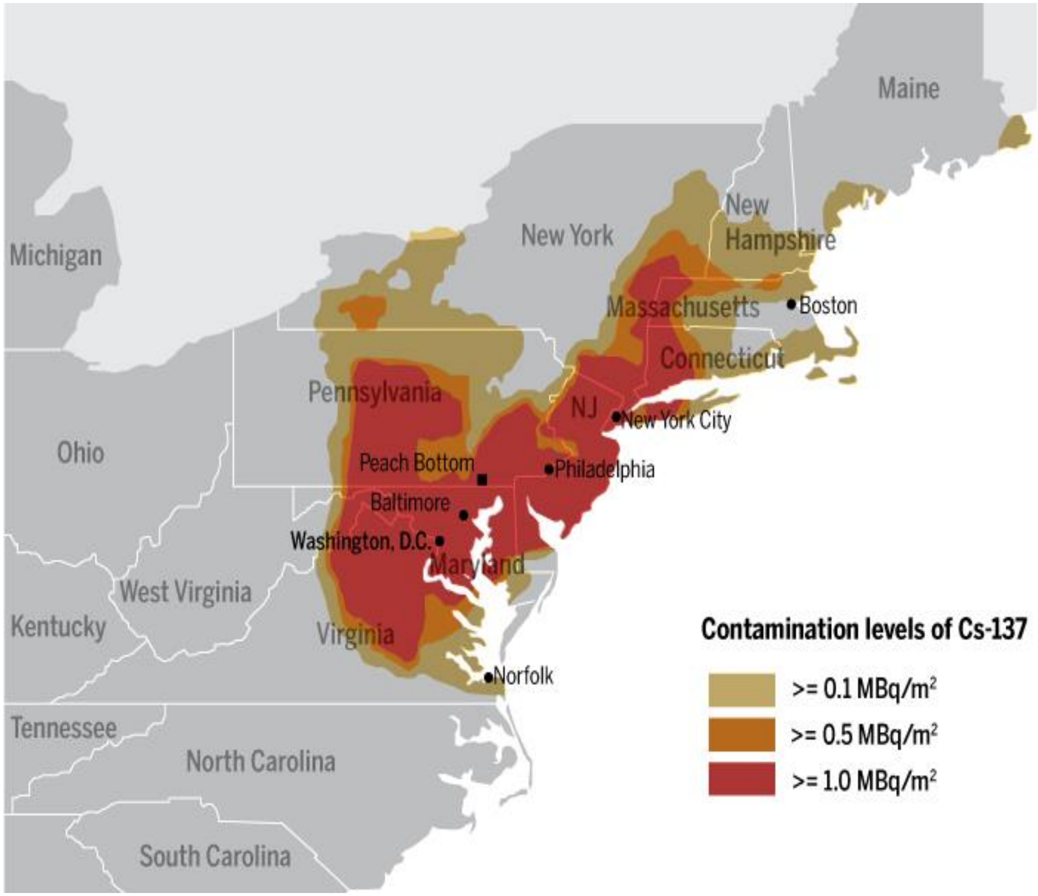
After closure, spent nuclear fuel from Indian point Units 1, 2 and 3 is planned to be stored onsite in a total 124 dry casks.

As of March 2019, IP has 43 dry casks (24 from Unit No. 2, 14 from Unit No. 3, and 5 from Unit No. 1)

Spent nuclear fuel from Unit 2 is also routinely transferred to the Unit 3 storage pool.

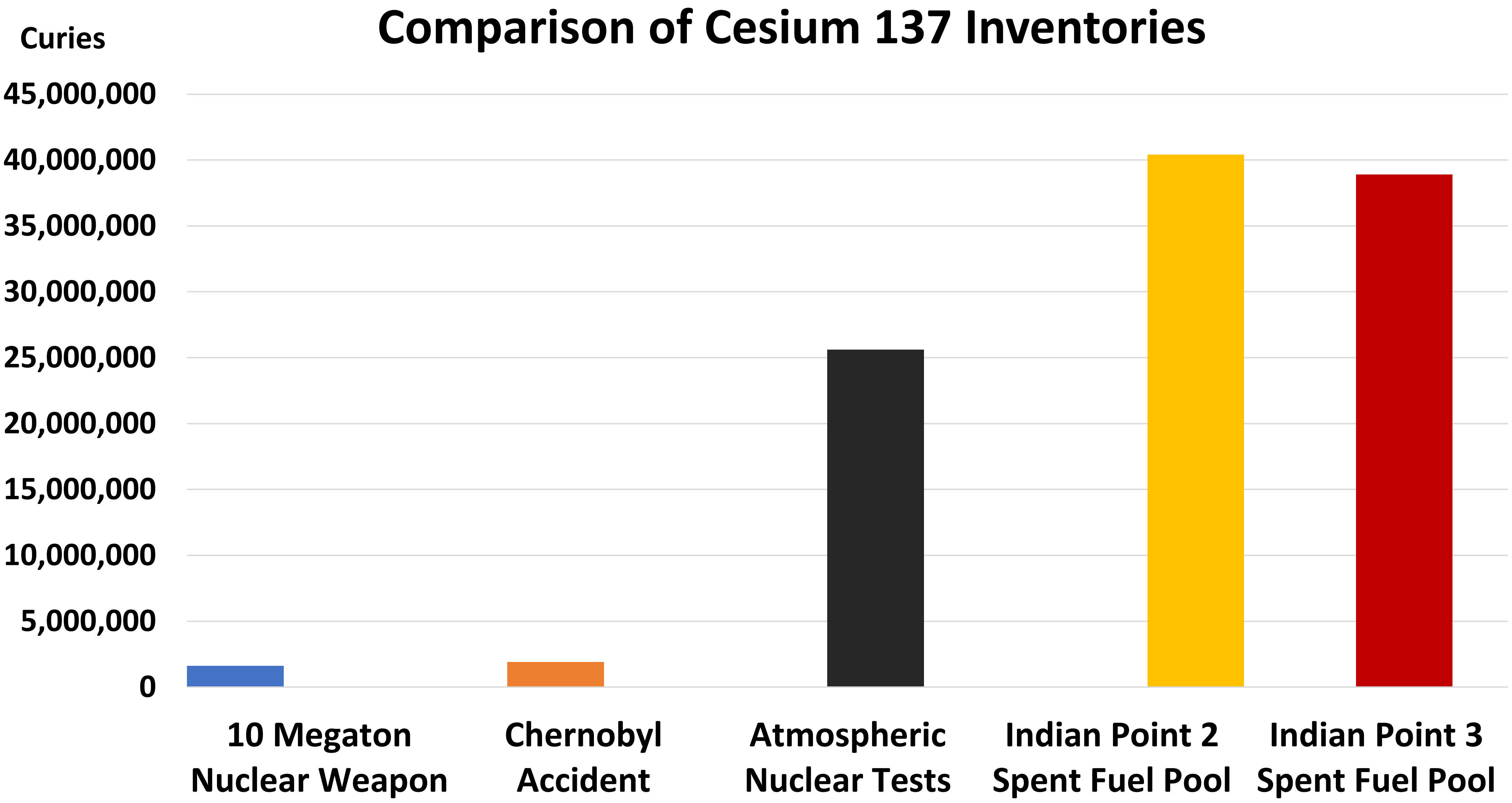
Heat from the radioactive decay in spent nuclear fuel is also a principal safety concern. A few hours after a full reactor core is offloaded, it can initially give off enough heat from radioactive decay to match the energy capacity of a steel mill furnace. This is hot enough to melt and ignite the fuel's reactive zirconium cladding and destabilize a geological disposal site it is placed in. By 100 years, decay heat and radioactivity drop substantially but still remains dangerous.

If the water in a reactor spent fuel pool is drained by and earthquake or an act of malice, decay heat can cause a catastrophic fire that could release enough radioactive material to contaminate an area twice the size of New Jersey. On average, radioactivity from such an accident, if it would occur at the Limmerick nuclear station in Pennsylvania, could force approximately 8 million people to relocate and result in $2 trillion in damages.



<u>The dangers of spent fuel fires can be greatly reduced by ending high density pool storage and expanded dry casks storage.</u>

Source: Science&Global Security (2016)



Sources: CDC 2000, NCRP No. 154, DOE GC-859, Exchange Monitor 01-2017, DOE EIS-0250, Appendix A, (PWR/ Burnup = 41,200 MWd/MTHM, enrichment = 3.75 percent, decay time = 23 years.)

High Burnup Spent Nuclear Fuel Issues

Burnup is a way to measure how much uranium is burned in the reactor. It is the amount of energy produced by the uranium. Burnup is expressed in gigawatt-days per metric ton of uranium (GWd/MTU).

According to the U.S. Nuclear Regulattory Commission (NRC) high burnup spent nuclear fuel is greater than 45GWd/MTU.

The NRC lacks a technical basis for the long-term stage and trans[port of high burnup SNF.

Pver the past 10-15 years, US utilities have begun using what is called high-burnup fuel. This fuel generally contains a higher percentage of uranium 235, allowing reactor operators to effectively double the amount of time the fuel can be used, reducing the frequency of costly refueling outages.

- **High-burnup waste reduces the fuel cladding thickness and a hydrogen-based rust forms on the zirconium metal used for the cladding, which can cause the cladding to become brittle and fail. In addition, under high-burnup conditions, increased pressure between the uranium fuel pellets in a fuel assembly and the inner wall of the cladding that encloses them causes the cladding to thin and elongate. And the same research has shown that high burnup fuel temperatures make the used fuel more vulnerable to damage from handling and transport; cladding can fail when used fuel assemblies are removed from cooling pools, when they are vacuum dried, and when they are placed in storage canisters.**

- **For disposal high-burnup SNF is significantly more radioactive and requires longer decay storage, a larger repository area, and/or greater temperature tolerance.**

"Full loadings of high burnup fuels in very large casks may require decades of aging in pools."

"Transportation may require additional aging, either in casks or pools."

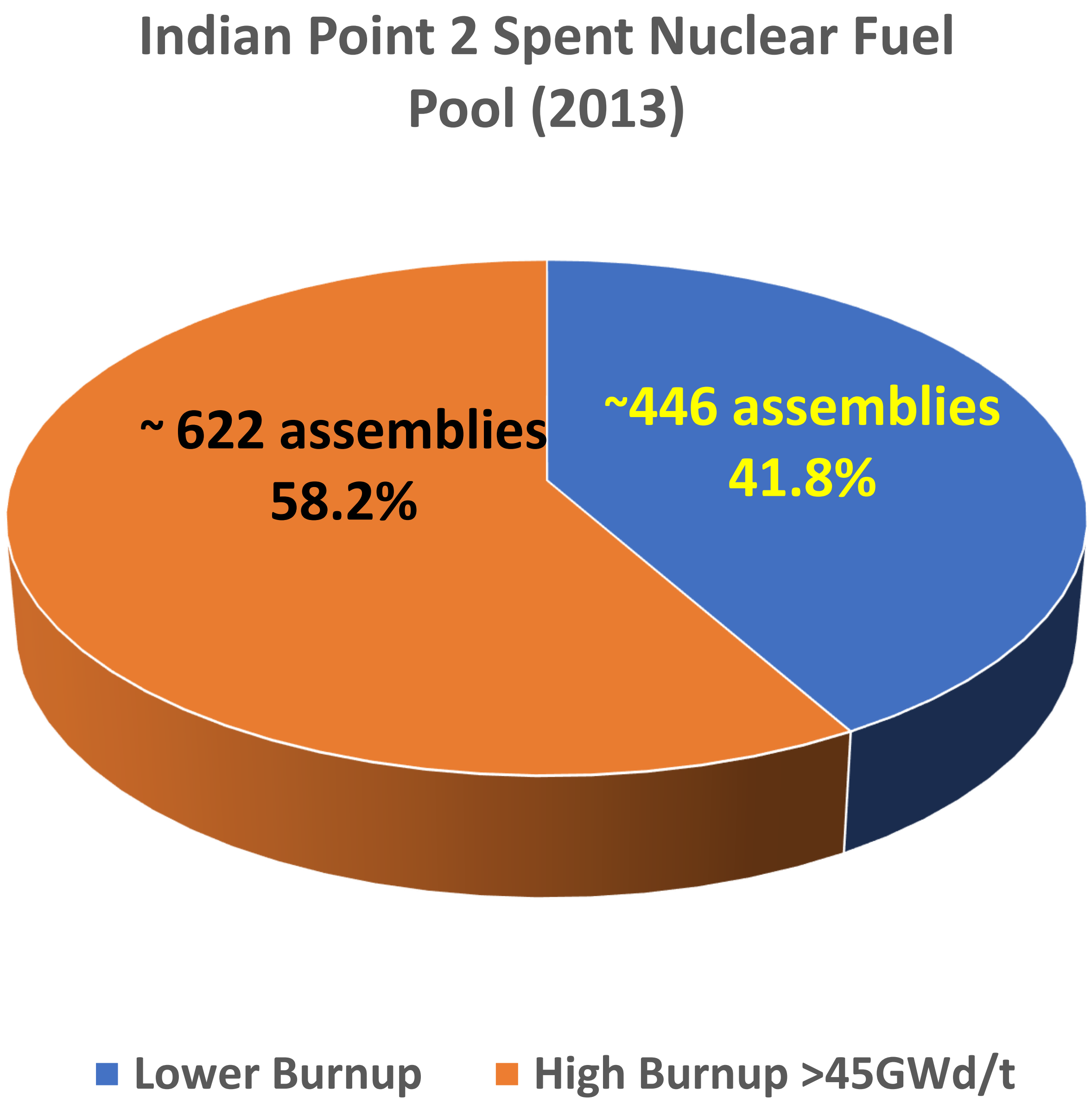
"Decades of storage (in either pools or casks) may be required before transporting very large casks and higher burnup fuels"

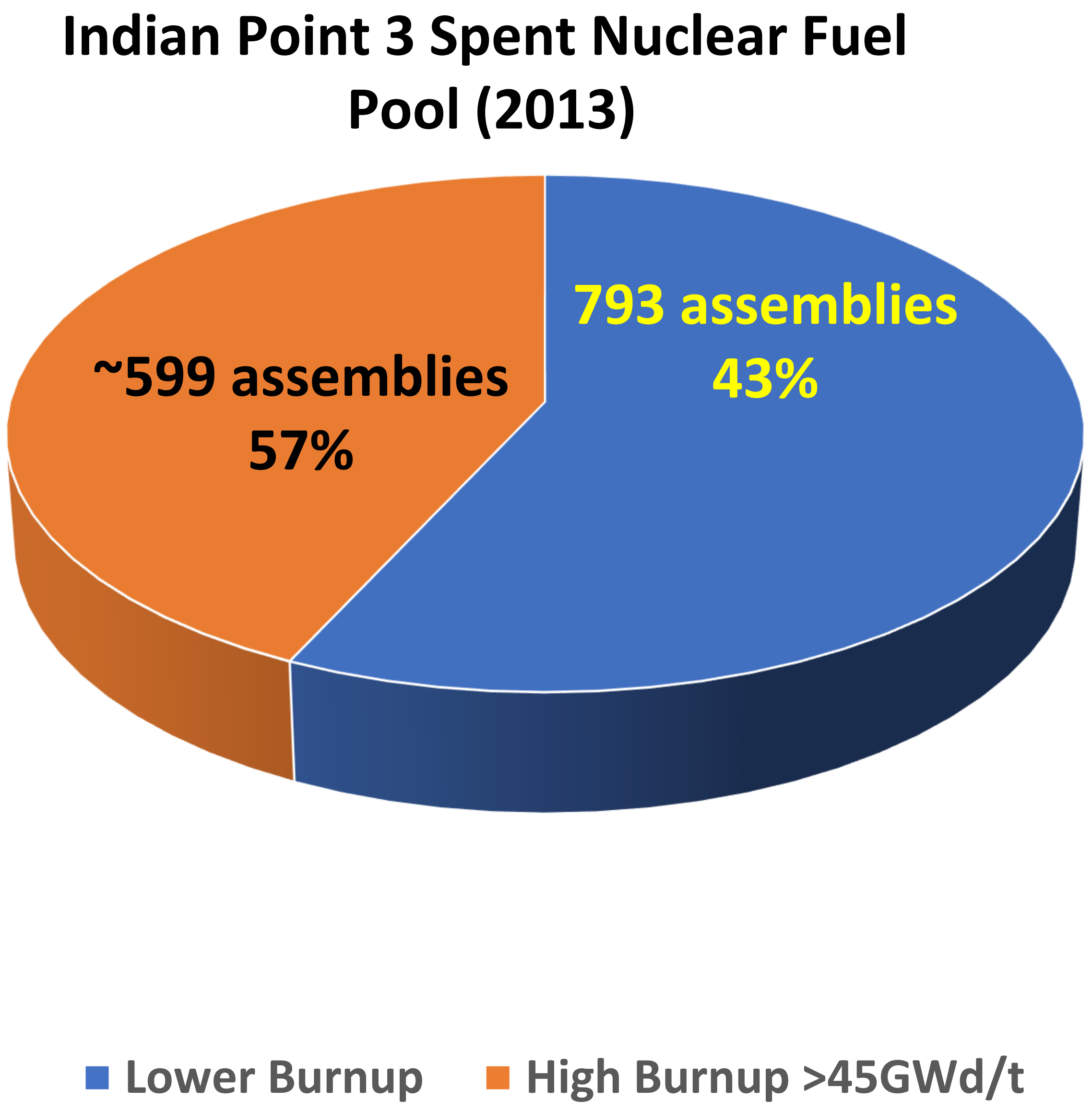
Sandia National Laboratory SAND2013-1698C
February 25, 2013

Sandia National Laboratories

"…some of the largest SNF canisters storing the hottest SNF would not be cool enough to meet the transportation requirements until approximately 2100."

(Nuclear Waste Technical Review Board, September 2019)



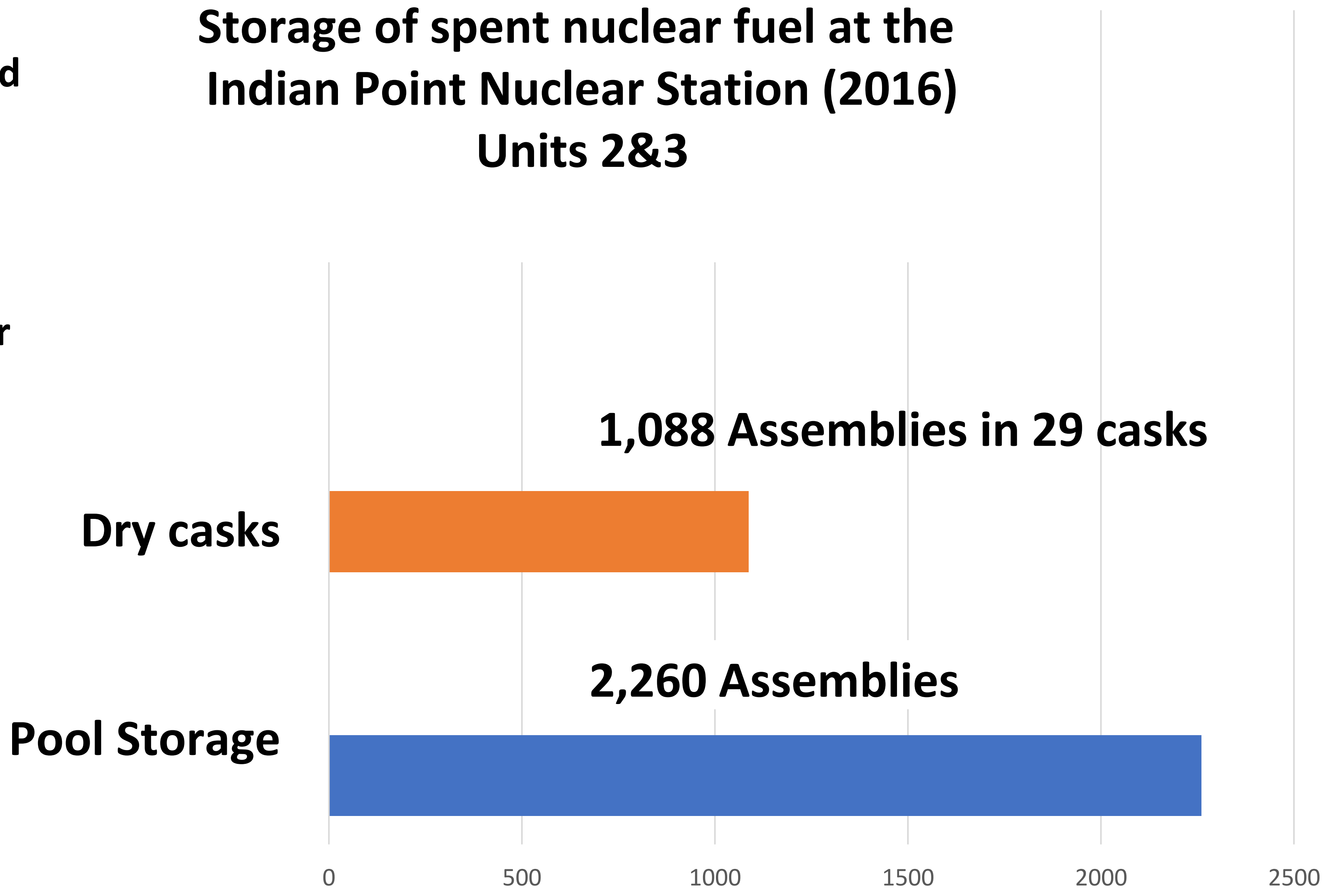


Source: DOE GC 859 data June 2013,

To date, high burnup spent nuclear fuel has not been placed in dry casks at Indian Point.

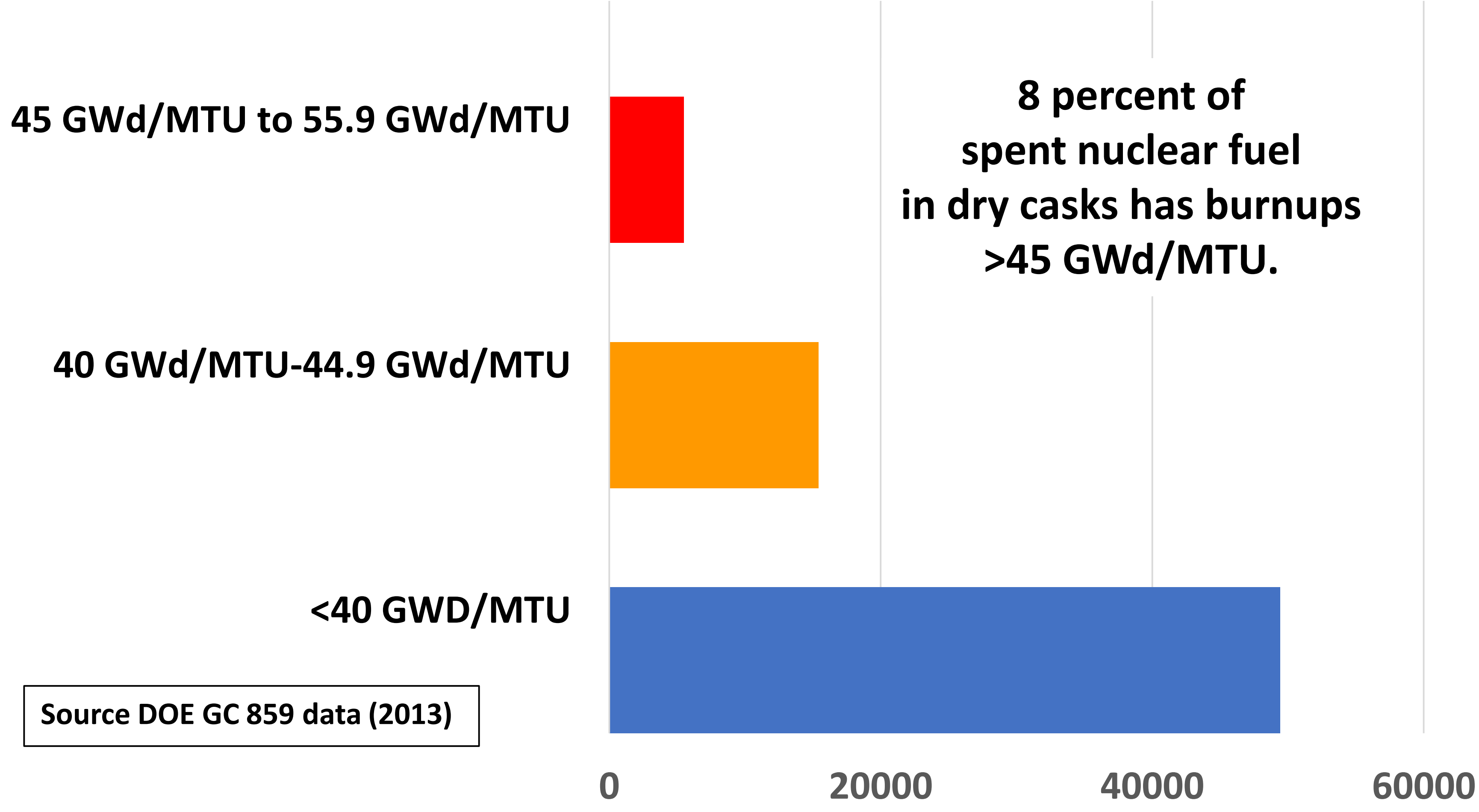
As of August 2014, Entergy was not authorized by the NRC to store high burnup spent nuclear fuel in dry casks.

NRC is currently reviewing proposals for dry casks that can hold larger amounts of high burnup SNF.



Sources: DOE, FCRD-NFST-2014-000602, Revision 2, August 2016, Exchange Monitor 01-2017.

Spent Nuclear Fuel Assemblies in Dry Casks at U.S. Power Reactor Sites (2013)



Source DOE GC 859 data (2013)

NRC allows a few high burnup assemblies, with higher decay heat to be mixed with lower burnup assemblies in a storage canister.

NRC's current regulatory guidance concedes that "data is not currently available" supporting the safe transportation of high burnup spent nuclear fuel.

Owners of the shuttered Maine Yankee and Zion reactors are not taking a chance and have packaged high burnup spent fuel as it were damaged goods, stored in double-shell containers instead of single-shell, to allow for safer transport.

Spent Nuclear Fuel Repackaging

The current generation of dry casks was intended for short-term on- site storage, and not for direct disposal in a geological repository. NRC has licensed 51 different designs for dry cask storage, 13 which are for storage only. None of the dry casks storing spent nuclear fuel are licensed for disposal.

By the time, DOE expects to open a repository in 2048, the number of large dry casks currently deployed is expected to increase from 1,900 to 12,000. Repackaging for disposal may require approximately 80,000 "small" canisters.

Existing large canisters can place a major burden on a geological repository –such as: handling, emplacement and post closure of cumbersome packages with higher heat loads, radioactivity and fissile materials.

Repackaging expenses rely of the transportability of the canisters, but more importantly on the compatibility of the canister with heat loading requirement for disposal.

Uncertainties

"Entergy Nuclear Indian Point 2, LLC's (Entergy) current spent fuel management plan for the IP-2 spent fuel is based in general upon: 1) a 2025 start date for DOE initiating transfer of commercial spent fuel to a federal facility (not necessarily a final repository), and 2) expectations for spent fuel receipt by the DOE for the IP-2 fuel. The DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority. Assuming a maximum rate of transfer of 3,000 metric tons of uranium/year,[4] the spent fuel is projected to be fully removed from the Indian Point site in 2059."

"This report should not be taken as any indication that the licensee knows how the DOE will eventually perform its obligations, or has any specific expectation concerning that performance ***(Emphasis added)."***

Entergy report regarding the decommissioning funding plan for Indian Point's Independent Spent Fuel Storage Facility to NRC December 17, 2015, P. 27 https://www.nrc.gov/docs/ML1535/ML15351A524.pdf

Conclusion

The basic approach undertaken in this country for the storage and disposal of spent nuclear fuel needs to be fundamentally revamped to address vulnerabilities of spent fuel storage in pools.

First and foremost, to protect public safety, high density pool storage of spent nuclear fuel should end.

Instead of waiting for problems to arise, the NRC and the Energy Department need to develop a transparent and comprehensive road map identifying the key elements of—and especially the unknowns associated with—interim storage, transportation, repackaging, and final disposal of all nuclear fuel, including the high-burnup variety.

The Energy Department has not ruled out the possibility that SNF may remain in surface storage for 300 years.

Otherwise, the United States will remain dependent on leaps of faith in regard to nuclear waste storage—leaps that are setting the stage for large, unfunded radioactive waste "balloon mortgage" payments in the future.