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How soon could all the spent nuclear fuel at San Onofre be moved? Where could it be moved to?

A community with stranded spent nuclear fuel might wonder WHEN the spent nuclear fuel can be transported away. They might wonder WHERE it could be moved to.

The electric utility that owns the spent nuclear fuel might wonder WHO PAYS for continued storage, for transportation of the SNF, and who retains liability should an accident occur during storage or during transportation.

Most communities do not know how long the spent nuclear fuel (SNF) is required to cool before it can be transported. The answer is — it depends. It depends on the enrichment and burnup of the spent fuel, on how many assemblies are packed together and on the particular canister and overpack design. Spent nuclear fuel is stored in 35 states in over 70 storage sites. [1] [2]

In 2018, the electric utility hired North Wind to conduct a study "to develop insights and information concerning commercially reasonable pathways for moving the spent nuclear fuel off site…" for the shuttered nuclear plant at San Onofre. (See Volume II, page v.) [3] [4] [5] That nuclear

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[1] U.S. Nuclear Waste Technical Review Board, *Evaluation of the U.S. Department of Energy Research and Development Activities on the Disposition of Commercial Spent Nuclear Fuel in Dual-Purpose Canisters*, February 2024. https://www.nwtrb.gov/our-work/reports/evaluation-of-the-u.s.-department-of-energy-research-and-development-activities-on-the-disposition-of-commercial-spent-nuclear-fuel-in-dual-purpose-canisters-(february-2024) See Figure 1, which states 37 states have NRC-licensed independent spent fuel storage installations, but two of those were never built, in Utah and New Mexico.

[2] Accounting of the number of states and sites with spent nuclear fuel in dry storage varies because commercial nuclear plant sites may have more than one license for dry storage and including Department of Energy managed spent nuclear fuel varies. Also, some NRC licenses were granted but no spent fuel storage facilities were built at Utah's Private Fuel Storage, New Mexico's proposed Holtec facility, or Texas' Interim Storage Partners. Also, commercial spent nuclear fuel for Three Mile Island nuclear power plant fuel debris is stored at a Department of Energy site at the Idaho National Laboratory and has an NRC license but is not where the reactor was located. DOE-managed fuel in Colorado at the Fort St. Vrain stranded fuel site is NRC-licensed but not managed by a commercial nuclear power utility. Naval, military and research spent nuclear fuel stored at five DOE sites are not included in commercial nuclear power plant spent fuel accounting and typically does not have an NRC license. So, not only does the status change over time, there are a variety of ways of including or excluding certain spent nuclear fuel storage sites in the U.S.

[3] North Wind, Volume I, *Action Plan for the Relocation of SONGS [San Onofre Nuclear Generating Station] Spent Nuclear Fuel to an Offsite Storage Facility or a Repository*, March 15, 2021. https://www.songscommunity.com/strategic-plan-for-relocating-spent-fuel/spent-nuclear-fuel-solutions-a-fresh-approach

[4] North Wind, Volume II, *Strategic Plan for the Relocation of SONGS [San Onofre Nuclear Generating Station] Spent Nuclear Fuel to an Offsite Storage Facility or a Repository*, March 15, 2021.

plant closed prematurely due to botched steam generator replacements. While the study by North Wind completed in 2021 said that some of the spent nuclear fuel could be moved as soon as 2030 — there was no place to move the spent nuclear fuel to. The study admitted that there appeared to be no movement forward to a repository at Yucca Mountain or any other site. Transportation of the spent nuclear fuel would require procurement of specialized rail cars and transport casks with long procurement lead times. Also, the study noted that there is no telling where in the queue that the San Onofre would be should a federal facility open.

The North Wind study found that regarding private (non-federal) consolidated interim storage that have been licensed by the NRC, should such facilities be built, there are issues of risk, liability, and indemnification that would have to be resolved, along with questions about who assumes the costs, procures the equipment, and who bears the responsibility for conducting SNF shipments. (See page 66 to 68 of Volume II of the North Wind study.)

Also, the study did not answer just how long some of the higher burnup fuel would have to cool before it could be transported. Some of the fuel may need to cool for 40 years or more before transportation but it could depend on proposed transportation cask design and evolving NRC licensing requirements.

The study for San Onofre's spent nuclear fuel, by Northwind, looked at potential options — short term options not permanent solutions — for places to move the spent nuclear fuel to. But ultimately, found no solution. The spent nuclear fuel will remain at San Onofre with no real action toward any permanent or temporary solution.

One problem was the liability of transportation was too much for the utility to take on. So, even if consolidated storage was available, say in New Mexico or Texas, unless the Department of Energy takes ownership of the spent nuclear fuel and moves the fuel, and constructs interim storage somewhere, the fuel stays at San Onofre.

The North Wind study specifically avoided the issue of radiological consequences, but, at least for some canisters, we may find out in may be as little as about 20 to 40 years of when the spent fuel was loaded into the canister because of chloride-induced stress corrosion cracking of the stainless steel from chloride that is known to spread in the atmosphere.

At San Onofre as well as at other sites with spent nuclear fuel in dry storage, there is no way to inspect the canisters for partial cracks, no way to repair a canister and no way to repackage a canister. There is no way to confine the radiological release from a breached canister. Any enclosure for a canister must provide adequate cooling of the fuel in the canister.

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https://www.songscommunity.com/strategic-plan-for-relocating-spent-fuel/spent-nuclear-fuel-solutions-a-fresh-approach

[5] North Wind, Volume III, *Conceptual Transportation Plan for the Relocation of SONGS [San Onofre Nuclear Generating Station] Spent Nuclear Fuel to an Offsite Storage Facility or Repository*, March 15, 2021. https://www.songscommunity.com/strategic-plan-for-relocating-spent-fuel/spent-nuclear-fuel-solutions-a-fresh-approach

All spent nuclear fuel canisters require cooling and this is provided by air circulation past the canister, even though it may not be obvious and it may appear that the canister is "underground." In reality, all spent nuclear fuel canisters are exposed to the atmosphere and the canister is the only barrier between the spent nuclear fuel and the environment.

There are other stranded fuel sites where spent nuclear fuel is in dry storage and the reactors and the spent fuel pool are gone. It may be impossible or problematic to try to use a pool for repackaging a canister, even if a spent fuel pool is available. So far, no Dry Transfer System has been designed.

Rather than try to site a repository, the Department of Energy is seeking consolidated storage as a temporary measure but the length of time that spent nuclear fuel would remain at the consolidated "interim" storage site is unknown. This may look like a solution to some people, but it shifts the problem to less densely populated areas where it is easier to connive and bribe the community leaders. The spent nuclear fuel canisters, moved to a new location, are still vulnerable to stress corrosion cracking. None of the proposed consolidated storage facilities have any capability for canister repair or repackaging or canister isolation. Consolidated "interim" storage of spent nuclear fuel is like a game of musical chairs to create the illusion of a solution.

The vulnerability of the dry storage of spent fuel depends on length of time in storage, the fuel burnup, the fuel temperature, and specific fuel and cladding designs, any off-normal conditions the fuel was exposed to, and other factors. Higher burnup fuels are more vulnerable due to increased time in the reactor and increased cladding stress due to more fission products.

Transporting the spent fuel to a consolidated interim storage site will mean that the fuel would later need to be transported again to go to a repository. There is no repository program in the U.S. This means that the high cost and serious safety problems with dry storage of spent nuclear fuel will become your children's or grandchildren's problem.

As the welded-closed thin-walled stainless steel canisters the fuel has been placed in experience corrosion or other degradation, it is only a matter of a few decades before the canisters breach — whether at the stranded fuel site, at an active reactor site or at a consolidated storage site.

The utilities are far more concerned about their own bottom line than about financial losses and human lives lost or shortened by the foolish and unsafe practices. The unsafe storage of spent nuclear fuel is licensed by the U.S. Nuclear Regulatory Commission. The NRC basically limits its concerns to the licensing period.

The dry storage systems used by the commercial nuclear power industry were licensed by the U.S. Nuclear Regulatory Commission, initially for twenty years. Canister aging mechanisms were ignored as the licensing was granted beginning in the late 1980s and only in 2012 did the

NRC formally acknowledge that the stainless-steel canisters were susceptible to stress corrosion cracking. [6] [7]

The U.S. Nuclear Regulatory Commission's 2014 Generic EIS for "Continued Storage" of spent nuclear fuel [8] assumed that if the spent nuclear fuel was not disposed of, then it would be repackaged about every 100 years. That generic EIS uses magical thinking to avoid stating that actual environmental and human health devastation of failing to confine the radioactive spent nuclear fuel.

The NRC's 2014 generic EIS for Continued Storage of spent nuclear fuel simply assumed that Dry Transfer Facilities would be used at every location spent nuclear fuel is stored, and would repackage the spent nuclear fuel as many times as needed, and about every 100 years. In 2024, no Dry Transfer Facility has been designed. No one has figured out who will pay for the Dry Transfer Stations.

The claim is often made that spent nuclear fuel is being safely stored. The North Wind study carefully avoided any issue pertaining to safety or radiological consequences. But, by DOE's own experts, the safety of long-term storage of spent nuclear fuel currently **lacks adequate technical basis**. And the problem is compounded by the higher burnup fuels being used by commercial nuclear utilities.

The Department of Energy acknowledged the gaps in the technical basis for continued storage of spent nuclear fuel, first in 2012. [9] Then in 2019, an additional gap was identified that was the lack of technical basis for understanding what the radiological consequences of a spent nuclear fuel canister breach would be. [10] **Each new fuel type from the use of HALEU will require additional research regarding the storage and disposal of the fuel. The Department of Energy acknowledges that it is already behind in researching the technical basis for fuel already in storage.** [11]

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[6] U.S. Nuclear Regulatory Commission, *Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters*, Information Notice 2012-20, 2012. https://www.nrc.gov/docs/ML1231/ML12319A440.pdf

[7] U. S. Nuclear Regulatory Commission, *Identification and Prioritization of the Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation of Spent Nuclear Fuel – Draft Report for Comment*, May 2012. ML120580143. This report contains tables ranking the level of knowledge and safety risk of spent nuclear fuel in storage and the dry storage systems. Stainless steel atmospheric stress corrosion cracking is acknowledged to have "low" level of knowledge and high research priority.

[8] Nuclear Regulatory Commission, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel*, U.S. Nuclear Regulatory Commission Office of Nuclear Material Safety and Safeguards, NUREG-2157, 2014.

[9] B. Hanson et al., *Gap Analysis to Support Extended Storage of Used Nuclear Fuel*, FCRD-USED-2011-000136, For the Department of Energy, January 2012.

[10] M. Teague et al., *Gap Analysis to Guide DOE R&D in Supporting Extended Storage and Transportation of Spent Nuclear Fuel: An FY2019 Assessment*, For the Department of Energy, SAND2019-15479R, 2019.

[11] Ned Larson, U.S. Department of Energy, Office of Nuclear Energy, "Back-end Management of Advanced Reactors (BEMAR)," U.S. Nuclear Waste Technical Review Board Public Meeting, Idaho Falls, Idaho, August 30, 2023.

Nuclear Waste Technical Review Board calls out the problem of stranded spent nuclear fuel lacking transportation licensing

The clock is ticking. Over three decades have already elapsed because commercial nuclear utilities began loading fuel into dry storage by 1986. Much of the fuel was loaded after about the year 2000. Most of the spent fuel is stored in welded-closed thin-walled canister; the rest is in bolted thick-walled casks. The general industry assumption is that dry storage of spent fuel will be acceptable for 100 years but the industry and the Department of Energy refuse to provide an estimate.

In its 2024 report, the NWTRB [12] again noted that "some loaded DPCs [dual-storage canisters] currently in storage are known to include contents [spent nuclear fuel] that do not meet the requirements of the associated Certificate of Compliance for transportation." The Board made a recommendation regarding "The implications (time, effort, and cost) of identifying and finding a resolution for commercial SNF canisters approved by the NRC for storage, but which include contents not currently approved by the NRC for transportation." The Board recommended that the Department of Energy give higher priority to the issue.

The spent nuclear fuel from traditional light-water reactors (pressurized water reactors and boiling water reactors) is transferred to a spent fuel pool after use in a reactor. The fuel cools and after adequate cooling, may be transferred to dry storage in either a cask or canister. Additional time to allow cooling of the fuel from the reduction of radioactive decay-generated heat may be needed before the fuel can be transported, depending on canister and the number of assemblies in the canister. The cooling time needed also depends on the initial fuel enrichment in uranium-235 and on the operating time in the reactor because longer operating time in the reactor produces more fission products.

Higher initial fuel enrichment and higher fuel burnup in the reactor create a thermally hotter fuel because of more fission products. The cooling time needed before the fuel can be placed in dry storage depends on the dry storage system. The cooling time needed prior to transportation depends on the transportation packaging.

When the spent nuclear fuel burnup is below about 35 Gigawatt-Days/Metric-ton (GWD/MTU), the fuel required about 5 years of cooling in the spent fuel pool before it could be placed in dry storage. But by the year 2000, most of the U.S. spent nuclear fuel at PWRs and BWRs exceeded 35 GWD-MTU. Fuel burnup above 45 GWD/MTU is considered "high" and fuel burnup has been climbing to levels above 55 GWD/MTU. At burnups of 55 GWD/MTU, the fuel may require 30 years of cooling in a pool before it can be placed in dry storage.

[12] U.S. Nuclear Waste Technical Review Board, *Evaluation of the U.S. Department of Energy Research and Development Activities on the Disposition of Commercial Spent Nuclear Fuel in Dual-Purpose Canisters*, February 2024. https://www.nwtrb.gov/our-work/reports/evaluation-of-the-u.s.-department-of-energy-research-and-development-activities-on-the-disposition-of-commercial-spent-nuclear-fuel-in-dual-purpose-canisters-(february-2024)

A 2013 presentation by Sandia National Laboratories provides charts of needed cooling times and the time before spent nuclear fuel can be transported. Less information was provided about the cooling times needed for higher fuel burnups. [13]

With higher fuel burnups, radioactively and thermally hotter fuels have been placed in dry storage and there may be decades of cooling in dry storage needed before the fuel, as packaged in canisters, could meet transportation requirements. The length of time needed before high burnup spent nuclear fuel may need to cool before allowed for transportation may decades, over 40 years. So, some communities with reactors that operated after about year 2000 who are hoping that consolidated interim storage means fuel will be leaving their community may be surprised to learn how long cooling may be required before the high burnup spent nuclear fuel could be transported.

For some casks or canisters, transportation licensing of the container was never obtained. There are over 70 sites with spent nuclear fuel. As an example, at 12 shutdown plant sites, 17 different canister designs were used, 8 different storage overpack designs and 8 different transport overpack designs. While higher enriched fuels that allowed higher fuel burnup were used, some of the spent fuel characteristics placed in the canisters may not meet existing transportation Certificate of Compliance requirements pertaining to 10 CFR 71 transportation requirements. [14] Not all dry storage systems were designed and licensed for transportation and so there are licensing challenges. If a cask or canister cannot be licensed for transportation, it would have to be repackaged. But the spent fuel pool may be gone and there is then a need for a Dry Transfer System but one hasn't been designed or built.

Existing requirements for transportation have not been met as the utilities loaded the spent fuel into the canisters, despite the canister having a transportation license. For example, higher initial uranium-235 enrichment, coupled with low operating time in the reactor means higher reactivity of the fuel. This means increased ability for a criticality and larger criticality power excursion event should water enter the canister. **One limited study found that half of the canisters had been loaded with spent fuel with a combination of conditions that increases criticality risk: high initial enrichment and low burnup in the reactor. The canisters were loaded with spent nuclear fuel that did not meet the required conditions for the Certificate of Compliance for the canister. [15] What were these utilities thinking?**

The 2019 NWTRB report found that "For an unknown but significant number of commercial SNF storage cask and canister types that are already approved for transportation, the CoCs for

[13] Christine Stockman and Elena Kalinina, Sandia National Laboratories, For the Department of Energy's National Nuclear Security Administration, *Cooling Times for Storage and Transportation of Spent Nuclear Fuel*, SAND2013-1698C, February 25, 2013.

[14] Jeffery Williams, Department of Energy, "Nuclear Fuels Storage and Transportation Planning Project," Nuclear Waste Technical Review Board Workshop, November 18-19, 2013.

[15] Nuclear Waste Technical Review Board, *Preparing for Nuclear Waste Transportation – Technical Issues that Need to be Addressed in Preparing for a Nationwide Effort to Transport Spent Nuclear Fuel and High-Level Radioactive Waste*, A Report to the U.S. Congress and the Secretary of Energy, September 2019. See Figure A-1.

transporting the casks and canisters must be amended and NRC-approved to broaden the scope of allowable contents (e.g., a wider range of fuel types, higher initial enrichments, and higher fuel assembly burnups.).

The implications, according to the NWTRB, are that unless the Certificate of Compliance for transportation can provide a technical case that supports the safe transportation of the SNF and gain NRC approval for its transportation, or be granted an exemption by NRC from some of the transportation requirements, the SNF would have to be removed from the welded canisters and repackaged into canisters or bare fuel casks that are approved by the NRC for transportation. [16] The safety of the transportation of spent nuclear fuel depends on spent fuel condition, but the condition of spent nuclear fuel in dry storage can't be inspected.

The NRC had granted licenses of the higher burnup fuel, without consideration of added storage, transportation or disposal implications. The electricity utilities had loaded combinations of high spent fuel into canisters such that transportation CoCs were not complied with. So, now the NWTRB recommends that DOE should give a higher priority to this problem. The U.S. Government Accountability Office reports DOE's rosy transportation and disposal cost estimates from the Department of Energy. There is massive dysfunction throughout the nuclear enterprise in the U.S., from the Department of Energy, the Nuclear Regulatory Commission, and it also includes the agencies Congress relies on for getting information from, including the Nuclear Waste Technical Review Board and the Government Accountability Office.

If the U.S. Congress actually had a clue as the already built-in costs of spent nuclear fuel management and disposal in this country, there is no way it would giving out more taxpayer money to make more and more liabilities.

In the Yucca Mountain repository design initially proposed in 2002, [17] it was assumed by DOE that a smaller amount of spent nuclear fuel would be loaded into a corrosion-resistant TAD canister. The utilities considered the TAD relatively expensive and opted for the cheapest dry storage systems licensed by the NRC.

The Department of Energy has been studying whether or not it could directly dispose of the existing spent nuclear fuel canisters without repackaging to a canister designed for disposal. The DOE insists that there are no show stoppers and that repository designs are

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[16] Nuclear Waste Technical Review Board, *Preparing for Nuclear Waste Transportation – Technical Issues that Need to be Addressed in Preparing for a Nationwide Effort to Transport Spent Nuclear Fuel and High-Level Radioactive Waste*, A Report to the U.S. Congress and the Secretary of Energy, September 2019. See Figure A-1.

[17] Department of Energy, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, Office of Civilian Radioactive Waste Management, DOE/EIS-0250, February 2002. https://www.energy.gov/nepa/articles/eis-0250-final-environmental-impact-statement

possible, in a variety of possible host rock types. [18] [19] Still, DOE has no proposed repository site(s) or designs.

The spent nuclear fuel being used in the 1990s and before that was not much of a criticality risk in canisters loaded years ago. But, with the increased use of higher and higher burnup fuels, there are many existing spent nuclear fuel dry storage canisters that would have a nuclear criticality if water entered the canister. Canister integrity needs to be maintained to prevent water from entering a canister.

Canister integrity is needed in order to prevent radiological releases of radioactive gases in the canister. In addition, canister integrity is needed in order to prevent oxygen ingress that would enable degradation of the fuel and cladding and processes. Oxygen ingress has been observed to cause fuel pellet swelling and damage. This may split apart the cladding, for example. Oxygen ingress may allow energetic or exothermic processes that worsen the radiological release from the canister. And canister integrity is also needed in order to prevent water entry into a canister, especially with the fuel loading in many of the canisters, which would allow criticality to occur if water ingress occurs. The pyrophoric nature, especially of degraded spent nuclear fuel, and its criticality risks, are among the issues that the Department of Energy admits it does not have an adequate technical basis for concluding anything but that it still hopes spent nuclear fuel storage is safe, at least, for a while longer.

Opposition to Department of Energy's Push for High-Assay Low-Enriched Uranium (HALEU)

The Department of Energy issued for public comment an Environmental Impact Statement (EIS) for acquiring high-assay low-enriched uranium (HALEU). [20] HALEU is uranium enriched up to as high as 20 percent in uranium-235, and is generally higher enrichment than the fuel used in current light-water reactors which is below 5 percent enriched. Higher enrichment allows longer operation without refueling, but with longer operation in a reactor, more fission products are generated. The higher enrichment complicates disposal and it also creates a nuclear weapons material proliferation problem which is the concern that the material may be stolen and used in a nuclear weapon.

People who have paid attention to past and ongoing harm from DOE's uranium fuel cycle, from uranium mining, milling, conversion, enrichment, reactor operation, spent nuclear fuel

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[18] E. Hardin et al., *Summary of Investigations on Technical Feasibility of Direct Disposal of Dual-Purpose Canisters*, Prepared for the U.S. Department of Energy, FCRD-UFD-2015-000129, Rev. 1; SAND2015-8712R, May 2015.

[19] E. Hardin, "Dual-Purpose Canister Direct Disposal Technical Feasibility Evaluation: Introduction and Summary," Presentation at the Used Fuel Disposition Annual Working Group Meeting, Law Vegas, Nevada, June 11, 2015.

[20] Department of Energy, *Draft Environmental Impact Statement for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)*, DOE/EIS-0559, March 2024. https://www.energy.gov/ne/haleu-environmental-impact-statement Public comment is open until April 22, 2024 and comments may be sent to HALEU-EIS@nuclear.energy.gov

storage and mismanagement, oppose DOE's proposal to make vast amounts of spent nuclear fuel and uranium fuel cycle radiological messes.

There are a wide variety of proposed advanced test reactors that could use HALEU feedstock. An Idaho National Laboratory presentation identifies TerraPower, X-energy, Oklo, Kairos Power, and Ultra Safe Nuclear. [21] The type of advanced reactor ranges from TerraPower's fast neutron, sodium-cooled Natrium reactor that uses uranium-zirconium fuel to X-Energy's high-temperature gas-cooled reactor that uses tri-structural isotropic TRISO fuel. Each new fuel type from the use of HALEU will require additional research regarding the storage and disposal of the fuel. The Department of Energy acknowledges that it is already behind in researching the technical basis for fuel already in storage. [22] The technical challenges and the costs increase with the wide array of new reactor fuels.

Public comment regarding the Department of Energy's *Draft Environmental Impact Statement for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)*, DOE/EIS-0559, issued March 2024, David B. McCoy, J.D., Executive Director of Citizen Action New Mexico writes:

> "The HALEU Is a completely flawed document that fails to consider the higher risk associated with increased uranium fuel content, buildup of more radionuclides in relation to interim pool storage safety, long term disposal safety, transportation exposures, disposal costs and greater long term risks to human health and the environment.
>
> The use of HALEU fuel has no demonstrable scientific basis for being a solution to the climate crisis for production costs and the time to implement the technology and deal with additional safety and disposal and proliferation/terrorism issues.
>
> The failed mirage of Yucca Mountain as a repository can only lead to the issue of reality that after 70 years, DOE still has no deep geologic repository and does not even have a viable candidate let alone identification of any safe, legal interim storage sites.
>
> Texas and New Mexico want no part of radioactive waste even from current rad toxicity and burnup rates. Citing EISs for Andrews TX and Holtec NM sites, the planned DOE disinformation of the HALEU EIS even ignores the Appellate Court decision rejecting interim storage licensing at those sites!
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> It is unknown how long pool storage and concrete dry storage can safely function for the higher rad heat containment or, if intended for existing reactor use, whether they are currently adequate in present form at existing reactor sites.

[21] Monica C. Regalbuto, *Idaho National Laboratory, Integrated Fuel Cycle Solutions HALEU Update*, Idaho Falls, Idaho, May 24, 2022.

[22] Ned Larson, U.S. Department of Energy, Office of Nuclear Energy, "Back-end Management of Advanced Reactors (BEMAR)," U.S. Nuclear Waste Technical Review Board Public Meeting, Idaho Falls, Idaho, August 30, 2023.

Repackaging facilities, even for current waste burnup levels, do not exist for later safe transportation and storage. Do utilities plan to insure transport of HALEU waste? What will the higher burnup rate mean for the corrosion levels and operations, if intended, at the aged nuclear reactors now licensed for additional 40 years by NRC? Three Mile Island deja vu?

It's time for DOE to Cut Through the Bullshit that nuclear power offers a clean viable power source compared to cheaper more cost-effective alternative technologies relating to climate change.

DOE should get off the nuclear band wagon and solve the problems at the back end of the fuel cycle."

Tami Thatcher's public comment submittal highlighting some of the many problems with DOE's HALEU push can be found on the Environmental Defense Institute website home page. [23]

Every phase of the uranium fuel cycle is polluting. DOE has not addressed the disproportionately high volume of containers needed for HALEU spent nuclear fuel and other disposal difficulties including the fact that the DOE does not have a spent nuclear fuel disposal program. The DOE is promoting consolidated storage of spent nuclear fuel as though it is a solution. The fact is, sites like San Onofre stranded fuel site can't ship the hotter spent nuclear fuel for several decades and won't ship this spent fuel because the electric utility refuses to take on the liability of transporting the spent nuclear fuel. And while the NRC unlawfully granted authorization for proposed consolidated storage in New Mexico and Texas, the DOE's HALEU EIS fails to mention that the licenses have been found unlawful in court and have been vacated. [24] The proposed consolidated storage facilities are not necessarily compatible with the advanced reactor fuels. The vast amount of additional spent nuclear fuel from DOE's advanced reactor and HALEU promotion is not being addressed in the DOE's HALEU EIS. The cost, the technical difficulty, the unsustainability, and the unacceptable risk to humans and the environment is not adequately addressed by the DOE's HALEU EIS.

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[23] Tami Thatcher, Public Comment Submittal on the Draft Environmental Impact Statement for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU), DOE/EIS-0559, April 22, 2024. www.environmental-defense-institute.org/publications/CommentDOEhaleu2024.pdf

[24] *NuclearNewswire*, Waste Management, "Court vacates Holtec's license for New Mexico spent fuel facility," April 3, 2024. https://www.ans.org/news/article-5915/court-vacates-holtecs-license-for-new-mexico-spent-fuel-facility/ The 5th Circuit Court of Appeals has vacated Holtec International's license for a consolidated storage facility in southeastern New Mexico. Also, last August 2023, the court vacated Interim Storage Partners' license for a similar facility in Andrews County, Texas. According to the court, the U.S. Nuclear Regulatory Commission did not have the authority to authorize a license for an away-from-reactor spent fuel storage facility.

Department of Energy renames and restarts the poisonous Portsmouth Gaseous Diffusion Plant to American Centrifuge Plant

The former uranium enrichment plant, the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio has been renamed the American Centrifuge Plant, LLC, a subsidiary of Centrus Energy Corporation. Too bad that name changes don't actually solve problems.

According to the Government Accountability Office, "Cleaning up 3 plants where uranium was enriched will cost billions of dollars and span decades. These sites – near Oak Ridge, Tennessee, Paducah, Kentucky; and Portsmouth, Ohio [actually near Piketon, Ohio] – are contaminated with radioactive and hazardous materials. [25]

The historical contamination, remaining contamination, the illnesses and cost of attempted cleanup is obscured in terse, colorful and sanitized factsheets by the Department of Energy (see https://www.energy.gov/environmental-cleanup) and see federal superfund sites on the ever-evolving U.S. Environmental Protection Agency website. Costs of previous failed privatization efforts are also not discussed.

The U.S. Government Accountability Office (GAO) states: "Natural uranium is comprised of approximately 99.3 percent of the uranium-238 isotope and 0.7 percent of the uranium-235 isotope – which undergoes fission to release energy. Uranium enrichment is the process of increasing the concentration of uranium-235 in a quantity of natural uranium to make LEU [low enriched uranium] to fuel nuclear power plants or to make HEU [high enriched uranium] which is used in nuclear weapons and as fuel by the U.S. Navy." [26]

In addition to U-235 and U-238, natural uranium ore includes uranium-234. The uranium-234 often isn't mentioned in the composition of natural uranium because of its low weight percent, but the U-234 in natural uranium provides significant radioactivity. The activity of the uranium-234 is nearly equal to the activity of the uranium-238.

The concentration of uranium-234 as well as the concentration of uranium-235 is elevated in enriched uranium fuel. And, recycled (or reprocessed) spent nuclear fuel concentrates the uranium-234 to even higher amounts.

Because new nuclear reactor fuel typically includes natural uranium-238 and naturally-occurring but higher concentrations of fissile uranium-235, you might wonder how the spent fuel

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[25] U.S. Government Accountability Office, *NUCLEAR CLEANUP Actions Needed to Improve Cleanup Efforts at DOE's Three Former Gaseous Diffusion Plants*, GAO-20-63, December 2019. https://www.gao.gov/products/gao-20-6

[26] U. S. Government Accountability Office, *Nuclear Weapons – NNSA Should Clarify Long-Term Uranium Enrichment Mission Needs and Improve Technology Cost Estimates*, GAO-18-120, February 2018. https://www.gao.gov/assets/gao-18-126.pdf This report notes that the location where aluminum-clad Advanced Test Reactor fuel was to be reprocessed at the Savannah River Site's, H-Canyon would have high costs and is not currently accepting materials for processing. The Department of Energy's H-Canyon (fuel processing plant) is over 50 years old and may have safety issues should an earthquake occur, according to the GAO report.

contains uranium-236, uranium-232 and uranium-233. The U-236, U-232 and U-233 can be made in the reactor or be contaminants from reprocessing.

Uranium-238 decays through a long series of radioactive isotopes. Radon and radium are just some of the decay progenies of uranium-238 before finally becoming a stable isotope of lead.

But many other radionuclides were released from the Portsmouth plant, including americium-241 that decays to neptunium-241. These radionuclides don't occur in natural uranium but are introduced from uranium resulting from reprocessing.

See Table 1 for radionuclide contaminants sent to Portsmouth from the Idaho National Laboratory. Other radiological contamination like americium-241 was also likely to have been sent to the Portsmouth enrichment plant, but plant managers and workers were not even told and the monitoring was deliberately inadequate.

Table 1. Radionuclide contaminants in INL reprocessed fuel shipped to Y-12 and Portsmouth.

Radionuclide	**Range, Weight**	**Comments**
Plutonium	0.001 ppb to 300 ppb	Pu-239 maximum 35.3 ppb, Pu-238 maximum 0.12 ppb The americium-241 is present in the dissolver product but is not discussed in the source report as being in the final reprocessed fuel product.
Neptunium-237	1.2 to 4 ppm	
Technetium-99	0.018 to 1.8 ppb	Technetium is very long-lived and very mobile in the environment.
Uranium-236	8.42 to 15.81 percent, Aluminum and Zirconium fuels	Uranium-236 results in significant radiation exposures due to decay product uranium-232 and its decay progeny, particularly thallium-208 with its 2.6 MeV (mega electron volt) gamma emission. Other manmade uranium isotopes are present in the dissolver product but are not discussed in the source report as being in the final reprocessed fuel product.

Table Source: L.C. Lewis et al., Prepared for U.S. Department of Energy, Environmental Management, DOE Idaho Operations Office, *Idaho National Engineering and Environmental Laboratory Site Report on the Production and Use of Recycled Uranium*, INEEL/EXT-2000-00959, September 2000. https://www.osti.gov/servlets/purl/768760

Note that the radionuclide technetium-99 is a weak beta and is difficult to monitor and so it often isn't monitored.

A major hazard in uranium enrichment processes comes from the chemically toxic and radioactive uranium hexafluoride.

I note that the Portsmouth uranium enrichment plant continued to use hexavalent chromium until the early 1990s as a corrosion inhibitor. [27] The use of hexavalent chromium at the Department of Energy site in Idaho was stopped by 1982, after extensive groundwater contamination. Hexavalent chromium damages DNA and children would be vulnerable and even more vulnerable if the parent had been exposed.

The Portsmouth Gaseous Diffusion Plant in Pike County, Ohio had a cancer incidence in 2010-2019 that was 15 percent higher than the U.S, the highest rate of all 88 Ohio counties. In the 1950s and 1960s, Pike county's cancer mortality was 12 percent below the U.S., with the gap closing by 1993. In 2009-2020, the cancer death rate in Pike County exceeded the U.S. by about 50 percent for all age groups, except for persons over age 75. For 2017 to 2020, for persons age 0 to 74, the all-cause mortality in the county was 85 percent, nearly twice that of the U.S. [28] Chemical and radiological exposures may need to be considered in light of increasing cancer and infant mortality rates in Pike County. [29] Throughout the uranium fuel cycle, the deaths stack up but the reason often is not acknowledged.

Carefully worded government documents deny that Portsmouth is the cause of cancer, all without a complete picture of the past contamination or the actual dose to humans, as if by design. [30] The U.S. Department of Health and Human Services writes as if inadequate monitoring means that there were no radiological releases from Portsmouth, during its operation or during cleanup, even though that is untrue. And the agency ignores the particle size, solubility and chemical form of contamination which would affect its harm in the human body. In fact, the radionuclide dose coefficients selected for the dose evaluation would likely grossly underestimate the actual harm for a variety of reasons and is unreliable. The denial of nuclear facilities being the cause of contamination and of health harm is something that the Government agencies do excel at. Portsmouth plant also released chemicals, including hexavalent chromium until the early 1990s, discussed previously.

No wonder the name of the Portsmouth Gaseous Diffusion Plant in Pike County, Ohio has been changed to the American Centrifuge Plant, LLC, a subsidiary of Centrus Energy Corporation. The shoddy operating and dumping practices of the Portsmouth plant has left

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[27] Fluor-BWXT Portsmouth, LLC, *U.S. Department of Energy Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report - 2020, Piketon, Ohio*, DOE/PPPO/03-1034&D1, September 2021.

[28] Joseph J. Mangano, Radiation and Public Health Project, *Health Risk to Local Residents for the Portsmouth Gaseous Diffusion Plant*, August 15, 2022.

[29] Joseph J. Mangano, Radiation and Public Health Project, *Mortality/Morbidity Study, 7 Counties Downwind of the Portsmouth Nuclear Site*, May 12, 2023. https://docs.google.com/viewer?url=https://local12.com/resources/pdf/fb76de1b-2b63-4f6f-a44a-89e64b25ae4e-Portsmouth2ndreportfinal002002.pdf&embedded=true

[30] U.S. Department of Health and Human Services, *Health Consultation – Evaluation of Environmental Radiological Sampling Data Collected from 2016 to 2022 Near the Portsmouth Site, U.S. Department of Energy Portsmouth Site (Formally known as Portsmouth Gaseous Diffusion Plant)*, March 29, 2024.

contaminated groundwater plumes and excessive cancers to workers and the public, yet it was all conducted in accordance with government requirements and the promise of adequate monitoring.

The Department of Energy, when faced with tremendous illnesses, deaths, project cancellations, and project failures, often resorts to name changing. Let's change the name of the Idaho National Engineering Laboratory to the Idaho National Engineering and Environmental Laboratory as the laboratory struggled to deal with its extensive radiological contamination. As the lab got comfortable again and brazenly continued to bury radioactive waste over the Snake River Plain aquifer and ramped up its airborne radiological releases, DOE changed the name to the Idaho National Laboratory. [31]

Legislation to advance unaffordable, unreliable nuclear energy as biased and incomplete testimony offered to Legislators (S.1111 and HR.6544)

Two bills, Senate bill S.1111 and House bill HR.6544, are being considered. [32] [33] Testimony was given by Idaho National Laboratory Director John Wagner and others.

Wagner portrayed the DOE's nuclear waste disposal problems as political even though he undoubtably knows this is not a balanced depiction. He knows his boss is the Department of Energy and he is not going to say anything unfavorable about DOE.

In the U.S., reprocessing of commercial spent nuclear fuel was conducted at West Valley, New York. One of the products of reprocessing is the liability of storing the extracted plutonium, lots and lots of plutonium. The plutonium creates weapons material proliferation risks. Because there are problems with spent nuclear fuel reprocessing, such as how environmentally polluting it is and how expensive it is, testimony offered by Idaho National Laboratory Director John Wagner called it "recycling." [34]

Testimony was also given about San Onofre's stranded spent nuclear fuel 100 ft from the Pacific Ocean. The testimony does point to how communities with stranded spent nuclear feel about it – but the testimony did not explain the radiological hazard looming over these communities.

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[31] Special Report, Environmental Defense Institute, *Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho*, December 2021 by Tami Thatcher at http://www.environmental-defense-institute.org/publications/INLcontamination.pdf

[32] S.1111 – ADVANCE Act of 2023, 118th Congress (2023-2024), Congress.gov. "This bill sets forth provisions to develop and deploy advanced nuclear fuel for the United States and certain allied countries, restrict the possession or ownership of enriched uranium from Russia or China, clean up hazardous land, and establish related requirements."

[33] H.R.6544 – Atomic Energy Advancement Act, 11ith Congress (2023-2024), Congress.gov. "This bill establishes various requirements to accelerate the deployment of nuclear energy technologies, such as advanced nuclear reactors."

[34] John C Wagner, *House Energy and Commerce Committee, American Nuclear Energy Expansion: Spent Fuel Policy and Innovation Hearing Testimony Summary*, April 10, 2024. https://www.congress.gov/event/118th-congress/house-event/117113

Waste that is poised to devastate the surrounding area of San Onofre from an airborne radiological release is insanely stored 100 ft from the coastline. Moving the spent nuclear fuel away from the coastline could delay the inevitable canister breaches and airborne radiological contamination. Naturally, there is the desire to move the spent nuclear fuel to another state and therefore shift the problem to another community.

Nor is a realistic time frame given for how long it will be before spent nuclear fuel could be moved. It did not explain how the electric utility is not willing to ship the spent nuclear fuel because of the financial liability involved. [35] [36]

No one is discussing the sale of sale of stranded fuel sites to low-asset businesses willing to take on the challenge – until the money runs out. Then communities will be stuck with spent nuclear fuel, with no deep-pocketed electric utility owning the spent nuclear fuel. [37] Cost estimates for stranded fuel sites continue to be low-balled by making failed and overly optimistic assumptions that DOE would take the spent nuclear fuel.

Also, the conflict that was created by the Nuclear Regulatory Commission's licensing of welded-closed thin-walled canisters for dry storage of spent nuclear fuel has created the continuing problem that under the Standard Contract, the Department of Energy believes it does not have an obligation to accept canistered spent nuclear fuel from commercial nuclear power plant licensees. [38]

Consolidated interim storage of spent nuclear fuel is being promoted, yet the problems facing the proposed consolidated storage in New Mexico and Texas were not described.

The taxpayer is going to be on the hook for the mess that the U.S. Nuclear Regulatory Commission and the Department have already made. Congress is seeking to trust NRC and DOE and is now seeking to made the spent nuclear fuel problem exponentially worse with new nuclear reactors.

Nuclear energy is too slow deploy and too expensive to combat climate change. In addition, to operate enough nuclear reactors to make any difference with climate change, the country will be buried in spent nuclear fuel.

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[35] Daniel Stetson, San Onofre Nuclear Generating Station Community Engagement Panel, American Nuclear Energy Expansion: Spent Fuel Policy and Innovation Hearing, April 10, 2024.

[36] Northwind, Volume II, *Strategic Plan for the Relocation of SONGS Spent Nuclear Fuel to an Offsite Storage Facility or a Repository*, March 15, 2021. https://www.songscommunity.com/strategic-plan-for-relocating-spent-fuel/spent-nuclear-fuel-solutions-a-fresh-approach

[37] LimnoTech, Prepared for The International Joint Commission's Great Lakes Water Quality Board, *Nuclear Power Decommissioning Practices: Case Studies and Recommendations for the Great Lakes Basin*, September 19, 2019. See page 5-4, "A sale of the site [Big Rock Point plant in Michigan] to Holtec International was announced in 2018."

[38] Philip L. Couture, Entergy Nuclear Operations, Inc., letter to the U.S. Nuclear Regulatory Commission, Subject: ISFSI Decommissioning Funding Plans (10 CFR 72.30), December 17, 2018. https://www.nrc.gov/docs/ML1835/ML18351A478.pdf

Ironic that fetal health harm from nuclear energy is ignored by U.S. Legislators

The U.S. NRC cancelled what would have been the first meaningful epidemiology study of health effects near US nuclear reactors, [39] despite the German epidemiology study of children living near nuclear plants have roughly double the incidence of cancer and leukemia and similar findings resulted from the study of clusters of childhood leukemia near nuclear sites including Sellafield, Dounreay and La Hague where an excess of 300-fold infant leukemia were found. [40] [41] [42]

Airborne radiological releases from nuclear power plants affect downwind residents but contaminated foods are distributed unevenly. Radioactive contamination that lands on pastures grazed by dairy cattle results in radioactively contaminated milk. Radioactive contamination also affects garden produce. Thus, the inhalation and ingestion of radionuclides varies according to location as well as diet. The harm depends on gender and the age of exposure and it is known that women are more vulnerable than men, and children are more vulnerable than adults. Radiological sampling of milk that was conducted in the U.S. allowed levels of radioactivity that we now know were harmful. Diminishing radioactivity levels in the diet were accompanied by immediate and significant morbidity and mortality reductions among infants and young children, from 1965 to 1970.

Joseph J. Mangano and others published a study, "Infant Death and Childhood Cancer Reductions after Nuclear Plant Closings in the United States. The study found that following nuclear power plant closures, decreases in the radioactivity of milk has been noted and reductions in deaths among infants who had lived downwind and within 64 km of each nuclear plant were noted. Cancer incidence in children younger than 5 years of age were also noted to fall significantly after the shutdowns. [43]

[39] NRC (Nuclear Regulatory Commission) 2010. NRC Asks National Academy of Sciences to Study Cancer Risk in Populations Living near Nuclear Power Facilities. NRC News No. 10-060, 7 April 2010. Washington, DC: NRC. The framework for the study was reported in "Analysis of Cancer Risks in Populations Near Nuclear Facilities; Phase I (2012). See cancer risk study at nap.edu.

[40] P Kaatsch et al., Int J Cancer, "Leukaemia in young children living in the vicinity of German nuclear power plants," 2008 Feb 15;122(4):721-6. http://www.ncbi.nlm.nih.gov/pubmed/18067131

[41] Spix C, Schmiedel S., Kaatsch P, Schulze-Rath R, Blettner M., Eur J Cancer, "Case-control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980-2003." 2008 Jan;44(2):275-84.Epub 2007 Dec 21. http://www.ncbi.nlm.nih.gov/pubmed/18082395

[42] Chris Busby, "Infant Leukaemia in Europe after Chernobyl and its Significance for Radioprotection; a Meta-Analysis of Three Countries Including New Data from the UK," Chapter 8 of *ECRR Chernobyl: 20 Years On – Health Effects of the Chernobyl Accident*, Editors C.C. Busby and A. V. Yablokov, 2006.

[43] Joseph J. Mangano, Jay M. Gould, Ernest J. Sternglass, Janette D. Sherman, Jerry Brown and William McDonnell, Radiation and Public Health Project, "Infant Death and Childhood Cancer Reductions after Nuclear Plant Closings in the United States," *Archives of Environmental Health*, Vol. 57 (No.1), January/February 2002.

Jay M. Gould and Benjamin A. Goldman would write in their book *Deadly Deceit – Low Level Radiation High Level Cover-Up* of excess infant deaths near the Department of Energy's Savannah River Site and near the 1979 Three Mile Island nuclear accident. [44]

Elevated rates of infant mortality and birth defects were found in communities near the Department of Energy's Hanford site, but workers were not told of these epidemiology results and newspapers did not report the findings. [45]

Following the 1986 Chernobyl nuclear disaster, a comprehensive study also found a spike in perinatal mortality (still-births plus early neonatal deaths) in several countries that received airborne radioactivity from Chernobyl. The amount of airborne radioactivity to cause this was far smaller than generally assumed. [46]

Robin Whyte wrote in the *British Medical Journal* in 1992 about the effect in neonatal (1 month) mortality and stillbirths in the United States and also in the United Kingdom. The rise in strontium-90 from nuclear weapons testing from 1950 to 1964 has been closely correlated, geographically, with excess fetal and infant deaths. The doses from strontium-90 due to atmospheric nuclear weapons testing were less than 50 millirem (or 0.5 millisievert), according the Chris Busby. Radioactive fallout from atmospheric nuclear weapons testing would not only include strontium-90, it would include iodine-131, tritium, cesium-137, and other radionuclides, including plutonium. [47]

Articles by Tami Thatcher for April 2024. Re-posted May 1, 2024 for minor editorial corrections.

Thatcher has a Bachelor of Science degree in Mechanical Engineering and worked as an Advisory Engineer for a Department of Energy contractor, specializing in nuclear facility probabilistic risk assessment and safety analysis. For over a decade, she has studies and written about nuclear energy accidents and risks, Department of Energy nuclear facility accidents and risks, environmental contamination around the Idaho National Laboratory, radiation protection issues for workers and the public, INL legacy cleanup issues, and spent nuclear fuel and high-level waste storage and disposal issues.

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[44] Jay M. Gould and Benjamin A. Goldman, *Deadly Deceit – Low Level Radiation High Level Cover-Up,* Four Walls Eight Windows New York, 1990. ISBN 0-941423-35-2. The finding of excess infant deaths near the Department of Energy Savannah River site around the 1970s and near the 1979 Three Mile Island nuclear accident are described in Jay Gould's book *Deadly Deceit*.

[45] Kate Brown, *Plutopia – Nuclear Families, Atomic cities, and the Great Soviet and American Plutonium Disasters,* Oxford University Press, 2013. ISBN 978-0-19-985576-6. Note that many publications use spelling variation Mayak instead of Maiak. *Plutopia* documents the elevated percentage of deaths among infants in the Richland population in the 1950s. Elevated fetal deaths and birth defects in Richland were documented by the state health reports, yet Hanford's General Electric doctors and the Atomic Energy Commission that later became the Department of Energy failed to point these statistics out. The local newspapers failed to write of it. The Department of Energy has continued to fail to tell radiation workers and the public of the known risk of increased infant mortality and increased risk of birth defects that result from radiation exposure.

[46] Alfred Korblein, "Studies of Pregnancy Outcome Following the Chernobyl Accident," from *ECRR Chernobyl: 20 Years On – Health Effects of the Chernobyl Accident*, Editors C.C. Busby and A. V. Yablokov, 2006.

[47] R. K. Whyte, *British Medical Journal*, "First day neonatal mortality since 1935: re-examination of the Cross hypothesis," Volume 304, February 8, 1992. https://www.bmj.com/content/bmj/304/6823/343.full.pdf