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Ten Years of the Idaho Cleanup Project Trying to Get the Integrated Waste Treatment Unit to Operate

The Department of Energy's Integrated Waste Treatment Unit (IWTU) was supposed to have finished treating liquid radioactive high-level waste (HLW) at the Idaho National Laboratory in 2012. Despite ten years of optimistic projections, the IWTU facility continues to be repaired and redesigned following non-radioactive test runs with "simulant."

The roughly 900,000 gallons of radioactive liquid "sodium-bearing waste" is stored in four decades-old tanks. Once treated, the liquid waste will be converted into a dry powdery material and placed in canisters. The treated solid material is highly soluble, similar to calcine waste, the high-level radioactive waste also from spent nuclear fuel reprocessing. The treated sodium-bearing waste, like the calcine, will be stored in Idaho indefinitely as the Department of Energy has no place to dispose of the treated sodium-bearing radioactive waste or the calcine.

The Department of Energy outlined some of the problems at the IWTU during the February 24 meeting of the Idaho Cleanup Project's Citizens Advisory Board. [1]

The Department of Energy states in its presentation that "Numerous challenges have impacted completion of confirmatory run." These challenges include:

- Vibratory feeder performance
- Mercury adsorber bed commissioning
- Transients and rapid system shutdowns
- Process off-gas blower seals
- Excessive total feed flow to the [Denitration Mineralization Reformer] DMR
- Liquid nitrogen delivery shortages.

The IWTU Power-point presentation was brief and essentially the same presentation given for the last several years with the exception of the list of recent challenges.

While I had planned on the February 24 meeting for weeks, I missed the required early sign-up deadline. The Department of Energy's website buried the agenda under the artwork and unless you opened the agenda, the signup deadline was not apparent.

[1] Idaho Cleanup Project Citizens Advisory Board, https://www.energy.gov/em/icpcab/idaho-cleanup-project-citizens-advisory-board-icp-cab February 24, 2022 meeting agenda and presentations.

Signup to attend the meeting had to occur on February 22, and the DOE's notice of the meeting was not sent to me until late February 23. Fortunately, the presentations are available on the ICP CAB website.

Idaho Environmental Coalition (IEC) President Ty Blackford gave a presentation to the ICP CAB. IEC assumed the Idaho Cleanup Project on January 1, 2022 following a 3-month transition from exiting Fluor Idaho.

California and Nevada not Embracing Nuclear Energy

Two states with extensive nuclear industry experience are not embracing nuclear energy. [2] While Nevada has no commercial nuclear power plants, the State of Nevada has extensive experience with the Department of Energy's nuclear weapons testing at the Nevada Test Site and the DOE's efforts to dispose of the nation's nuclear waste in Nevada.

And its not just the high cost of constructing nuclear power plants, it is the problem of the high cost of storing the spent fuel used in a reactor. And it is the problem that there is still no solution for disposal of the radioactive spent nuclear fuel that will prevent the migration of radioactive material over the millennia that the waste is radiotoxic.

California's problems with commercial nuclear power plants won't end when the plants in the state are shutdown. The spent nuclear fuel from operating the nuclear power plants in California has no place to go. The Department of Energy is responsible for taking ownership of the radioactive spent nuclear fuel that remains hazardous and a risk to the environment for millennia. But the Department of Energy has no disposal facility and has no program for a disposal facility. The DOE cannot even collect fees for paying for a fraction of the cost of disposing of spent nuclear fuel, because a court found that DOE had no spent fuel disposal program.

The DOE would like to give the impression that parking lot dumps, like the spent fuel storage facilities proposed for New Mexico and Andrews, Texas are a solution. But those facilities are not designed for the long-term. And when their U.S. Nuclear Regulatory Commission license expires and there is still no disposal facility, these states will be stuck with radioactive waste that cannot be repackaged and has no place to go.

The thin-walled metal canisters that the spent nuclear fuel is being stored in are stainless steel and are known to be susceptible to chloride-induced stress corrosion cracking within a couple decades. There is no way to repair a cracked canister and no way to repackage the fuel into a new canister. The U.S. NRC allowed unsafe canisters to be used for packaging spent nuclear fuel. Only now is the NRC beginning to admit that although the capability of repackaging the spent

[2] Jennifer McDermott, AP, *The Idaho Falls Post Register*, "Majority of US states pursuing nuclear power for emission cuts," January 19, 2022. "The split over nuclear power in U.S. states mirrors a similar debate unfolding in Europe…"

nuclear fuel was a requirement, that they actually don't have a way to repackage the fuel if defects in the canister are found or if fuel loading errors were made. **Leave the problems to future generations — that is the U.S. Nuclear Regulatory Commission's and the Department of Energy's approach.**

The Department of Energy has continued to characterize the nation's spent nuclear fuel inventory as able to fit on a single football field. Yet, whether characterized as 15 ft deep for 69,000 metric tons or 30 ft for 83,000 metric tons, the characterization is very misleading.

Although the proposed Yucca Mountain repository license submittal was for 70,000 metric tons of storage, as limited by the Nuclear Waste Policy Act, it has been projected that for past and expected nuclear reactor operation in the U.S., by 2055 there will be roughly 10,000 canisters (or 140,000 metric tons heavy metal) of spent nuclear fuel needing disposal, and a significant portion of them would be capable of going critical if water ingress occurs. [3]

The fact is that the Department of Energy was needing 41 miles of waste emplacement tunnels (or drifts) at the proposed Yucca Mountain repository as limited by law to 70,000 metric tons of spent nuclear fuel. And this assumed repackaging and positioning the waste to limit the thermal heat load. [4] Even so, the repository could heat up and invalidate the geological stability of the repository.

The space needed for a repository is also affected by the need to limit the potential for multiple criticalities, should one package go critical. The DOE has found that criticalities are to be expected. The ability of the spent fuel to go critical depends on the enrichment in fissile material, the buildup of fissile material during reactor operation, the presence of fission products (reduces the ability to go critical but changes over time), and whether the neutron absorbers in the container remain intact. Some of the higher enriched fuel now used by the commercial nuclear industry, even with neutron absorbers intact, will go critical if the canister is partially or fully flooded with unborated water.

The Department of Energy, without actually credible analysis, used to argue that the probability of criticality occurring in a repository was low. But that is no longer true because the commercial utilities began using higher enrichments in the fuel for their nuclear plant. This fuel is often referred to as "high burn-up fuel" because the fuel can be operated longer in a nuclear reactor.

[3] Alsaed Abdelhalim, Enviro Nuclear Services, LLC, Spent Fuel and Waste Disposition, *Review of Criticality Evaluations for Direct Disposal of DPCs and Recommendations*, SFWD-SFWST-2018-000***, SAND2018-4415R, April 20, 2018. https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2018/184415r.pdf

[4] U.S. Department of Energy, *Draft Supplemental 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*, DOE/EIS-0250F-S1D, October 2007. https://www.energy.gov/sites/prod/files/EIS-0250-S1-DEIS-Summary-2007_0.pdf

The Department of Energy has had to admit that criticality could occur after containers corroded and there was no assurance that neutron absorbers would be intact or that geometries separating fissile material would be maintained.

The Department of Energy's originally envisioned inventory for Yucca Mountain had included 2 percent enriched commercial spent nuclear fuel and the residual vitrified high-level waste from reprocessing at West Valley. [5] It was expanded substantially when the Navy ceased reprocessing the high enriched naval and DOE research fuels by 1992 and it meant that now these fuels would require disposal. And it was another substantial change when the DOE identified the surplus weapons plutonium, potentially for disposal at Yucca Mountain.

The disposal of surplus plutonium from weapons production included for disposal at the proposed Yucca Mountain Repository created additional criticality concerns.

Two scientists from Los Alamos National Laboratory would explain how the plutonium-239 posed a particularly high criticality risk at Yucca Mountain. [6] [7] The Department of Energy has continued to argue that while criticality is possible at Yucca Mountain, it is sufficiently unlikely and of unimportant consequence if it does occur. [8] But the risk of criticality posed by the disposal of surplus weapons plutonium (and spent nuclear fuel) at Yucca Mountain is substantial and not to be casually dismissed, no matter how emphatically the DOE tries to arm-wave the risk away. **And in addition, the criticality risks remain after 10,000 years, yet there is no regulatory requirement to assess or limit the criticality risk after 10,000 years, either at Yucca Mountain or WIPP.**

The regulations for the proposed Yucca Mountain repository provide some inappropriate leeway regarding criticality and groundwater protection after 10,000 years giving the Department of Energy room to wiggle regarding criticalities (and their fallout) that occur after 10,000 years even though the criticality risks don't peak until after 25,000 years. Groundwater protection after 10,000 years is limited to only those events deemed more likely than an annual probability of 1.0E-4/yr. But there are thousands of years to be exposed to a potential criticality event.

Over time, the criticality risk doesn't go away. For pressurized water reactor (PWR) fuel arranged as it would be in a canister known as a 32-PWR, having initial 4 percent enrichment (and operated in a reactor to 40 GW-d/MT burnup), k-effective versus time was determined. The higher the k-effective value, the higher the reactivity. A k-effective value at or above 1.0 (or above about 0.98 for margin) when flooded with water can go critical.

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[5] Spent nuclear fuel and high-level waste (HLW) resulting from spent nuclear fuel reprocessing are specific types of radioactive waste; however, some documents use the term ***high-level waste*** to mean both the spent nuclear fuel and the waste from spent nuclear fuel reprocessing.

[6] C. D. Bowman and F. Venneri, Los Alamos National Laboratory, *Underground Autocatalytic Criticality from Plutonium and Other Fissile Material*, LA-UR 94-4022, 1994.

[7] C. D. Bowman, Los Alamos National Laboratory, *Underground Supercriticality from Plutonium and Other Fissile Material*, LA-UR-94-4022A, 1994.

[8] Rob P. Rechard et al., Sandia National Laboratory, *Consideration of Criticality when Directly Disposing Highly Enriched Spent Nuclear Fuel in Unsaturated Tuff: Bounding Estimates*, May 1996.

While the criticality risk of the fuel is high in the first 100 hours after shutdown and remains at its highest during the first year, the reactivity, or k-effective, declines during the first 100 years. **However, after about 100 years, the k-effective climbs steadily (and the criticality risk), peaking at about 25,000 years after its use in a reactor before starting to decline again.** [9]

The heat load of the spent nuclear fuel placed in the repository poses a risk to the structure of the repository and the DOE never actually decided whether to use a "hot" repository or a "cool" repository design. The amount of waste and how it is spaced in the repository obviously affect the ability to cool thermally hot spent nuclear fuel.

In reality, which is not where DOE spin-doctors live, there needs to be space to allow thermal heat removal to limit the heat buildup and limit the temperatures in the repository. Next, there is the need to design a container to keep a single container from going critical and this can limit the fuel assemblies that can go in a container. Then the fuel must be spaced to prevent multiple containers from going critical if one goes critical, which is not a remote possibility. And finally, there is the requirement to limit the trickle-out to groundwater. This involved spreading out the spent nuclear fuel so that the trickle-out of radionuclides would be diluted as water infiltrates the repository and radionuclides leach out from corroded containers so that the contamination from the repository remains below the drinking water standards imposed on the repository.

As you can see, imagining the volume of spent nuclear fuel clustered together, stacked in a football field, is nothing like the reality of the difficulty actually faced in hoping to contain the leach out of radionuclides over time as containers corrode and water infiltrates the waste.

The Department of Energy, makes another misleading statement, that spent fuel is a solid. [10] Keep it dry and in an inert gas rather than expose it to air, and usually the spent fuel is a solid. Still, radioactive gases that have built up in the fuel are gases and heat up the fuel, those gases can be released. Depending on the condition of the cladding, hydrides that have built up when the fuel was stored in water, the uranium or zirconium hydrides can offgas hydrogen if the fuel is exposed to air. Hydrogen offgassing can make cutting into spent nuclear fuel canisters a tricky business — which no one has tackled yet.

[9] Energy Workshops, *2018 SFWST Annual Working Group Meeting, Las Vegas, Nevada May 22 to May 24*, 2018. https://energyworkshops.sandia.gov/nuclear/2018-sfwst-rd-team-meeting/ See presentation #05 on direct disposal of spent nuclear fuel, page 4 the figure of K-effective versus time, and see page 10 for regulations that dismiss fallout effects on groundwater for criticality events after 10,000 years if less than 1.0E-4 annual probability at https://energyworkshops.sandia.gov/wp-content/uploads/2018/05/05-Direct-Disposal-of-Spent-Nuclear-Fuel-in-Dual-Purpose-Canisters-RD-Path-Forward-SAND2018-5437-PE.pdf

[10] Department of Energy, Office of Nuclear Energy, *5 Fast Facts about Spent Nuclear Fuel*, March 30, 2020. https://www.energy.gov/ne/articles/5-fast-facts-about-spent-nuclear-fuel "In fact, the U.S. has produced roughly 83,000 metrics tons of used fuel since the 1950s—and all of it could fit on a single football field at a depth of less than 10 yards."

Oxidation can occur if the spent nuclear fuel is exposed to air. Normally, spent nuclear fuel canisters are sealed after put helium, an inert gas, into the canister. Much about spent fuel degradation with exposure to oxygen and the pyrophoric behavior of uranium and zirconium has been learned by the Department of Energy, the hard way. [11] [12]

For some idea of how uranium behaves, consider that uranium in a 30-gallon inner drum inside a barrel, disposed of at the Idaho National Laboratory from the Rocky Flats weapons plant, upon excavation, ignited and material was forceable expelled, hitting the cab of the excavator. Oxygen introduced to the inner drum caused **rapid oxidation that released hydrogen from uranium hydride** and resulted in a fire and some self-propelled movement of material. [13]

We haven't really touched on the state of affairs with regard to proving that a repository can actually safely contain the waste over millennia. The Department of Energy sees that problem as simply one of "public perception."

The Department of Energy needs two spent nuclear fuel repositories and doesn't even have one. Although the proposed Yucca Mountain repository license submittal was for 70,000 metric tons of storage, as limited by the Nuclear Waste Policy Act, it has been projected that for past and expected nuclear reactor operation in the U.S., by 2055 there will be roughly 10,000 canisters (or 140,000 metric tons heavy metal) of spent nuclear fuel needing disposal, and a significant portion of them would be capable of going critical if water ingress occurs. [14]

The Nuclear Waste Policy Act remains the law; it limits the quantity of spent nuclear fuel from commercial nuclear power plants to 63,000 metric tons heavy metal (MTHM), 2,333 MTHM for DOE SNF and 4,667 MTHM for HLW. The quantity of commercial SNF, DOE SNF, and DOE-managed HWL are each greater than DOE's allotment for the first repository. [15] But DOE hasn't obtained its first repository, which by law, would be at Yucca Mountain.

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[11] Primer on Spontaneous Heating and Pyrophoricity, DOE-HDBK-1081-2014, 2014 https://www.standards.doe.gov/standards-documents/1000/1081-BHdbk-2014/@@images/file

[12] Brett Carlsen et al., *Damaged Spent Nuclear Fuel at U.S. DOE Facilities, Experience and Lessons Learned*, INL/EXT-05-00760, November 2005. At https://inldigitallibrary.inl.gov/sites/sti/sti/3396549.pdf See Appendix A for an experience in 1980 when transporting spent fuel. A previously unknown phenomena occurred which was oxygen scavenging from the air by exposure of fuel at the points of cladding failure, which enlarged the existing cladding breaks. From this experience, it was learned that the transported fuel required use of an inert gas such as helium in spent fuel shipments. Further experience is described when the high temperature fuel was submerged back into the pool, resulting in overpressure, in steam and spalling of fuel material from the fuel rods, fuel debris and contamination of the pool.

[13] Kevin Daniels et al., Idaho Cleanup Project, CH2M-WG Idaho, LLC, "Independent Investigation Report of the November 2005 Drum Fire at the Idaho National Laboratory Site," RPT-190, March 2006. https://ar.icp.doe.gov/images/pdf/200605/2006051600209TUA.pdf

[14] Alsaed Abdelhalim, Enviro Nuclear Services, LLC, Spent Fuel and Waste Disposition, *Review of Criticality Evaluations for Direct Disposal of DPCs and Recommendations*, SFWD-SFWST-2018-000***, SAND2018-4415R, April 20, 2018. https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2018/184415r.pdf

[15] U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017. See p. 15.

The Department of Energy promised to begin disposal of spent nuclear fuel by 1998. Then came other promised dates that have come and gone. The U.S. Nuclear Regulatory Commission believed those empty promises from the Department of Energy, expecting to disposal by 1998, then 2008, and then by the first quarter of this century. [16] The Department of Energy's rapidly evolving waste emplacement concepts continued to evolve as every assumption about how the repository would contain the waste didn't hold up. No utility has packaged its spent nuclear fuel into DOE's recommended "transport, aging and disposal" TAD canister. The Yucca Mountain repository concept also relies on never designed titanium drip shields that no one honestly believes are feasible to install decades after the waste is emplaced.

Department of Energy has no spent nuclear fuel repository program and hasn't since 2010. The Department of Energy **has no credible cost estimate for the costs of disposal of now-existing spent nuclear fue**l plus the fuel from already operating reactors. Few people know that there is already more than double the amount of spent nuclear fuel (and high-level waste) than Yucca Mountain was set to legally hold. And few people know that if nuclear energy were to make a dent in climate, we would need a new Yucca Mountain every year.

The Department of Energy was struggling for years to keep the radionuclide trickle-out doses below EPA standards. But something would happen to drastically lower the Department of Energy's trickle out problem and radiation doses between 2007 and 2008 when the DOE submitted its license application for Yucca Mountain to the NRC. I had trouble understanding how the predicted doses dropped from a couple hundred millirem to less than 1 mrem/year for post-10,000-year time frame. Both the earlier and later submittals had assumed perfect titanium drip shield performance, despite the implausibility of ever installing them in the repository.

The problem of the estimated high radionuclide trickle-out from Yucca Mountain ended when Sandia took over the modeling of radionuclide trickle out and elected to squash the assumed water infiltration rates through the proposed Yucca Mountain repository. **A review of Sandia's modeling for Yucca Mountain that yielded estimates of low radiation doses from water contamination from the trickle out of radionuclides found that the Sandia models were technically indefensible**. [17]

That independent review of DOE's calculations had been contracted by the DOE but withheld from the State of Nevada. The review's conclusion was that the Department of Energy's modeling, by Sandia, of water infiltration to the disposed of waste **did not provide a credible representation of water infiltration at Yucca Mountain**.

In other words, because the periodic spikes in water infiltration had raised the estimated radiation dose, the water infiltration spikes were simply removed from the modeling in order to drive the estimated radiation exposures down. The contamination trickle-out problem that had

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[16] Nuclear Regulatory Commission, 10 CFR 51, Waste Confidence-Continued Storage of Spent Nuclear Fuel, Federal Register, Vol. 78, No. 178, September 13, 2013.

[17] Senate Hearing 109-523, Yucca Mountain Repository Project, May 16, 2006. https://www.govinfo.gov/content/pkg/CHRG-109shrg29473/html/CHRG-109shrg29473.htm

previously estimated 95th percentile radiation doses above 1000 mrem/yr (yes, one thousand mrem/yr) and would struggle to meet the 100 mrem/yr median requirement by EPA regulations now had contrived the modeling to slash the estimated radiation dose to a person living 15 km (or 11 miles) downgradient to less than 1 mrem/yr. [18]

The Department of Energy is also focusing on trying to say that multiple criticalities in a waste repository won't add that much harm to a disposal repository's already estimated harm.

The Department of Energy stated it had collected $28.2 billion from commercial nuclear utilities for the "Nuclear Waste Fund." The U.S. Court of Appeals agreed to end DOE's collection of fees because DOE did not have waste disposal program for spent nuclear fuel and also because the DOE's latest fee assessment covered an enormous range of possible costs, from somewhere between $25 billion and $2 trillion dollars, so there was no way to determine the adequacy of the fees paid. [19]

The court found that the DOE's 2011 plan to somehow find a spent nuclear fuel disposal facility by 2048 was "pie in the sky." [20]

Under the 1982 Nuclear Waste Policy Act, DOE was to have a disposal facility by 1998. And nuclear utility customers would pay one-tenth of a cent for every kilowatt hour of nuclear-generated electricity in to the Nuclear Waste Fund. The collection of the fee ended on what is being called "zero day," May 16, 2014. [21]

In FY-2020, various funding appropriations for interim storage of spent nuclear fuel have been put forth. Two consolidated interim storage sites, one New Mexico and near it in southwest Texas, are pursuing licenses from the Nuclear Regulatory Commission. [22] [23] [24] Because current regulations limit the Department of Energy's role involving interim storage when no license for a

[18] Letter from Council for the State of Nevada to Secretary of the U.S. Nuclear Regulatory Commission, State of Nevada's Supplement to its June 4, 2008 Petition Asking the NRC to Reject DOE's Yucca Mountain License Application as Unauthorized and Substantially Incomplete, July 21, 2008. The letter cites the review of DOE's infiltration model performed at DOE's request by ORISE (Oak Ridge Institute for Science and Education). ORISE provided the results of this independent review to DOE on April 30, 2008. http://www.state.nv.us/nucwaste/news2008/pdf/nv080721nrc.pdf

[19] Steven Dolley, Elaine Hiruo, and Annie Siebert, *S&P Global Platts*, "Federal court orders suspension of US DOE nuclear waste fund fee," November 19, 2013. https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/111913-federal-court-orders-suspension-of-us-doe-nuclear-waste-fund-fee

[20] Ibid.

[21] World Nuclear News, Zero day for US nuclear waste fee, May 16, 2014. https://www.world-nuclear-news.org/Articles/Zero-day-for-US-nuclear-waste-fee

[22] Tami Thatcher comment submittal for Environmental Defense Institute for the NRC's draft Environmental Impact Statement for the Holtec Consolidated Interim Storage Facility Project, Docket NRC-2018-0052, September 2020 at http://www.environmental-defense-institute.org/publications/CommentNRCdEISHoltecT.pdf

[23] David B. McCoy, Citizen Action New Mexico, comment submittal for the NRC's draft Environmental Impact Statement for the Holtec Consolidated Interim Storage Facility Project, Docket NRC-2018-0052, September 2020 at http://www.environmental-defense-institute.org/publications/CommentNRCdEISHoltecM.pdf

[24] Environmental Defense Institute comments by Tami Thatcher on the Interim Storage Partners proposed Consolidated Interim Storage at the Waste Control Specialists site in Andrews County, Texas at http://environmental-defense-institute.org/publications/CommentNRC2018Texas.pdf

disposal facility has been obtained, some of the bills put forth in Congress are trying to change that.

In the last decade, there's been a lot of focus in the Department of Energy's spent fuel disposal research on disposal in a salt medium. [25] [26] And the proposed placement of two consolidated interim storage facilities is located within 30 miles of the salt mine disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The U.S. has decided by the 1970s that it needed a deep geologic repository in order to contain the radionuclides in spent fuel and high-level waste over the thousands of years, actually over a million years, that the radionuclides remain radiotoxic. After 50 years of trying, the Department of Energy is no closer to obtaining a solution for safely containing the nation's spent nuclear fuel and high-level waste.

The Department of Energy wants people to think that "interim" or actually "indefinite" storage of spent nuclear fuel is satisfactory. The Department of Energy wants to ramp up and make more spent nuclear fuel so DOE doesn't want people to understand the truth of what burden, in terms of cost and in terms of the release of radionuclides to the environment, what devastation to humanity and all life, that this involves.

In addition to the unsolved technical difficulties and the cost of disposing of the spent fuel and high-level waste are the issues of cost and risk for "continuing storage" of spent nuclear fuel, above ground, are something the Department of Energy is also not being truthful about.

The failure of the Department of Energy to secure a solution for the disposal of spent nuclear fuel has resulted in some commercial nuclear utilities having to result to rather torturous litigation in order to get the DOE to pay some of the utilities' expenses for continued storage of the spent nuclear fuel. The 1982 Nuclear Waste Policy Act allowed the Department of Energy to enter into contracts with commercial nuclear utilities, with the Department of Energy promising to take ownership of the spent nuclear fuel.

In 2014, it was estimated by contractors for the Department of Energy that by 2035, half of the commercial spent fuel inventory in the US would be stored in approximately 5,000 dual-purpose-canisters. And if no nuclear power reactors were built, but existing reactors continued to run as projected, the spent nuclear fuel inventory was projected to be approximately 139,000 metric tons heavy metal (MTHM) by 2055, or 10,000 canisters in 2055. [27]

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[25] Henrik Lijenfeldt et al., Spent Fuel and Waste Science and Technology, *Summary of Investigations on Technical Feasibility of Direct Disposal of Dual Purpose Canisters*, SFWD-SFWST-2017-000045, September 2017. https://info.ornl.gov/sites/publications/Files/Pub102524.pdf

[26] Energy Workshops, *2018 SFWST Annual Working Group Meeting, Las Vegas, Nevada May 22 to May 24*, 2018. https://energyworkshops.sandia.gov/nuclear/2018-sfwst-rd-team-meeting/ See presentation number 68 and others.

[27] E. Hardin et al., Spent Fuel and Waste Disposition, Prepared for U.S. Department of Energy, Office of Used Nuclear Fuel Disposition, *Investigations of Dual-Purpose Canister Direct Disposal Feasibility (FY14)*, FCRD-UFD-2014-000069 Rev. 1, October 2014.

But as the utilities sought to be paid for continuing costs of caring for spent nuclear fuel after the 1998 date the DOE was to have a repository for the spent fuel, many would have to fight in court. The Department of Energy fought strenuously to avoid compensating the utilities, saying that the problem was "due to an unavoidable delay." Years of litigation ultimately found that the Department of Energy did need to pay for some of the costs of continuing spent fuel storage and settlements with utilities. [28] But the settlements for partial breach of contract only cover the time up to the date of the court filing. So additional settlements must continue to be requested as time moves on but the spent fuel doesn't.

Commercial power utilities with stranded fuel, that shutdown their nuclear reactors, also wanted to shut down the spent fuel pools. Other utilities simply ran out of space in their spent fuel pools. The only answer was to put the spent fuel into dry storage casks or canisters.

There are various dry storage systems licensed by the U.S. Nuclear Regulatory Commission. And most of the fuel is in thin-walled stainless steel canisters rather than bolted-lid containers. For many of the canisters, thin means so thin-walled that the Department of Energy is loath to mention just how thin: about 0.5 to 0.5625 inches of wall-thickness of the canister containing about 10 metric tons of spent nuclear fuel. [29]

The dry storage systems used by the utilities were never designed for disposal of the spent nuclear fuel at Yucca Mountain or any other disposal facility. Some of the containers can't be transported, [30] but those that can, are referred to a dual-storage-canisters, meaning they can be stored in place and also transported.

Various presentations and reports for the Department of Energy display a disclaimer stating "This is a technical presentation that does not take into account the contractual limitations under the Standard Contract. Under the provisions of the Standard Contract, DOE does not consider

https://www.energy.gov/sites/prod/files/2014/10/f19/7FCRDUFD2014000069R1%20DPC%20DirectDispFeasibility.pdf

[28] EveryCRSReport.com, Contract Liability Arising from the Nuclear Waste Policy Act (NWPA) of 1982, R40996, February 1, 2012. https://www.everycrsreport.com/reports/R40996.html

[29] E. Hardin et al., Fuel Cycle Research and Development, Prepared for U.S. Department of Energy Used Fuel Disposition Campaign, *Assumptions for Evaluating Feasibility of Direct Geologic Disposal of Existing Dual-Purpose Canisters*, FCRD-UFD-2012-000352, Rev. 1, November 2013. (SAND2013-9780P), https://www.osti.gov/servlets/purl/1673713 See Appendix A.

[30] E. Hardin et al., Fuel Cycle Research and Development, Prepared for U.S. Department of Energy Used Fuel Disposition Campaign, *Assumptions for Evaluating Feasibility of Direct Geologic Disposal of Existing Dual-Purpose Canisters*, FCRD-UFD-2012-000352, Rev. 1, November 2013. (SAND2013-9780P), https://www.osti.gov/servlets/purl/1673713 p. 24: Storage-only canister systems include the MSB (24-PWR, Energy Solutions) and the NUHOMS-24PS, -24PH, -24PHB< -24PHBL, -52B and -07P (Transnuclear). These canisters currently exist at the Idaho National Laboratory, and at the Calvert Cliffs, Surry, Oconee, Arkansas Nuclear One, Palisades, Davis-Besse, Point Beach, Susquehanna, and H.B. Robinson nuclear power plants. These are sealed canisters, not to be confused with non-canistered cask systems (storage-only or storage-transportation) which have bolted closures.

spent fuel in canisters to be an acceptable waste form, absent a mutually agreed to contract modification." [31]

According to a decommissioning document submitted to the NRC regarding one utility's canistered spent fuel, "the government's [DOE's] stated positions with respect to such acceptance [of spent fuel in canisters], including assertions in legal proceedings, have been inconsistent." And as recently as 2008, the Department of Energy continued to give empty promises to the U.S. nuclear power electrical generating utilities of promised dates for opening Yucca Mountain by 2020. [32]

In 2009, the Department of Energy Secretary Steven Chu stated that Yucca Mountain was no longer an option. [33] In 2010, President Obama created the Blue-Ribbon Commission on America's Nuclear Future and the commission issued its report in 2012. [34] The BRC's strategy included "**prompt efforts** to develop one or more geologic disposal facilities" and "p**rompt efforts** to develop one or more consolidated interim storage facilities." [35]

Originally the Department of Energy had envisioned and had partially designed a "transport, aging, and disposal" container called the "TAD." It was to be highly corrosion resistant. The license application by the DOE for Yucca Mountain assumes that spent nuclear fuel is placed into TADs and that the TADs don't corrode for 10,000 years. (Other containers, like the multi-purpose canister, were assumed for Department of Energy high-level waste and spent fuel.) Inside Yucca Mountain, the commercial spent fuel was to be protected by the TAD, the neutron absorber in the TAD, additional metal waste package coverings, and the titanium drip shield protects the container of spent nuclear fuel. And in all this fanciful imagining, the likelihood of criticality is deemed to be "low." [36] And the trickle out of radionuclides from the dissolving containers and the fuel they hold is deemed to be so slow that water downgradient from the Yucca Mountain disposal site doesn't cause more than a 1 mrem/yr radiation dose.

Just a few problems with unloading the welded, thin-walled canisters and putting that spent nuclear fuel in a TAD. First of all, no design for a TAD was ever completed or licensed. Second

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[31] E.L. Hardin and D.J. Clayton, Sandia National Laboratories, R.L. Howard, J.M Scaglione, E. Pierce and K. Banerjee, Oak Ridge National Laboratory, M.D. Voegele, Complex Systems Group, LLC, H.R. Greenberg, J. Wen and T.A. Buscheck, Lawrence Livermore National Laboratory, J.T. Carter and T. Severynse, Savannah River National Laboratory, W. M. Nutt, Argonne National Laboratory, Prepared for: U.S. Department of Energy, Office of Used Nuclear Fuel Disposition, *Preliminary Report on Dual-Purpose Canister Disposal Alternatives (FY13)*, FCRD-UFD-2013-000171, Revision 1, December 2013. https://www.energy.gov/sites/prod/files/2013/12/f5/PrelimRptDPCDisposalAlternativesR1.pdf

[32] Dominion Energy Kewaunne, Inc., Kewaunee Power Station Post-Shutdown Decommissioning Activities Report, February 26, 2013. https://www.nrc.gov/docs/ML1306/ML13063A248.pdf

[33] U.S. Department of Energy, "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," January 26, 2013.

[34] Blue Ribbon Commission on America's Nuclear Future, "Report to the Secretary of Energy," January 2012.

[35] Dominion Energy Kewaunne, Inc., Kewaunee Power Station Post-Shutdown Decommissioning Activities Report, February 26, 2013. https://www.nrc.gov/docs/ML1306/ML13063A248.pdf

[36] Scientific Analysis/Calculation Administration Change Notice, ANL-DO0-NU-000001, Screening Analysis of Criticality Features, Events, and Processes for License Application, Yucca Mountain Project, 2008. https://www.nrc.gov/docs/ML0907/ML090720250.pdf

of all, despite NRC regulations requiring the canisters they licensed to allow the spent fuel to be retrievable, it isn't.

The NRC licensed the dry storage canisters in use at many commercial nuclear power plants in the U.S. The NRC codified the requirement in its regulations, including 10 CFR 72.122(1), which states

> *Storage systems must be designed to allow ready retrieval of spent fuel, high level radioactive waste, and reactor-related GTCC [greater-than-class C] waste for further processing or disposal.* [37]

The canisters used in the US were approved by the NRC but were never actually designed for ready retrieval of spent fuel. So little attention was paid to corrosion issues that degradation including the neutron absorber material in the canisters as well as spent fuel pool racks has occurred and in just a few years. The majority of currently loaded spent nuclear fuel canisters in the US used boron carbide with aluminum, known as Boral. Despite optimism by repository researchers for this type of neutron absorber to last for thousands of years, [38] degradation has already been occurring. [39]

The U.S. Nuclear Waste Technical Review Board (NWTRB) recommended the "design and demonstration of dry-transfer fuel systems for removing fuel from casks and canisters following extended dry storage." [40]

It would seem that the NRC may have started to recognize the difficultly involved with grinding open a welded canister, perhaps with a degraded neutron absorber so the criticality was more likely, and somehow deftly preventing the fuel from being exposed to oxygen, while using the shielding of the water in the spent fuel pool, with fuel of the temperature above boiling, and all with virtually no way to inspect the status of the fuel or the neutron absorber in the canister, while assuring that the fuel remained subcritical and was not further damaged during the transfer of fuel.

A study updated in 2019 by the Department of Energy confirms that the NRC had no documented evaluation of the consequences of spent nuclear fuel canister failure. The NRC

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[37] B. B. Bevard et al., Oak Ridge National Laboratory, *BWR Spent Nuclear Fuel Integrity Research and Development Survey for UKABWR Spent Fuel Interim Storage*, ORNL/TM-2015/696, October 2015. https://info.ornl.gov/sites/publications/files/Pub60236.pdf (discusses U.S. NRC regulations and the issue of spent fuel retrievability from canisters in the U.S.)

[38] E. Hardin et al., Spent Fuel and Waste Disposition, Prepared for U.S. Department of Energy, Office of Used Nuclear Fuel Disposition, *Investigations of Dual-Purpose Canister Direct Disposal Feasibility (FY14)*, FCRD-UFD-2014-000069 Rev. 1, October 2014. See page 4-1. https://www.energy.gov/sites/prod/files/2014/10/f19/7FCRDUFD2014000069R1%20DPC%20DirectDispFeasibility.pdf

[39] U.S. Nuclear Regulatory Commission, Generic Issue 196. https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML042670379

[40] U.S. Nuclear Waste Technical Review Board, *Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel*. Arlington, Virginia, 2010. pp. 14 and 125, (at www.nwtrb.gov) as cited in https://info.ornl.gov/sites/publications/files/Pub60236.pdf

has prepared the draft Environmental Impact Statement for the proposed Holtec consolidated interim storage facility in New Mexico without having any documented basis for the consequences of an expected event, leakage of a spent nuclear fuel canister. [41]

Instead of using thin-walled welded canisters that cannot be adequately inspected or repaired, the Swiss required the use of bolted thick-walled casks. They store them in a building, away from ocean salt spray air, for example. They have a hot cell for repackaging a cask if needed. Read more at SanOnofreSafety.org. [42]

The NRC's response has typically been to admit there's a problem while not actually admitting there's a problem. With regard to the inability to retrieve spent nuclear fuel from NRC-licensed canisters, the NRC solution seemed to be to remove the regulation or provide guidance that gives gibberish saying there's no need to inspect canister internals, unless, of course, there's a safety issue. [43]And forget about opening a welded canister, it would lead to elevated worker radiation exposures. The full extent of the inability to open a spent fuel canister of higher enriched fuel with a potentially degraded neutron absorber in the canister internals isn't really fessed up to.

But the Department of Energy has now for some years investigated the direct disposal of these canisters, rather than remove the fuel from the canisters and repackage them into the more corrosion resistant TAD as stated in Yucca Mountain's license application to the NRC. [44]

The Department of Energy's research during that last decade has been examining the behavior of different geologic mediums including clay-rich (argillaceous) media including shales, hard rock (crystalline or granite), or salt but not much research any more for volcanic "tuff" as found at Yucca Mountain.

The elephant in the room regarding the safety and disposal of the growing number of welded-closed spent nuclear fuel canisters prevalently used by U.S. commercial nuclear power utilities is rarely discussed.

While cutting open these spent nuclear fuel dry storage canisters may be possible, in twenty years of talking about it, the method to use for cutting open the canisters has not been decided. No design has progressed beyond a vague conceptual stage. Nor have the risks been presented.

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[41] U.S. Department of Energy, Spent Fuel and Waste Science and Technology, Gap Analysis to Guide DOE R&D in Supporting Extended Storage and Transportation of Spent Nuclear Fuel: An FY2019 Assessment, SAND2019-15479R, December 23, 2019. https://www.osti.gov/servlets/purl/1592862

[42] SanOnofreSafety.org webpage "Swiss Solution – Swiss nuclear waste storage systems exceed US safety standards" at https://sanonofresafety.org/swiss/

[43] Federal Register, Fuel Retrievability in Spent Fuel Storage Applications, A Notice by the Nuclear Regulatory Commission on June 8, 2016. https://www.federalregister.gov/documents/2016/06/08/2016-13569/fuel-retrievability-in-spent-fuel-storage-applications

[44] Energy Workshops, *2018 SFWST Annual Working Group Meeting, Las Vegas, Nevada May 22 to May 24*, 2018. https://energyworkshops.sandia.gov/nuclear/2018-sfwst-rd-team-meeting/ See presentation #05 on direct disposal of spent nuclear fuel, https://energyworkshops.sandia.gov/wp-content/uploads/2018/05/05-Direct-Disposal-of-Spent-Nuclear-Fuel-in-Dual-Purpose-Canisters-RD-Path-Forward-SAND2018-5437-PE.pdf

The U.S. Department of Energy's proposed Yucca Mountain spent fuel and high-level waste repository discussed dry transfer and wet transfer systems for years, and wildly vacillated about the size of spent fuel pools and capability of dry transfer systems, especially in regard to how to repackage commercial spent nuclear fuel received in non-disposal canisters. [45] [46]

In one study performed for the Department of Energy in 2000, two options for cutting open the non-disposable spent nuclear fuel canisters were discussed. [47] But neither option included any specific method for the proposed remote cutting operation and the radiological accident risks were not evaluated. The study did acknowledge that determining the specific methods for cutting open the canisters would be a significant task. The range of safety issues associated with cutting open canisters containing high burnup fuel now used by utilities was not developed.

In a study for the Department of Energy published in 2015, eight proposed methods for cutting open non-disposable canisters were evaluated, [48] indicating that no method has actually been fully designed or used.

And what about the dry transfer system designed for the Idaho National Laboratory that remains to be built? The environmental impact statement (EIS) for the proposed Idaho Spent Nuclear Fuel Facility addressed the need to repackage only very specific Department of Energy spent nuclear fuel: high-temperature gas-cooled Peach Bottom reactor fuel, light-water breeder reactor Shippingport fuel, and research TRIGA fuel. [49] The easy-breezy EIS assumes away fuel drop events and essentially all accidents. [50] These fuels are less susceptible to oxidation than typical uranium oxide fuels used by the commercial nuclear power generating industry in the U.S. There are no operations involving large welded closed commercial spent nuclear fuel canisters at the proposed Idaho Spent Fuel Facility designed by Foster Wheeler Environmental Corporation.

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[45] P. W. McDaniel et al., Prepared for U.S. Department of Energy by Bechtel SAIC, *Yucca Mountain Project Surface Facilities Design*, November 2002. https://www.osti.gov/servlets/purl/808023

[46] Senate Hearing 109-523, Yucca Mountain Repository Project, May 16, 2006. https://www.govinfo.gov/content/pkg/CHRG-109shrg29473/html/CHRG-109shrg29473.htm

[47] Prepared for U.S. Department of Energy by TRW Environmental Safety Systems Inc., Civilian Radioactive Waste Management System Management & Operating Contractor, *White Paper: Waste Handling Building Conceptual Study*, TDR-WHS-SE-000002 Rev 00, October 2000. https://www.osti.gov/servlets/purl/893534-wmX91n/

[48] Sven Bader et al., *A study of transfer of UNF [used nuclear fuel] from non-disposable canisters – 15388, WM Symposia, Inc.*, July 2015. **https://www.osti.gov/biblio/22824303**

[49] Training, Research, and Isotope reactor fuel by General Atomics (TRIGA) fuel was used in various reactors built by General Atomics and is high enriched fuel. Many of the 1600 TRIGA fuel elements are stored at the Idaho National Laboratory in 2004 when the EIS was written but additional shipping to the INL was also needed.

[50] U.S. Nuclear Regulatory Commission, *Environmental Impact Statement for the Proposed Idaho Spent Fuel Facility at the Idaho National Engineering and Environmental Laboratory in Butte County, Idaho*, NUREG-1773, 2004. https://www.nrc.gov/docs/ML0404/ML040490135.pdf design by Foster Wheeler Environmental Corporation.

In 2010, the U.S. Nuclear Waste Technical Review Board (NWTRB) recommended the "design and demonstration of dry-transfer fuel systems for removing fuel from casks and canisters following extended dry storage." [51] But this still hasn't happened.

In addition to the costs associated with spent nuclear fuel disposal because the industry's welded canisters were not considered suitable for disposal, the U.S. Nuclear Regulatory Commission has not grappled with the safety ramifications of not being able to retrieve spent fuel from these canisters, should one be damaged. [52]

In a dangerous and exceedingly dishonest way, the NRC has stipulated that aging degradation will not be included in its risk assessment of the canisters, despite known high likelihood, ineffective inspection programs and essentially no means for addressing aging degradation of the dry storage canisters predominantly used by the commercial nuclear industry.

The stainless steel that the canisters are made of has long been known to be vulnerable to aging failures such as chloride-induced stress corrosion cracking. The NRC has even recognized that such events are to be expected and yet continues to officially deemed the events "incredible." What are the potential radiological consequences of spent fuel canister breaches? I'll discuss that in the next article.

To underscore the extent of the U.S. Nuclear Regulatory Commission's lack of concern for the cost or even feasibility of its assumptions regarding consolidated interim storage, it is interesting to review the license the NRC granted for the proposed facility in Utah, the Private Fuel Storage facility.

The U.S. Nuclear Regulatory Commission granted a license for interim storage of spent nuclear fuel in Utah, in 2005, to Private Fuel Storage (PFS), on the Goshute Indian Reservation. The facility was fought by the State of Utah and not built. The concerns by the State of Utah included the problem that the Department of Energy in October 2005 had announced a strategy to accept disposal canisters rather than the dual purpose (storage and transportation) canisters to be used at PFS. [53] The proposed interim storage facility at Utah would not have capability to repackage the canisters to a type approved of by the Department of Energy.

The NRC Licensing Board said that the issue was of no concern for the NRC. **If the canisters required repackaging, then the canisters shipped to PFS in Utah would have to be shipped back to the utilities, at the utilities expense, to repackage the canisters.** To the NRC,

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[51] U.S. Nuclear Waste Technical Review Board, *Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel*. Arlington, Virginia, 2010. pp. 14 and 125, (at www.nwtrb.gov) as cited in https://info.ornl.gov/sites/publications/files/Pub60236.pdf

[52] Read the Environmental Defense Institute December 2020 newsletter, including "Devil in the details of the Standard Contract with the Department of Energy under the NWPA" and "The 'Nuclear Waste Fund' fee is no longer being collected from commercial nuclear power utilities – because the Department of Energy has no spent fuel disposal program," at http://www.environmental-defense-institute.org/publications/News.20.Dec.pdf

[53] Yucca Mountain Repository Project, Senate Hearing 109-523, May 16, 2006, https://www.govinfo.gov/content/pkg/CHRG-109shrg29473/html/CHRG-109shrg29473.htm

the issue did not affect the PFS licensing approval or the environmental impact statement for PFS. [54]

The NRC decided that it was not the NRC's problem if there was no place to ship the canisters to and no financial resources to ship or repackage the canisters. And the NRC didn't care if it actually was not possible to safely retrieve the spent fuel from the non-disposable canisters and place the spent fuel into different canisters.

The license was granted to PFS by the NRC only by the NRC refusing to care about the costs, risks and lack of capability to actually repackage the canisters. The NRC just said the problem didn't exist because the canisters at PFS would be shipped back to the utilities. Those utilities could include stranded fuel sites with no capability to repackage the canisters. This is how short-sighted, immoral and outrageous the U.S. NRC is. And the same thing is happening as the NRC prepares to approve consolidated interim storage in New Mexico and Texas.

Ironically, the entire stated reason for the consolidated interim storage proposed at New Mexico and Texas is to repurpose the land where the spent nuclear fuel is currently stored — and this is where the canisters would be sent back to for repackaging or if the license at the interim storage facility was not extended.

The NRC refuses to admit that a canister leak of significant size is credible. There is no way that an environmental impact statement could yield an acceptable result if the NRC was truthful. And the full extent of the damage to the fuel in the canister as the fuel oxidizes over time will "unzip" the cladding and allow fuel pellets to relocate inside the canister. This also makes the criticality risk higher, should a moderator (such as water) enter the canister.

Unlike the radiological consequence evaluation from the 2008 YM Supplement, most NRC radiological release evaluations, assume that the canister leak is very small, releasing only a fraction of the releasable material from the canister and the inhalation continues for 30 days. The duration of 30 days is stipulated by the NRC on the basis that actions will be taken within 30 days to terminate the release. [55] But there is no technically valid basis for concluding that any action can be taken to terminate the release because there is no technology to repair a canister containing spent fuel and no means for removing the spent fuel from the canister. There is no means developed to place a leaking canister into a sealed confinement such as a cask. Nor is there capability to provide adequate heat transfer for the long term with a container-in-a-container approach.

As oxygen enters the canister, any cladding damage will allow the uranium to oxidize. The uranium fuel matrix will swell, further damaging the cladding. It is not clear that NUREG-2224 fuel release fractions are adequate.

[54] In The Matter Of Private Fuel Storage L.L.C., Docket No. 72-22, November 14, 2005, Applicant's Response to State of Utah's Motion to Reopen the Record and to Amend Utah Contention Utah UU, Docketed USNRC. ML053260506.

[55] U.S. Nuclear Regulatory Commission, Interim Staff Guidance – 5, Revision 1, Confinement Evaluation, See Attachment to ISG-5 Revision 1, page 11 https://www.nrc.gov/reading-rm/doc-collections/isg/isg-5R1.pdf

For Yucca Mountain evaluations, canister leakage from outdoor storage of aging dry canisters was not evaluated despite the long-term storage of a high number of canisters to allow additional cooling of the canister to limit the thermal loading of the repository.

For Yucca Mountain evaluations, the radiological releases from spent fuel were assumed to occur inside buildings with highly effective HEPA filters, that were assumed to be 0.9999 effective. With the dose evaluated to a receptor (the location of the maximally exposed individual) located miles from the facility, the estimated doses remained less than one rem, but only by ignoring realistic unfiltered radiological release scenarios.

The Department of Energy's estimated Yucca Mountain pre-closure radiological doses and the NRC's independent fuel storage installations are stated to have low radiological doses. **But the reality is that these agencies excel at whittling down the radiological doses on paper, while actually exposing the public to much higher, and sometimes lethal, potential accident radiological release doses with their proposed facilities.**

The annual costs of continued storage will be paid for by the U.S. tax payer, at Department of Energy sites like the Idaho National Laboratory for DOE research spent nuclear fuel and for commercial nuclear spent fuel as utilities sue the Department of Energy for those costs. And the multi-billion-dollar costs of repackaging the spent nuclear fuel as the containers corrode is not something the U.S. Nuclear Regulatory Commission nor the Department of Energy want citizens to think about.

Department of Energy Seeks Input on Consent-Based Siting of Nuclear Waste

The Department of Energy's Notice in the Federal Register last December is asking for input on the use of a "consent-based" siting process for "interim" storage of spent nuclear fuel. [56]

The Department of Energy has, after decades of trying, been unable to obtain a spent nuclear fuel (and high-level waste) disposal facility, please see the previous article in this newsletter. Many communities don't want their nuclear waste to remain in their state. So, the DOE wants to move its waste from where it is currently stored, to a new location in communities deemed more easily bribed and coerced.

The new "interim" storage locations will be stuck with the leaking canisters and no place to send this waste to. But, states with radioactive waste will be glad to send the waste anywhere as long as its not in their backyard any more.

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[56] Department of Energy Federal Register Notice, "Notice of Request for Information (RFI) on Using a Consent-Based Siting Process To Identify Federal Interim Storage Facilities, December 1, 2021. https://www.federalregister.gov/documents/2021/12/01/2021-25724/notice-of-request-for-information-rfi-on-using-a-consent-based-siting-process-to-identify-federal

Past law makers recognized that these so-called “interim” storage locations would take the heat off of finding solutions for permanent waste disposal and they placed limits on the amount of waste that could be placed in interim storage.

The Department of Energy wants to remove these limits and store unlimited amounts of spent fuel at these above ground parking lot dumps. The Nuclear Information and Resource Service (nirs@nirs.org) also has useful information about the DOE’s consent-based lie and bribe scheme. The DOE must not target and coerce the most vulnerable communities into accepting nuclear waste dumps under the guise of “consent.”

Submit your comments by March 4 and tell DOE to prioritize environmental justice, listen to community voices, and respect non-consent in managing nuclear waste. Comments can be submitted electronically to *consentbasedsiting@hq.doe.gov* and need to include “RFI: Consent-Based Siting and Federal Interim Storage” in the subject line of the email.

The last time the Department of Energy collected public comments on “consent-based” siting of “interim” storage, the DOE promptly removed the public comments from public access. I attended on of those sessions, traveling over 300 miles to give comment. At that session, the Department of Energy told many lies and presented many lies in its poster sessions. For example, the DOE said that it was researching the disposal of high-level waste (HLW) called “calcine” that is stored at the Idaho National Laboratory and was planning to dispose of it North or South Dakota. But the DOE failed to say that neither state would allow the DOE to commence the research. They didn’t want highly soluble, powdery radioactive waste injected into deep boreholes, despite the DOE trying to say to them that it was “only research.”

A consent-based process requires ***informed consent***. The Department of Energy continues to lie about the hazards of the waste it is producing and how it is forcing future generations to bear the enormous costs and the horrible consequences of not containing the waste.

Any rationale person who cares about human health and the environment knows that we must stop making nuclear waste.

The sites DOE is seeking are unlikely to be “temporary” or “interim” as claimed because it has no plans for a long-term repository or management program.

The Department of Energy did not respond to or even make publicly available the public comment for consent-based siting in 2015, six years ago. The DOE must commit now to making those public comments and future public comment readily publicly available.

The Department of Energy (and the U.S. Nuclear Regulatory Commission) claim the spent nuclear fuel is safely stored where it is now. It that is true, why transport the spent fuel across the country to new interim storage sites?

The typical spent nuclear fuel canisters are in contact with air cooling and will start leaking into the atmosphere. The nuclear industry would rather have this happen in New Mexico or southern Texas than at each nuclear power plant in the U.S. When the spent fuel canisters do develop leaks, it will be easier for the NRC to inadequately monitor the radioactivity releases in New Mexico or Texas, and claim that the releases are within their regulations even if it requires evacuation of some areas.

I suspect also that the Department of Energy wants to move the spent fuel to New Mexico and/or Texas to ultimately force New Mexico and/or Texas to accept disposal of the radioactive waste underground in those states, despite the inability of those locations to safely confine the waste for millennia.

The Poop on Department of Energy Worker Bioassay Programs

In addition to lung counting using gamma spectrometry, Department of Energy worker bioassay programs also assess urine and fecal sample radioactivity if an intake is suspected.

The basic methodology is to determine if a specific radionuclide is detected and if so, to use the established tables of excretion fraction to estimate the initial intake of that radionuclide. Not all recent International Commission on Radiological Protection reports are readily available for public access. An older report that is accessible illustrates the method and some of the data for plutonium-239 and americium-241. [57]

When the radionuclide, i.e., plutonium-239 is known, and the clearance class (clearance within weeks for Class W (or Type M) or clearance within years for Class Y (or Type S), then the excretion factor corresponding to the elapsed time since the intake can be used to estimate the intake.

For example, if a fecal sample taken 1 day after the intake is 200 disintegrations per minute (dpm) of plutonium-239 by bioassay, the 200 dpm Pu-239 is divided by the fecal excretion fraction of 4.24E-2 to obtain an estimate of the intake, of 4717 dpm (or 2.1 nanocuries). [58]

The excretion fraction varies with elapsed time from the intake. The method is the same for urine bioassay results.

For the bioassay results from one worker at the ZPPR event on November 8, 2011, it is interesting to review the urine and fecal bioassay results and the estimated dose by Battelle Energy Alliance.

From Table 1, you can see that data on different days yield differing estimated plutonium-239 intakes, based on the urine bioassay samples.

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[57] Brookhaven National Laboratory, Prepared for the U.S. Nuclear Regulatory Commission, *Interpretation of Bioassay Measurements*, NUREG/CR-4884, 1984. (ML11285A018)

[58] Example to convert dpm to nanocuries:
4717 disintegrations per minute * (1 minute/60 seconds) * (E9 nanocuries/ 37E9 dps) = 4717/2220 = 2.1 nCi or 2.1 nanocuries.

Table 1. Bioassay urine results above Decision Level for one worker using the conventional method.

Elapsed Time	Pu-239 Volume Normalized Urine Data	Pu-239 Excretion Fraction for Inhalation (Type S)	Estimated Pu-239 Intake, dpm	Estimated Pu-239 Intake, nCi
1 day	0.2321 dpm	2.35E-6	98766 dpm	44.5 nCi
5 day	0.0191 dpm	4.55E-7	41978 dpm	18.9 nCi

Table notes: The excretion fraction is for Type S, years for clearance from the body and is from Battelle Energy Alliance's dose estimation report. Activity is given in disintegrations per minute and also nanocuries.

The ZPPR contamination was known to include high amounts of americium-241 and plutonium-239 based on knowledge of plate composition and radioactive decay to the accident in 2011 and also from analysis of nasal swipe contamination. The ratio of americium-241 to plutonium-239 based on activity ratio is Am-241 activity multiplied by 1.5 to estimate plutonium-239 activity. (In some dose estimates when all plutonium nuclides, not just Pu-239 were being estimated, the multiplier of 1.7 was used.)

The plutonium-239 "intake" estimate by Battelle Energy Alliance from the urine bioassay was far lower than a conventional estimate, see Table 2.

Table 2. BEA estimate yields far lower intake for bioassay urine results than conventional method for plutonium-239.

Intake methodology based on urine bioassay	Estimated Pu-239 Intake, dpm	Estimated Pu-239 Intake, nCi
Conventional method, all inhalation, based on Day 1 urine bioassay	98,766 dpm	44.5 nCi
Conventional method, inhalation, based on Day 5 urine bioassay	41,978 dpm	18.9 nCi
BEA creative approach for urine bioassay	5994 dpm	2.7 nCi

Table notes: The excretion fraction is for Type S, years for clearance from the body and is from Battelle Energy Alliance's dose estimation report. Activity is given in disintegrations per minute and also nanocuries.

Usually, the americium-241 could be estimated from a ratio of the plutonium-239 activity. However, for urine excretion the americium-241 biological clearance time can differ from plutonium-239. It is not safe to estimate the americium-241 activity in urine from the plutonium-239 activity. Also, when chelation drugs are administered, the influence of the drug could differ for americium-241 than plutonium-239. In fact, the urine bioassay showed a higher americium-241 to plutonium-239 ratio than found from the nasal swipes or the fecal analysis. Compounding the problem was the destruction of the americium-241 bioassay urine sample for the elapsed time of 1 day, when it would have had the highest activity.

The fecal bioassay results were above Decision Level for all fecal samples within seven days of the event and also above Decision Level 224 days after the event. Being above Decision Level means that the detection of radioactivity was clearly distinct from and above background levels.

There are some important things to note about the fecal bioassay results (see Table 3). Not mentioned is the low gram amount of the fecal sample for Day 1 (the elapsed time of 1 day); the sample was about 100 grams when 350 grams would be typical. The vomiting of the worker after the event was ignored. Also, fecal bioassay is not expected to be affected by chelation which was administered the day of the accident.

Table 3. Bioassay fecal results above Decision Level for one worker using the conventional method.

Elapsed Time	Pu-239 Fecal Sample Activity	Pu-239 Excretion Fraction for Inhalation (Type S)	Estimated Pu-239 Intake, dpm	Estimated Pu-239 Intake, nCi
1 day	2380 dpm	5.21E-2	45,681 dpm	20.6 nCi
3 day	75 dpm	1.31E-1	Dpm	0.26 nCi
5 day	86.14 plus 18.38 = 104.52 dpm	3.64E-2	2871.4 dpm	1.29 nCi
6 day	0.899 dpm	1.73E-2	51.97 dpm	0.023 nCi
7 day	0.154 dpm	8.13E-3	18.9 dpm	0.0085 nCi
224 day	0.127 dpm	1.36E-4	933.8 dpm	0.42 nCi

Table notes: The excretion fraction is for Type S, years for clearance from the body but is not listed in Battelle Energy Alliance's dose estimation report so the factors listed are older, from NUREG/CR-4884. Activity is given in disintegrations per minute and also nanocuries. While I did not present Type M results in this table, the estimated intake from Type M (or Class W) for elapsed time of 1 day is 25.3 nCi and higher than the elapsed time of 1 day intake estimate for Type S, but for the other elapsed time is quite similar to the Type S results.

While the method does not predict the same intake for each of the samples, it is important to note the elevated intake for the first fecal sample and also for the elapsed time of 5 days. **It is also important to note that after the elapsed time of 224 days after the event, the fecal bioassay results are not decreasing and are still above decision level, thus are confidently detecting above normal radioactive material from the inhalation of plutonium and americium during the event.**

For the fecal bioassay results, the americium-241 is in the expected ratio to plutonium-239 for a ZPPR plate. However, the low intake results for Day 5 as well as BEA's creatively low intake are unreasonably low because the Day 1 fecal excretion was 2380 dpm (1.07 nCi). See Table 4.

Table 4. BEA estimate yields far lower intake for bioassay fecal results than conventional method for plutonium-239.

Intake methodology based on urine bioassay	Estimated Pu-239 Intake, dpm	Estimated Pu-239 Intake, nCi
Conventional method, all inhalation, maximum based on Day 1 fecal bioassay	45,681 dpm	20.6 nCi
Conventional method, inhalation, based on Day 5 fecal bioassay	2871.4 dpm	1.29 nCi
BEA creative approach for fecal bioassay	4950 dpm	2.23 nCi

Table notes: The excretion fraction is for Type S, years for clearance from the body and is from Battelle Energy Alliance's dose estimation report. Activity is given in disintegrations per minute and also nanocuries.

The americium-241 and plutonium-239 were the primary contributors to ZPPR event inhalation dose. Plutonium-238 also contributes to dose. When Type M clearance is assumed, a higher dose is estimated and accounting for additional americium-241 ingrowth from Pu-241 is not as important as when Type S, years of clearance time is assumed. **For the 50-year retention in the body, BEA neglected to account for additional americium-241 ingrowth from Pu-241 decays after the inhalation event.**

The assessment of the worker dose for the worker closest to the plutonium inhalation of plutonium-239, americium-241 and other radionuclides also can consider nasal swipe contamination levels, area contamination swipes and lung counts.

Because BEA was found to have caused the ZPPR accident by ignoring multiple warnings of unacceptably high risk to workers, BEA needed the estimated doses from the accident to be low. Compelling evidence indicates that the actual dose exceeds 5 rem effective whole body dose, yet BEA's dose estimate is 102 millirem, see Table 5.

BEA's dose estimate is low because that is the dose that would allow BEA to claim that the accident they caused at the ZPPR facility did not have significant consequences. The estimation of Ralph Stanton's radiation dose by Battelle Energy Alliance of 102 millirem was a gross underestimate of his radiation dose.

Table 5. Overall americium-241 and plutonium-239 intake estimates from the ZPPR event.

Methodology	Amercium-241 Intake	Plutonium-239 Intake	Estimated effective whole-body dose, rem
Maximum from conventional urine bioassay	29.7 nCi	44.5 nCi	> 6 rem
Maximum from conventional fecal bioassay	13.7 nCi	Type S: 20.6 nCi , Type M: 25.3 nCi	Around 3 rem
Maximum from nasal swipes (from 4000 dpm in missing logbook). This is the recovered activity, not the "intake"	*0.667 nCi recovered in nasal swipe. Actual intake must be far higher.*	*1.1 nCi recovered in nasal swipe. Actual intake must be far higher.*	
Maximum from area contamination swipes, 5.5 million dpm swipe, used 5 million dpm with 5 minute inhalation.	833 nCi	1417	> 200 rem
Maximum from omitted 59.5 keV lung count (assumes Type M)	20.4 nCi	34.68 nCi	6 rem
Maximum from 17.5 keV lung count results (assumes Type M)	877 nCi	1491 nCi	265 rem
BEA creative approach for bioassay for intake (Assumes Type S and 70 percent inhalation/30 percent ingestion)	1.55 nCi	2.72 nCi	0.102 rem BEA dose not credible.

The dose from the plutonium and americium inhalation event at the Idaho National Laboratory's ZPPR facility was certainly above 5 rem effective whole-body dose and for the symptoms he experienced and the long-term low lymphocyte blood counts, his dose was significantly above 5 rem.

I present the lung counting and other bioassay results in a Power-Point presentation available on the Environmental Defense Institute website at http://www.environmental-defense-institute.org/publications/PowerptLungCount.pdf

Why Ignoring the Plutonium-241 Releases and Bioassay is a Problem

In radiation worker bioassay programs, the Department of Energy has tended to forget about the americium-241 ingrowth from plutonium-241. This means that along with other radiation monitoring program defects, the worker radiation dose estimates left out the full addition from americium-241.

A conference paper from 2015 describes the problem of americium-241 ingrowth. [59] The extent of the americium-241 ingrowth problem depends on the source of the material. For weapons grade plutonium, there was less plutonium-241 to begin with, and less problem omitting the americium-241 ingrowth. But with various nuclear fuels, "fuel grade" plutonium means more plutonium-241 and that means more americium-241 from the decay of plutonium-241.

Bioassay programs monitoring plutonium-239 do not necessarily include monitoring of plutonium-241. And even when to dose from plutonium-239 was recognized to be from a 50-year committed effective dose, the ingrowth of americium-249 from plutonium-241 has been ignored.

This is the case with Battelle Energy Alliances' dose estimates for workers contaminated by the Idaho National Laboratory's Materials and Fuels Complex accident in 2011 at the Zero Power Physics Research Reactor (ZPPR). The analysts looked at the plutonium-241 dose conversion factors and decided that since it was below that of plutonium-239 and americium-241 known to be in the ZPPR plate at the time of the accident. And even after taking months to estimate the radiation doses, BEA incorrectly ignored the additional americium-241 ingrowth from plutonium-241 in the plate and this contributes to underestimation of the radiation dose.

It is important to understand that when plutonium-239 is created in a nuclear reactor, that plutonium-240 and plutonium-241 are also created. In many cases, the beta decay of plutonium-241, and its lower dose conversion factor compared to plutonium-239 caused various analysts to dismiss the importance of plutonium-241.

The problem with plutonium-241 is that it rather rapidly decays to americium-241, see Table 6.

Beta decay

Pu-241 ------------------→ Am-241

Half-life 14.4 years

[59] Kevin Konzen, Navarro Research and Engineering Inc fir the Idaho Cleanup Project (CH2M-WG Idaho, LLC), "Am-241 Ingrowth and its Effect on Internal Dose," Department of Energy EFCOG Conference Paper, Los Alamos, NW on October 20-21, 2015. https://www.researchgate.net/publication/283087983

Table 6. Plutonium and americium radioactive half-lives.

Nuclide	Half-Life, Years	Weight Percent, Weapons Grade	Weight Percent, ZPPR Plate, 2011	Weight Percent, LEU Rx	Weight Percent, Pu-238 Heat Source
Pu-238	87.7 year	0.05 %	0.0 %	1.50 %	90.00 %
Pu-239	24,110 year	93.60 %	25.0 %	58.10 %	9.10 %
Pu-240	6,564 year	6.00 %	3.3 %	24.10 %	0.60 %
Pu-241	14.35 year	0.40 %	0.1 %	11.40 %	0.03 %
Pu-242	375,000 year	<0.05 %	<0.1 %	4.90 %	<0.01 %
Am-241	433 year	Assumed zero when fresh.	10 % after 28.3 years since plate made. Highly Time dependent	Highly Time dependent	

While plutonium-241 has significantly lower dose conversion factors (DCFs) and lower harm per curie, plutonium-241 decays into americium-241. And americium-241 has a dose conversion factor higher than Pu-241 and near that of Pu-239. See Table 7.

Table 7. Dose conversion factors (DCF) for plutonium and americium-241.

DCF	Pu-238	Pu-239	Pu-240	Pu-241	Am-241
Type M DCF, (rem/curie)	1.10E+8	1.20E+8	1.20E+8	**2.20E+6**	1.00E+8
Type S DCF, (rem/curie)	4.10E+7	3.10E+7	3.10E+7	**3.10E+5**	3.18E+7

Table notes: Type M and Type S refer to material solubility, with Type M being moderately soluble and Type S being insoluble. Values from International Commission on Radiological Protection (ICRP) 78.

Even when the Pu-241 mass percent (or isotopic abundance) is very low, it results in the highest activity concentration for weapons grade and reactor grade plutonium in these materials.

The low dose conversion factor for the plutonium-241 beta decay has often mislead analysts to neglect plutonium-241 dose contribution and even more importantly, to neglect the americium-241 in-growth from Pu-241 over the assumed 50 years that the material may be building up in the body. Plutonium and americium are highly retained in the body.

Americium-241 ingrowth from Pu-241 can account for up to 14 percent and 62 percent of the total alpha decays for weapons grade and reactor grade plutonium, according to the 2015 conference paper. This study also noted that typically bioassays are taken for Pu-238, Pu-239 and Pu-240 combined and Am-241, but without considering Pu-241. Dose calculation programs have not typically included Am-241 ingrowth unless the plutonium-241 activity was specified.

This study also noted that the transfer rates for blood compartment removal half-time from the body for plutonium and for americium are different. Pu biological transfer from the blood compartment half time is 18 hours, while the americium-241 blood compartment half time is only 0.5 hours. This also points to the greater significance of the early americium-241 urine results which were destroyed by Battelle Energy Alliance for a worker involved with the November 8, 2011 accident at the Zero Power Physics Research Reactor (ZPPR).

When the Department of Energy stated its historical the releases from the Idaho National Laboratory, typically they left out mentioning the Pu-241 and also the americium-241. They didn't want to mention these unmentionables, as sometimes the releases were due to nuclear weapons-related research. But the DOE understated the radiological releases from the Idaho National Laboratory and they underestimated the radiation doses to the public.

And when the Department of Energy continues to claim that disproportionately high concentrations of radioactive contamination in southeast Idaho from americium-241 are due to former nuclear weapons testing, and occur is higher amounts relative to plutonium-239 than would be from former nuclear weapons testing, it is time for the truth about ongoing Idaho National Laboratory weapons related radionuclide emissions.

See our recent report, *Airborne Radiological Releases from the Idaho National Laboratory and the Increasing Radioactive Contamination in Southeast Idaho,* for trends in DOE's reported INL radiological airborne effluent releases, the Department of Energy's estimated effective whole-body dose from the airborne releases, and the levels of radioactive contamination in air, milk, lettuce, wheat and soil from the DOE's environmental surveillance program. [60]

Articles by Tami Thatcher for March 2022.

[60] 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