Public Comment Submittal on the U. S. Nuclear Waste Technical Review Board (NWTRB) meeting held in Idaho Falls, Idaho, on August 29 and 30, 2023.

Comment submittal by Tami Thatcher on September 8, 2023, Revision 1

Sent by email to leslie@nwtrb.gov

BACKGROUND

The U.S. currently generates about 20 percent of the nation's electricity with nuclear reactors with 93 nuclear reactors in operation, based on Power Reactor Information database information from February 2, 2022. The number of nuclear reactors for commercial electricity generation has declined from a peak of 112 reactors to 104 reactors from 1998 to 2014 but despite varying numbers of reactors in operation, the contribution of nuclear energy to the percent of the nation's electricity generation has remained about 19 to 20 percent of the nation's electricity generation throughout those years.

Since 2016, while many reactors have been taken permanently out-of-service due to aging and not being economical to operate, there have been two nuclear reactors added (TVA's Watts Bar Unit II and one AP1000 unit at Georgia's Vogtle site). A second unit at Vogtle is finally expected to come on line next year in 2024. [1] The two light-water reactor AP1000 reactors are coming online at about double the initially expected cost and many years later than expected despite nuclear industry experts claiming that construction cost issues had been solved by modular construction.

The spent nuclear fuel from these reactors is currently generated at about 2200 metric tons per year. Spent fuel and high-level waste is currently stored at 113 sites in 39 states. [2] Many more nuclear reactors have been retiring than are being brought on line in the U.S. The U.S. currently has about 90,000 metric tons of spent nuclear fuel from commercial nuclear reactors. [3] The average age of nuclear reactors in the U.S. is over 40 years old and additional permanent reactor shutdowns can be expected due to uneconomic operation and unexpected need for repairs.

Congress created the U.S. Nuclear Technical Waste Review Board in the 1987 Nuclear Waste Policy Amendments Act (NWPA Act) to evaluate the technical and scientific validity of

[1] U.S. Energy Information Administration, as of August 24, 2023 at https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php

[2] U.S. Nuclear Waste Technical Review Board, A Report to the U.S. Congress and the Secretary of Energy, Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward," April 2021. [Current rate of spent nuclear fuel inventory is about 2,200 metric tons per year.]

[3] U.S. Department of Energy, Office of Nuclear Energy, *Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel*, April 2023. [States that at present nuclear energy generates nearly 20 percent of U.S. electricity production and that approximately 90,000 metric tons of heavy metal of spent nuclear fuel have been generation from commercial nuclear power generation.]

activities undertaken by the Secretary of Energy to manage and dispose of the nation's spent nuclear fuel and high-level radioactive waste.

The proposed Yucca Mountain repository license submittal was for 70,000 metric tons of storage, as limited by the Nuclear Waste Policy Act. Various projections for the growing amount of spent nuclear fuel have estimated, even without much new reactor deployment, 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. The amount of spent nuclear fuel will depend on the permanent shutdown of existing reactors and deployment of new reactors, which changes for year to year.

The U.S. already foreseeably needs two spent repositories the size of Yucca Mountain and doesn't have one repository. Increasing the number of operating reactors in the U.S. will greatly add to the nation's unfunded taxpayer liability for managing and disposing of spent fuel and the new reactors under development will disproportionately add to that burden. The Department of Energy has no spent fuel disposal program and had to stop collecting fees for spent fuel disposal. Even the Department of Energy is admitting that the proposed Yucca Mountain repository is not viable. No estimate of the taxpayer liability for spent nuclear fuel storage, repackaging, transportation, disposal, or reprocessing has been presented.

Lacking a permanent solution for the spent fuel, and divorced from consideration of where a repository would be sited, the DOE is now seeking a community, anywhere, to accept a consolidated interim spent fuel storage facility.

Recently the U.S. Nuclear Regulatory Commission had issued licensed for privately owned away-from-reactor consolidated interim storage facilities, one in New Mexico and one in Texas. Both states have now passed legislation opposing these facilities. Also, in August, a court of appeals ruled that the NRC did not have the authority to license the Texas consolidated interim storage facility because the authority to do so had not been given to the NRC. [4]

The U.S. Nuclear Waste Technical Review Board (NWTRB) held a summer meeting August 29 and 30, 2023. None of these important obstacles and recent experiences to siting a consolidated interim spent fuel storage facility were discussed at the August meeting regarding state opposition to private consolidated interim storage in New Mexico and Texas.

During the NWTRB meeting on August 29, three countries, Canada, Sweden and Switzerland, provided presentations on the status of their repository siting. And a description of

[4] United States Court of Appeals for the Fifth Circuit, State of Texas; Greg Abbott, Governor of the State of Texas; Texas Commission on Environmental Quality; Fasken Land and Minerals, Limited; Permian Basin Land and Royalty Owners, versus Nuclear Regulatory Commission; United States of America, No. 21-60743. Filed August 25, 2023. The court found that the Atomic Energy Act did not delegate authority to the U.S. Nuclear Regulatory Commission to license a private, away-from-reactor storage facility for spent nuclear fuel. And the Nuclear Waste Policy Act doesn't permit the NRC to authorize an away-from-reactor spent fuel storage facility. The court found that the NRC does not have authority to issue the license to the Texas consolidated spent fuel facility. The court vacated the NRC's license of the proposed Texas consolidated interim storage facility.

one past failed Nuclear Waste Negotiator effort in the U.S., in Iowa, to site consolidated interim storage in the 1990s was described.

Currently, the Department of Energy is not attempting to site a geologic repository but is seeking the figure out the messaging and the incentives to get a community to sign up to allow a consolidated interim spent fuel storage facility. The DOE emphasized that it will use a flexible, adaptive, but not yet defined approach to entice a community to sign up for consolidated interim storage. **The DOE stated that it would use carefully filtered messaging in order to persuade the community's leaders.**

On both August 29 and August 30, the DOE emphasized its outreach to states and tribes and its intention to have special consortia seeking to identify people and possible incentives that would be effective in gaining approval by a community to have consolidated interim storage of spent nuclear fuel. The DOE stated that consortia members will have ready access to DOE experts, special computerized tools and access to "unfiltered" information. **The non-tribal communities and tribes, it was stated, would not have access to DOE experts, special tools, or to "unfiltered" information.** The messaging and story-telling to attain siting that was most effective would be studied and applied by DOE.

With regard to transparency, the DOE also stated that the public would not be given or allowed access to information about its information gathering and discussions with consortia. The operation to convince and provide "incentives" to persuade a community into accepting a consolidated interim storage facility will be conducted in secrecy.

This is from a DOE consent-based siting presentation by DOE on consortia groups on August 30: ["The list of partners and States engaged is preliminary and expected to evolve" and is taken from DOE's August 30, 2023 presentation on Consent-Based Siting.]

- Group 1 American Nuclear Society and South Caroline Universities Research and Education Foundation, Northern Arizona University, University of New Mexico, South Carolina State University and City College of New York
- Group 2 Arizona State University, and "to be determined" (TBD), may include to-be-determined schools, libraries, civic organizations, faith-based organizations
- Group 3 Boise State University and National Tribal Energy Association, Arizona State, Colorado State, Idaho State, Montana State, U of Idaho, U of Wyoming, U of Michigan
- Group 4 Clemson University, South Carolina Universities Research and Education Foundation
- Group 5 Energy Communities Alliance, Partners to be determined
- Group 6 Good Energy Collective, University of Notre Dame
- Group 7 Holtec International, with Nuclear Energy Institute, U of Florida, McMahon Communications (MA), Agenda Global (DC), American Nuclear Society of IL, and Nuclear Energy Institute
- Group 8 Keystone Policy Center with Social and Environmental Research Institute, GDFWatch (UK), National Association of Regional Councils

- Group 9 Missouri University of Science and Tech with U of Missouri-Columbia (MO), U of Illinois and Taylor Geospatial Institute (MO), and St. Louis U (MO)
- Group 10 North Carolina State U, Northern Chumash Non-profit (CA), Mothers for Nuclear (CA), and Tribal Consent Based Coalition (Diablo Canyon Nuclear Power Plant, CA)
- Group 11 Rensselaer Polytechnic Institute, with Schenectady Foundation (NY)
- Group 12 Southwest Research Institute with Deep Isolation (CA), Westra Consulting (NE), Community Transition Planning (MI), Prairie Island Indian Community Tribal Nation (MN) Xcel Energy (MN), Decommissioning Plant Coalition, and Two other communities
- Group 13 Vanderbilt University with Rutgers University (NJ) and Oregon State University (OR)

A presentation on August 30 concerning spent fuel performance during dry storage was very brief but did identify worse than unexpected performance of spent fuel cladding. Larger than expected reductions of cladding yield and ultimate strengths were found after heat treatment. The reduced material strengths can facilitate creep and may have significant implications for spent fuel performance during storage, transportation and disposal. **Reduced cladding yield and ultimate strengths may have significant implications for licensing (and relicensing) of current and future systems.**

This work is tardy, incomplete and also being conducted in ways that are prone to not produce reliable results for the wide variety of fuel burnups and conditions the fuel is exposed to. The implications of unresolved problems with continued storage of spent fuel, and especially the higher burnup fuels, in terms of accident risks and costs were not discussed. The thin-walled canisters prevalently in use are welded closed and cannot be opened to inspect the fuel. There is a wide variety of spent fuel cladding types and variable conditions that the fuel can be subjected to that may compromise its condition. **Furthermore, while the fuel can be inspected while in a storage pool, there is currently no way to inspect spent fuel stored in canisters prior to transportation.**

A presentation was also provided by the DOE on enormity of the needed investigations to evaluate the safety of spent fuel storage, transportation and disposal for the wide variety of advanced reactors being proposed. The presentation addressed the "Back-End Management of Advanced Reactors (BEMAR)." The DOE believes it must continue to accept any and all new fuel designs but it all depends on murky and inexplicable DOE's General Council for creating contracts with nuclear reactor developers.

The DOE acknowledged that it had insufficient information to assess the behavior of these proposed new or advanced reactor spent nuclear fuels. The DOE is apparently compelled to accept any and all possible new fuel designs and will not put in place research to understand the fuel characteristics needed to know the safety during storage, transportation or disposal. The DOE does not plan to commence any study of the spent fuel characteristics until the reactors are

up and running and are more advanced than initial prototype reactors. The plan is to study, only belatedly, after these spent fuels are generated, the safety of the advanced fuels storage, transportation and disposal characteristics.

The DOE spent fuel research is another taxpayer liability and the belatedness of this research creates public health and safety problems that the DOE (and the U.S. Nuclear Regulatory Commission) appear to ignore and will not be discussing with communities DOE will target to seek approval for consolidated interim storage of spent nuclear fuel site(s).

I am providing written comments in addition to my oral public comments at the two days of meetings.

EXECUTIVE SUMMARY

NWTRB meetings should not deteriorate into an unquestioning pro-nuclear propaganda forum where facts about spent fuel storage safety and disposal cost and difficulties are simply avoided. The temptation has been to avoid full disclosure of the serious risks associated with dry storage and transportation and the significant knowledge gaps and weaknesses in spent fuel performance during storage, transportation and disposal, as well as their inevitable costs. Overall, the August NWTRB meeting was not conducive toward protecting the public interest.

The temptation has also been to avoid the truth of how slowly progress is being made in the U.S., and actually that it appears that there is no meaningful progress being made toward addressing the nation's growing spent nuclear fuel problem, all while the DOE is seeking to accelerate the rate of making more spent nuclear fuel.

While the NWTRB asked pertinent questions from the presenters, all too often, it seemed that ideology was given precedence over facts and the DOE was getting away with excuse-making and considerable nonsensical responses to questions. Also, the most important technical presentations were crammed into the last portion of the meeting. Insufficient time was allocated toward the ongoing but incomplete high burnup fuel study findings that point to serious deficiencies in validating the safety of fuel storage, transportation and disposal.

The nonsensical path DOE is on for "no advanced reactor left behind," no matter what it costs in terms of dollars and in safety, also did not have adequate coverage during the meeting. And despite DOE's excuses that they didn't have adequate information to know how the new small modular reactors and advanced reactors would impact obtaining deep geological disposal for the waste, other researchers have estimated that these new fuels will take up far more space in a repository, on an energy produced basis.

The nuclear waste from the variety of small modular reactors (water-, molten-salt-, and sodium-cooled SMR designs) has been evaluated and can be expected to "increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30" for each megawatt

produced. [5] The DOE is actively promoting reactor designs with no consideration of how this greatly increases the nation's spent nuclear fuel storage and disposal problems.

DOE stated in its presentations that consortia members receive money and will have special access to Department of Energy experts and to the "unfiltered" information. The public will not have access to DOE experts or to the "unfiltered" information. And the DOE stated that information sharing between DOE and the consortia will not be made public. The lack of transparency is completely unacceptable and in opposition to any aim toward good stewardship and protection of human health and the environment. In fact, it supports a lack of honesty and accountability as unidentified consortia and the DOE are seeking who and how to connive and bribe. Universities have often been continued sources of misinformation regarding nuclear issues, and they tend to seek Department of Energy and military funding with more rigor than they seek to protect human health and the environment. For-profit businesses in the nuclear industry tend to seek short-term profits and also tend to go bankrupt. Westinghouse Hitachi went bankrupt during construction of the Vogtle units in Georgia.

The persistence of the assertion by nuclear boosters that WIPP can take the nation's spent nuclear fuel is an area that the NWTRB should address the implications and truth of. The size and weight of the spent nuclear fuel canisters, the waste form and quantity, the geology as well as the existing agreements, should be examined for honest assessment of feasibility for disposal of defense waste as well as commercial spent fuel.

There remain significant gaps in the understanding of the performance characteristics in high burnup fuels now being used in U.S. commercial nuclear reactors, despite the high burnup fuels being approved by the U.S. Nuclear Regulatory Commission. These gaps mean that there is inadequate basis for concluding that spent fuel can be safely stored, transported and disposed of. **The high burnup fuels increase the problems associated with maintaining cladding integrity.**

The study of low burnup fuels put into use before about 2000 that were used in a reactor at burnups averaging about 35 gigawatt-days per metric ton of uranium (GWd/MTU) does not bound the issues for higher burnup fuel. Furthermore, the study of high burn fuels at modest burnup, above perhaps 45 GWd/MTU, does not bound the even higher burnups now being used. The longer the fuel is burned in the reactor, the more fission products and actinides such as plutonium that build up and the greater the challenges to maintain fuel cladding integrity. There is weakness in the basis for the assuming adequate safety during long term storage of spent fuel, performance during routine transportation and performance in transportation accidents, particularly in light of extended storage times and of fuels exposed to off-normal conditions during reactor operations, pool storage, transportation, etc.

[5] Lindsay M. Krall, Allison M. Macfarlane, and Rodney C. Ewing, *PNAS*, "Nuclear waste from small modular reactors," Received June 26, 2021, Published May 31, 2022, https://doi.org/10.1073/pnas.2111833119.

There are various vintages and types of zirconium fuel cladding. Zirconium cladding is thin, with thicknesses ranging from 0.2 to 0.8 mm. The zirconium cladding surrounds the stack of small uranium pellets that are from 1.0 to 1.5 cm in length and perhaps 9 to 13 mm in diameter. The length of the fuel pin or rod varies but may be 350 cm long.

There are many variables that influence fuel cladding integrity: cladding composition and manufacturing processes, average and peak burnup while used in a reactor, primary coolant water chemistry, length of time stored in a pool, the drying process used for dry storage packaging and others. But the belated investigations of cladding are limited and may not address all cladding types, operating conditions, fuel burnups, and so on. The means that considerable uncertainty remains regarding fuel cladding performance during storage and transportation and is likely to remain even after additional but not exhaustive investigations have been conducted.

Higher burnup means more hydrogen in the cladding and more challenges to maintaining cladding integrity. [6] Certain zirconium cladding types build up more oxide and experience more hydrogen absorption than others. A study conducted without determining the hydrogen concentration in the cladding may lead to erroneous conclusions, for example. The higher the hydrogen concentration in the cladding, the greater the challenge more maintaining cladding integrity.

Reduced cladding integrity means reduced safety during storage and transportation. But licensing and assertions about safety have typically been based on limited evaluations, often of low burnup fuels and only stored for short durations.

Gaps in knowledge led to identifying spent fuel research needs by 2013. The research conducted since 2013 is still largely incomplete now in 2023. The incomplete and ongoing efforts are needed to study the safety of high-burnup nuclear fuel behavior, of fuels already in use, during storage, transportation and disposal of high burnup spent nuclear fuel.

The spent fuel cladding and the spent fuel canisters are vital for the safety of spent fuel during storage and transportation. Neither the Department of Energy nor the Nuclear Regulatory Commission are ensuring the safety of spent fuel in storage or during transportation. Rather, it appears that they would rather simply promote propaganda that spent fuel storage and transportation is safe than actually have a verifiable basis for asserting that it is safe. Also, the DOE's plan for addressing advanced reactor fuels is a recipe for disaster.

The often-repeated statements that the nuclear industry is still studying canister aging issues and the consequences of thin-walled welded canister breach or the cladding integrity issues will be of no comfort when a community is forever contaminated and lives are shortened by the breach of even just one spent fuel canister.

[6] U.S. Nuclear Waste Technical Review Board, *A Report to the U.S. Congress and the Secretary of Energy – Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Sent Nuclear Fuel During Extended Storage and Transportation*, July 2021.

OVERVIEW OF MEETING PRESENTATIONS

While the siting of deep geological repositories in the three countries of Canada, Sweden and Switzerland have resulted in selecting the site for disposal, or narrowing down the potential sites to two sites as in Canada, no repository has been constructed in these countries. The cost of design and construction was not presented. The operation of spent fuel repositories is likely many decades away. The presentations focused mainly on how these countries approached gaining community acceptance and admitted that it has taken a long time and a lot of effort.

The U.S. Department of Energy is currently not studying or seeking a site for a geologic repository, but is developing a process for consent-based siting for interim above-ground consolidated storage, divorced from any connection to a proposed reprocessing or disposal site for the spent nuclear fuel.

The DOE emphasizes that its approach is flexible, adaptive and still being developed. In other words, there is no program and nothing to review.

The DOE has created the consortia of various members, including for-profit businesses, non-profits and higher education to aid in finding a willing community to site an above-ground interim storage facility. Currently thirteen groups have been identified, with seven of these including one or more universities. **DOE stated in its presentations that consortia members receive money and will have special access to Department of Energy experts and to the "unfiltered" information.**

The consortia will have available more features in software tools provided by DOE such as CURIE. Also, the DOE stated that information sharing or collection between DOE and the consortia will not be publicly released. The consortia members are to gather information about potential host communities that may be willing to engage to learn more about having a consolidated interim spent fuel facility located in their community.

The consortia are also to provide contacts and helpful information about the incentives to aid the process. The consortia are to "map public values, interests, and goals;" "innovate stakeholder engagement;" and "report outcomes and strategies."

The DOE also stated that the public would not have access to information about its information gathering and discussions with consortia. The operation to connive and bribe a community into accepting a consolidated interim storage facility will be conducted in secrecy.

The consortia members receive DOE funding. Then in Phase 1B, there is a Funding Opportunity Announcement to communities interested in learning more. This is said to enable mutual learning. DOE has stated that it is not looking for volunteer hosts in this phase.

The DOE plans to carefully craft and filter information to convince leaders and members of a community that a consolidated interim storage facility is safe and the incentives and rewards will make it worth it.

The DOE presentations emphasized engagement with communities, trust-building, and environmental justice. The DOE presentations emphasized tribal engagement and providing resources for tribal participation.

DOE's presentations listed areas of study to be "intergenerational equity" and community values and also taxpayer liabilities, but provided no meaningful information concerning any of these topics.

The final presentations of the meeting briefly presented the partially completed and unreleased results from the study of U.S. high burnup fuel. Gaps in knowledge identified in 2013 have been partially completed now in 2023. These studies are vital to understanding spent fuel performance during storage, transportation and disposal. The extent that abnormal conditions may occur such as elevated temperatures, transportation accident stresses and so forth may invalidate current assumptions and models continues to be studied.

The high burnup fuel was licensed by the U.S. Nuclear Regulatory Commission and began being used in U.S. commercial nuclear reactors, without needed studies beforehand. **Research of high burnup fuel performance is incomplete but has resulted in the unanticipated discovery of reduced yield strength and ultimate strengths in the fuel cladding following heating.** The reduced cladding performance may have significant implications for licensing (and relicensing) of current and future systems. No assessment of the safety degradation was provided and problems can be far greater with the even higher burnup fuels. Problems with DOE and non-DOE research of high burnup fuel include issues with research methods and reliability of the studies. While studies of general attributes of typical fuel may be useful, this may not be protective of certain spent fuel, that due to its combination of attributes or conditions during operation or handling or following transportation.

In regard to proposed advanced reactor designs and higher burnup fuels, the Department of Energy is actively promoting these reactors. There are perhaps 30 to 40 new reactor (and fuel) designs in the works. The DOE is agreeing it will accept responsibility for ownership, management and disposal of this wide variety of fuels. And the DOE is planning that no study of the fuel characteristics pertinent to safe storage, transportation or disposal of the new fuels will be conducted after prototype reactors are developed because DOE will wait for the later development of the commercially deployed fuels. This will mean that many years after new spent fuel types are generated, the DOE would only then commence study of the spent fuel characteristics affecting safety of storage, transportation and disposal.

In other words, the DOE's plan is to allow producing spent nuclear fuel in advanced reactors and go ahead with this **despite the lack of a validated and adequate basis for understanding the spent fuel characteristics and safety during storage, transportation and disposal.** Only after the new spent fuels are being generated will the taxpayer funded research commence on the study of spent fuel from advanced reactors.

For background information, high burnup fuel is nuclear fuel that contains more than about 3 percent uranium-235. Early commercial nuclear reactors used about 2 or 3 percent enriched in U-235 fuel. High burnup fuel of nearly 5 percent allows the fuel to be used longer in a reactor. However, as the fuel is fissioned in a reactor, radioactive fission products and neutron capture products build up. High burnup fuel builds up more fission products and has more decay heat to contend with. It also builds up more plutonium isotopes. This complicates spent fuel storage and disposal. Criticality risks during storage and disposal are also greater.

A new form of fuel called high-assay low-enriched uranium (HALEU) fuel is up to 20 percent enriched in uranium-235. This is the type of fuel TerraPower's *Natrium* and X-energy TRISO fueled reactors plan to use. While blending of existing highly enriched uranium might be used to make HALEU fuel, when used in a nuclear reactor, the spent HALEU fuel creates additional difficulties in managing of spent fuel.

DEEP GEOLOGIC DISPOSAL SITING PROBLEMS

The Department of Energy has no program for obtaining deep geologic disposal. The DOE is not allowed to collect fees for spent fuel disposal because it has no program. However, the review of international experience is relevant and appropriate for the DOE to study. The presentations by Canada, Sweden and Switzerland discussed the challenges of siting a repository and what might be learned from these limited successes. But perspective on the amount of spent fuel, as well as the type of fuel, in Sweden and Switzerland compared to the US was not made during the presentations. It should be noted that the form of the fuel in Canada from its CANDU reactors is lower enrichment and lower fuel burnup than used in the U.S (below 20 gigawatt-days per metric ton of uranium (GWd/MTU), lowering the fission product buildup, the thermal heating and the criticality risk of the CANDU fuels.

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. [7]

The Department of Energy is responsible for taking ownership of the nation's spent nuclear fuel. The Department of Energy promised to begin disposal of spent nuclear fuel by 1998. In 2010, Yucca Mountain was defunded. In 2014, "Zero Day," the Department of Energy had to stop collecting fees from rate payers for spent nuclear fuel disposal because it has no program to obtain a deep geologic repository. [8] [9]

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

[8] 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

Small reactors, some considered "advanced" reactors also create disproportionately more spent fuel, compounding already untenable spent fuel disposal issues. The design of the NuScale fuel, for example, will require more space in a deep geologic repository, on an energy equivalent basis, than large light-water reactor spent fuel. And whereas existing light-water spent fuel would fit 4 assemblies in a canister, the number of assemblies from a NuScale reactor could be restricted to 1 or perhaps less per disposable canister.

The nuclear waste from the variety of small modular reactors (water-, molten-salt-, and sodium-cooled SMR designs) has been evaluated and can be expected to "increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30" for each megawatt produced. [10] The DOE is actively promoting reactor designs with no consideration of how this greatly increases the nation's spent nuclear fuel storage and disposal problems.

Only by asking presenters did I learn that Sweden has only 14,000 metric tons of spent fuel and Switzerland has only 3500 MT of spent fuel. The U.S. currently has 90,000 MT and will soon have over 140,000 MT. The size of the proposed but never granted a license to construct Yucca Mountain facility was 70,000 MT. The U.S. already needs to plan for over 140,000 MT spent fuel in a few years.

While Canada, Sweden and Switzerland have selected disposal sites (or candidate sites), these countries are still decades away from construction and operation. The effectiveness and likely even the feasibility of these repositories is also unknown. The cost of these repositories is also unknown and needs to be addressed at least by studying a reasonable range of expected costs.

The meeting presentations focused on the ways to convince a community into accepting consolidated interim storage of spent fuel. Suggestions were made to remind people that this is "our" spent fuel and a community that accepts the waste is helping the country.

Experience has already shown that it can take decades to site a permanent repository and would take many decades to construct a repository after that.

The State of Nevada was astutely aware that the DOE's analysis claims for container robustness against corrosion and the claimed limited water infiltration and trickle-out were not just unreliable, the claims were known to be scientifically unjustified. The final stated low radiation doses from the trickle-out of radionuclides relied on the installation of thousands of undesigned and impossible to install titanium drip shields.

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[9] 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

[10] Lindsay M. Krall, Allison M. Macfarlane, and Rodney C. Ewing, *PNAS*, "Nuclear waste from small modular reactors," Received June 26, 2021, Published May 31, 2022, https://doi.org/10.1073/pnas.2111833119.

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. [11]

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 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. [12]

The Department of Energy's rapidly evolving waste emplacement concepts continued to evolve as every assumption about how the Yucca Mountain repository would contain the waste didn't hold up. Also, no utility has packaged its spent nuclear fuel into DOE's recommended "transport, aging and disposal" TAD canister.

The Department of Energy initially hand-waved away criticality concerns in the Yucca Mountain repository. After analyses were finally conducted especially for the use of higher enriched or "high burn-up" fuels, the agency began claiming that multiple criticalities in the waste repository wouldn't add that much harm to a disposal repository's already estimated harm. Criticality risks peak in 25,000 years, despite government standards for criticality risk ending in 10,000 years.

When the question of spent nuclear fuel disposal is raised, nuclear promotors decline to give meaningful answers about the enormous cost and technical difficulty. They avoid discussing the consequences of leaving spent fuel above ground in aging containers. They would never describe permanent evacuations and health catastrophe, and extensive permanent radiological contamination that will occur if spent fuel is not isolated from groundwater, freshwater and the atmosphere.

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

[12] 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

CONSOLIDATED INTERIM STORAGE SITING PROBLEMS

The DOE has no program to obtain a deep geologic repository and is seeking above-ground consolidated interim storage, divorced from the location of a repository, when at best a geologic repository is many decades away.

It may be the way that DOE wants to make it appear that progress is being made on the spent fuel waste problem. Making it appear that progress is being made may make it seem to the uninformed public and to lawmakers that producing more spent fuel is sustainable. The truth is that it is neither affordable nor sustainable.

When DOE's own staff say things like "all a community needs is five square miles of land" in order to have a consolidated interim spent fuel storage facility, they reveal their ignorance or their intention to deceive.

First of all, the size of a consolidated storage away-from-reactor is currently limited by Nuclear Waste Policy Act (NWPA). The maximum size for consolidated interim storage is 15,000 metric tons and additional size limits and requirements are included in the NWPA of 1982, as amended in 1987. The fear that the Department of Energy would seek large consolidated storage facilities and fail to achieve a deep geologic repository was addressed in the NWPA. The reason is that if there is no disposal facility, then the spent fuel has no place to go and the consolidated interim storage will not safely contain the waste over the long term. Stranded fuel at reactor sites will not safely contain the waste over the long term either. But lumping the spent fuel in one or two states helps make it seem like the issue is being solved and reduce the perceived urgency to develop real solutions.

Recently the U.S. Nuclear Regulatory Commission had issued licensed for privately owned away-from-reactor consolidated interim storage facilities, one in New Mexico and one in Texas. Both states have now passed legislation opposing these facilities. Also, in August, a court of appeals ruled that the NRC did not have the authority to license the Texas consolidated interim storage facility because the authority to do so had not been given to the NRC. [13]

SPENT FUEL DRY STORAGE SAFETY ISSUES

Spent fuel in dry storage is stored in a variety of casks or canister designs, but predominantly in thin-walled stainless steel canisters. These canisters have long been known to be susceptible to chloride-induced stress corrosion cracking and other failure mechanisms. Stating that the NRC only licenses the canisters for a few years (within 20 years) does not solve the problem of what

[13] United States Court of Appeals for the Fifth Circuit, State of Texas; Greg Abbott, Governor of the State of Texas; Texas Commission on Environmental Quality; Fasken Land and Minerals, Limited; Permian Basin Land and Royalty Owners, versus Nuclear Regulatory Commission; United States of America, No. 21-60743. Filed August 25, 2023. The court found that the Atomic Energy Act did not delegate authority to the U.S. Nuclear Regulatory Commission to license a private, away-from-reactor storage facility for spent nuclear fuel. And the Nuclear Waste Policy Act doesn't permit the NRC to authorize an away-from-reactor spent fuel storage facility. The court found that the NRC does not have authority to issue the license to the Texas consolidated spent fuel facility. The court vacated the NRC's license of the proposed Texas consolidated interim storage facility.

to do when there is no way to isolate or repair a damaged canister, whether or not the NRC license has expired.

It is acknowledged that the NRC's licensing ignored these age-related mechanisms of spent fuel canister failure in its risk assessments, using the flawed rationale that the license is only for a limited period. But what is the community going to do when a canister fails? And why has the NRC withheld a radiological dispersion analysis of a bounding case for a canister failure?

The DOE is planning to transport spent fuel to consolidated interim storage all without having a final deep geologic repository or a plan for spent fuel reprocessing. Transportation of the canisters will likely be even less safe after decades of storage in dry storage due to the fuel as well as canister aging.

The spent fuel at a consolidated storage facility, licensed for perhaps 20 or 40 years. may have no place to go when the license expires. And there are known gaps such as that the industry does not have a way to isolate a damaged canister or repair a damaged canister.

Any community accepting consolidated interim storage, especially when the canisters cannot be inspected for cracks and cannot be repaired, is courting disaster. When the spent fuel canisters fail, the gases and radioactivity will be released to the air and to the surrounding community. The DOE's tools need to include radiological dispersion computer codes for the breach of one or more spent fuel canisters, from aging or terrorism. These communities need to also understand that no method for repackaging welded-closed thin-walled canisters has been developed and none is planned for consolidated interim storage facilities. The radiological release from a single spent fuel canister can provide lethal radiation doses and extensive radiological contamination that cannot be remediated. Permanent evacuation may be needed.

Reprocessing of spent nuclear fuel is often raised and the claim was made at the meeting that spent fuel is not a "waste" but is instead a "resource." The cost and the radiological pollution must be discussed when reprocessing is suggested at the solution. The fact that reprocessing generates far greater volumes of radioactive waste must also be discussed. The reality of the extensive airborne and waste water pollution that has always accompanied chemical reprocessing must be discussed, despite various government entities not monitoring and reporting the contamination. Separation techniques such as pyroprocessing for sodium-cooled reactors involve extensive airborne radiological releases. Failure to monitor and report the radiological contamination does not mean it should be ignored. Nor should the adverse health effects from reprocessing be ignored. If reprocessing is to be pursued, the costs and environmental polluting of the reprocessing need to be addressed when the consolidated interim storage is accepted.

While the U.S. Nuclear Regulatory Commission has assumed that continued storage of spent fuel will need repackaging, no technology has been developed to repackage the spent fuel either for at-reactor sites or an away-from-reactor consolidated interim storage site.

And even though the U.S. NRC's own regulations required that welded canisters allow the fuel to be retrievable, in fact, no technology has been developed to remove the fuel once in a

welded canister. Radioactive gases and hydrogen will make this a dangerous and radiologically hazardous activity. No repackaging capability is being sought for at-reactor dry storage or consolidated storage. The plan is to wait until spent fuel canister aging creates airborne radiological catastrophes in any community with at reactor fuel storage, stranded fuel storage (where the reactor is no longer operating) or consolidated interim storage.

Consolidated interim spent fuel storage is a single barrier away from an airborne radiological release. Stranded spent fuel at reactor sites and away-from-reactor consolidated interim storage of spent fuel both have the potential for large airborne radiological releases, even if the facility is partially below grade. Canister aging, criticalities and other accidents, and acts of terrorism will cause serious airborne radiological releases, disrupting lives and requiring evacuation.

The nuclear industry has admitted that they currently have no ability to inspect canisters for cracks. They have no ability to "detect the flaws" or "understand and characterize the flaws." [14]

In 2010, the NWTRB recommended the "design and demonstration of dry-transfer fuel systems for removing fuel from casks and canisters following extended dry storage." [15] But this still hasn't happened. **No status of DOE's progress on past NWTRB recommendations was provided at the meeting, no matter how urgently action is needed.**

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 a canister be damaged. [16]

To gain an idea of the contents of a single spent fuel canister, see Table 1 below. The estimated inhalation dose may be based on out-of-date dose conversion factors.

The dose from Table 1 is for a person standing in the radiological plume 500 meters from the canister for 30 days. Also, the respirable fraction is assumed to be 1.0, consistent with Department of Energy assumptions for high burnup fuel. [17]

An acute radiation dose exceeding 400 rem is considered lethal. **The acutely high doses in Table 1 far exceed 400 rem**, and this perhaps explains why the NRC refuses to admit that a

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[14] Donna Gilmore, SanOnofreSafety.org, Press Release, "Regulators consider whether to allow San Onofre nuclear waste to be stored in defective Holtec storage system," January 24, 2019. https://sanonofresafety.files.wordpress.com/2019/01/pressrelease2019.jan24nrc2pm.pdf

[15] 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

[16] 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

[17] Department of Energy, Yucca Mountain Repository SAR, Docket No. 63-001, DOE/RW-0573, Rev. 1, https://www.nrc.gov/docs/ML0907/ML090700894.pdf Ch 1.6, Page 1.8-18 [286]

canister leak of significant size is credible. The U.S. NRC has also been eliminating requirements for canister monitoring and capability for emergency response.

Table 1. Selected commercial spent nuclear fuel inventory in a canister.

Nuclide [a]	Inventory per Assembly (Ci) [b]	Number of Assemblies	Release Fraction [c]	Release (Ci)	Eff DCF [d] (mrem/uCi)	Inhalation Dose at 500 m for 30 days (rem)
Hydrogen-3	5.0E2	36	0.15 (gases)	2700	6.40E-2	0.11
Iodine-129	3.6E-2	36	0.15 (gases)	0.1944	1.74E2	0.02
Krypton-85	5.8E3	36	0.15 (gases)	31320	0	0
Cobalt-60	3.3E1	36	1 (crud)	1188	2.19E2	166.51
Strontium-90	6.5E4	36	3E-5 (volatiles)	70	1.3E3	58.24
Ruthenium-106	1.3E4	36	3E-5 (volatiles)	14	4.77E2	4.27
Cesium-134	4.1E4	36	3E-5 (volatiles)	44	4.6E1	1.29
Cesium-137	1.1E5	36	3E-5 (volatiles)	119	3.19E1	2.43
Barium-137m	9.9E4	36	3E-3 (fines)	10692	?	?
Plutonium-241	8.0E4	36	3E-3 (fines)	8640	8.25E3	45,619
Yttrium-90	6.5E4	36	3E-3 (fines)	7020	8.44	37.9
Promethium-147	2.3E4	36	3E-3 (fines)	2484	39.2E1	623
Europium-154	6.2E3	36	3E-3 (fines)	669.6	2.86E2	122.5
Curium-244	1.4E4	36	3E-3 (fines)	1512	2.48E5	239,985
Plutonium-238	6.8E3	36	3E-3 (fines)	734	3.92E5	184,146
Antimony-125	1.9E3	36	3E-3 (fines)	205.2	1.22E1	1.6
Europium-155	1.8E3	36	3E-3 (fines)	194.4	4.14E1	5.15
Americium-241	8.8E2	36	3E-3 (fines)	95.04	4.44E5	27,007
Plutonium-240	4.0E2	36	3E-3 (fines)	43.2	4.29E5	11,861
Plutonium-239	1.8E2	36	3E-3 (fines)	19.44	4.29E5	5337
					Total (rem) At 500 m for 30 days, Inhalation dose	~400,000 rem

a. The list of radionuclides is incomplete and only includes some of the radionuclides typically contributing the most to radiation dose.

b. Inventory per assembly based on Yucca Mountain Supplement 2008, Appendix E at ML081750216. The number of pressurized water reactor assemblies involved was 36 PWR assemblies, at 5 percent enrichment, 80 gigawatt-days/metric ton uranium (GWd/MTU), and decay time of 5 years, per Appendix E of the 2008 YM Supplement.

c. Release fractions based on U.S. NRC, Dry Storage and Transportation of High Burnup Spent Nuclear Fuel, NUREG-2224, November 2020, ML20191A321, Table 3-1, for "accident-fire conditions." There are many variations in the release fractions used in past radiological release evaluations. (The release fraction for

gases (0.3), volatiles (2E-3), fuel fines (2E-3) had been assumed for oxidation release in DOE-RW-0573, Rev. 1, for high burnup fuel.)

d. The effective dose conversion factors (mrem/microcurie) are from 1999 and somewhat out of date, from a Private Fuel Storage analysis, ML010330302. Chi/Q for 500 meters is multiplied by breathing rate, 1.94E-3 (s/m^3) * 3.3E-4 (m^3/s) = 6.4E-7 must be multiplied by the curies inhaled and the effective dose conversion factor.

e. The YM Supplement does not reveal the atmospheric dilution factor used for the 11-mile dose (10,200 meters), nor were the documents cited as source documents actually revealing the atmospheric dilution factor, the Chi/Q for the public dose. (ML-90770783 did not include the public and ML090770554 available online was incomplete.) ML092360330 gives the distance to the public but not the atmospheric dilution factor, which the Department of Energy appears to go to great lengths to avoid revealing. The 2007 Bechtel SAIC report, 000-00C-MGR0-02800-000-00B is not found on NRC's Adams database. Also, according to the YM Supplement, the 95th percentile dose for a noninvolved worker for the canister scenario, Table E-11, is inexplicably lower than the 50th percentile dose. This appears to be an error. But for the 50th percentile dose, no exposure time or dilution factor given, the dose was 0.21 rem. Removing the HEPA filters would yield a 2100 rem dose to the noninvolved worker. The doses to the involved workers or workers deemed close to the canister accident are not given. In any case, a 500-rem dose is acknowledged to kill 50 percent of people in short order and based on the experience of SL-1 emergency responders said to have received 20 rem doses, the other 50 percent are not going to live more than a few years.

The NRC makes statements that a canister leakage would not exceed regulatory requirements. This sophistry doesn't mention that keeping doses below, say, 25 rem, could require permanent evacuation of residents. There is no discussion of the fact that home and automobile insurance policies exclude radiological events.

When consolidated interim storage makes it seem like progress is being made — and that storage is somewhere else in a low population zone, the temptation is to believe that the problem is being solved. Obtaining a repository becomes someone else's problem.

The experience in the U.S. is that when states become more educated about spent nuclear fuel and the lack of trustworthiness of the Department of Energy, the states object to allowing more spent fuel in their state.

Recently both New Mexico and Texas have passed laws prohibiting consolidated interim storage in their states. Texas has recently succeeded in opposing the NRC license of a private consolidated interim storage facility proposed for Andrews, Texas. Whether or not deemed lawful, building consolidated interim storage sites when there is no disposal or other disposition plan on the horizon puts the community hosting the consolidated interim storage site at risk of permanent evacuation – sooner or later.

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 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. [18]

Spent fuel cladding failure would allow the relocation of fuel pellets in a manner that could increase the criticality risk, particularly during transportation. The consequences of a gross breach of spent fuel cladding on criticality risk during transportation is the subject of ongoing study and the radiological consequences have not been disclosed. [19]

In fact, informed consent cannot be given by a community that does not have access to the actual accident risks and accident consequences, which the DOE and the NRC are withholding.

MORE SPENT FUEL DRY STORAGE SAFETY ISSUES REGARDING THIN-WALLED WELDED CANISTERS

The use of thin-walled welded canisters for dry fuel storage systems began because commercial nuclear utilities were running out of space to store spent fuel in their spent fuel pools. It had been assumed that the spent fuel would be shipped away for reprocessing but that proved uneconomical and highly polluting. It was then assumed that the Department of Energy would commence taking the spent fuel for disposal in a repository by 1998 but that didn't happen. However, when canister systems were being designed and licensed, engineering shortcuts and cost-cutting was based on the flawed assumption that these canisters would only be in service for perhaps twenty years. The NRC did not require a canister repackaging system to be designed although it has assumed such a system is needed to support continued storage of spent fuel. It was likely assumed that it would become the Department of Energy's problem to design a way to open the canisters to replace aging canisters or to load the spent fuel into containers deemed appropriate for disposal.

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. [20] 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.

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[18] 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

[19] U.S. Nuclear Waste Technical Review Board, *A Report to the U.S. Congress and the Secretary of Energy – Evaluation of the Department of Energy's Research Program to Examine the Performance of Commercial High Burnup Sent Nuclear Fuel During Extended Storage and Transportation*, July 2021. See page 29 and 39.

[20] 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/

In a study for the Department of Energy published in 2015, eight proposed methods for cutting open non-disposable canisters were evaluated, [21] indicating that no method has actually been fully designed or used.

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." [22] 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. [23]

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 deem the events as not credible.

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

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[21] 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 or https://archivedproceedings.econference.io/wmsym/2015/papers/15388.pdf

[22] 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

[23] 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

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

PFS. [25] Regarding the proposed PFS consolidated interim storage facility, the NRC claimed the problem didn't exist because the canisters at PFS would be shipped back to the utilities.

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

The NRC who licenses an authorized dry storage facility doesn't seem to care if there is no place to return the spent fuel canisters to and no financial resources to ship or repackage the canisters upon expiration of the license and no system developed for canister repackaging.

Instead of using thin-walled welded canisters that cannot be adequately inspected or repaired, the Swiss required the use of bolted thick-walled metal casks. They store them in a building, away from environmental exposures such as ocean salt spray air, for example. The Swiss require a hot cell for repackaging a cask if needed. [26]

INFORMED CONSENT AND RADIATION HEALTH HARM

The community contemplating hosting a consolidated interim storage site should have access to radiological dispersion codes. And the radiological harm from radiation inhalation, ingestion or external radiation needs to be based on the known harmful effects of radiation to humans.

The community has the right to know how an aging canister's radiological release or how sabotage can make their community unlivable. Community leaders need to review currently unresolved issues for dry storage spent fuel systems licensed in the U.S. [27]

The radiation exposure from routine operations, from transportation and from breach of spent fuel canisters need to be correctly assessed. Worker's radiological exposures as well as radiological exposures along the transportation routes need to be understood for the real effects, not the low-balled estimates the DOE has typically used, for radiation dose conversion factors.

The Health Physics Society in the U.S. still states on its website that there is no discernable health harm below 10 rem. [28] This is despite many studies that find cancer harm even at doses below 10 rem and received in incremental doses.

The Department of Energy has continued to ignore the study of over 300,000 radiation workers that also showed higher than expected cancer risk to adult workers. [29] [30] The study of

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[25] 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.

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

[27] Seirra Club letter to the U.S. Nuclear Regulatory Commission, RE:Advanced Notice of Proposed Rulemaking (ANPR): Regulatory Improvements for Decommissioning Power Reactors, Docket ID NRC-2015-0070, March 21, 2016. https://www.nrc.gov/docs/ML1608/ML16082A004.pdf

[28] See Health Physics Society, "Radiation Benefit and Risk Assessment" at https://hps.org. Accessed July 17, 2023.

over 300,000 radiation workers found elevated cancer risks in adults, mostly men, exposed to doses below perhaps 400 millirem per year and for only about a decade.

In the 1950s, Dr. Alice Stewart found increases in childhood leukemia and cancer rates in children who were exposed *in utero* to medical radiation in doses less than 500 millirem. [31] [32]

Before the late 1990s, radiation risks to females were generally treated as roughly equal to the radiation risks to males. But by the late 1990s, studies of the survivors of the atomic bombing of Japan in 1945 by the International Commission on Radiation Protection (ICRP) had higher radiation risk harm to women than men, for the same dose. And the studies showed higher cancer risk to children, especially female children, than to adults for the same dose. The National Research Council BEIR VII report issued in 2006 found even higher risks to women and children. [33] [34] [35]

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. [36]

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[29] David B. Richardson et al., "Risk of cancer from occupational exposure to ionizing radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS), BMJ, v. 351 (October 15, 2015), at http://www.bmj.com/content/351/bmj.h5359 Richardson et al 2015] doi: 10.1136/bmj.h5359. (This cohort study included 308,297 workers in the nuclear industry. Also, please note that studies of high leukemia risk in radiation workers and of ongoing studies to assess health effects of high and low-linear energy transfer internal radiation must also be studied in addition to this one on external radiation.)

[30] David B. Richardson et al. Department of Epidemiology, University of North Carolina, Chapel Hill, North Carolina, "Site-specific Solid Cancer Mortality After Exposure to Ionizing Cohort Study of Workers (INWORKS)," *Epidemiology*, January 2018. PMC 2019 January 01.

[31] Gayle Greene, *The Woman Who Knew Too Much – Alice Stewart and the Secrets of Radiation*, The University of Michigan Press, 1999. ISBM 0-472-11107-8

[32] John W. Gofman, M.D., Ph.D., Committee for Nuclear Responsibility, Inc., "Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis," 1990. (See page 741, "Diagnostic irradiation on the order of 1 to 2 rads, delivered to the fetus in utero provoked about a 50% increase in the frequency of a variety of childhood cancers and of childhood leukemia." And page 746, "the risk in cancer-leukemia risk with each additional film is consistent with a linear relationship between number of films (@ 200-400 millirads per film) and cancer-leukemia risk.)

[33] "Health Risks from Exposure to Low Levels of Ionizing Radiation BEIR VII – Phase 2, The National Academies Press, 2006, http://www.nap.edu/catalog.php?record_id=11340 The BEIR VII report reaffirmed the conclusion of the prior report that every exposure to radiation produces a corresponding increase in cancer risk. The BEIR VII report found increased sensitivity to radiation in children and women. Cancer risk incidence figures for solid tumors for women are about double those for men. And the same radiation in the first year of life for boys produces three to four times the cancer risk as exposure between the ages of 20 and 50. Female infants have almost double the risk as male infants.

[34] Arjun Makhijani, Ph.D., Brice Smith, Ph.D., Michael C. Thorne, Ph.D., Institute for Energy and Environmental Research, *Science for the Vulnerable Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk*, October 19, 2006.

[35] Read the Environmental Defense Institute August 2020 newsletter article, "Rising radiation-induced cancer incidence rates and higher risks to women and children," at http://www.environmental-defense-institute.org/publications/News.20.Aug.pdf

[36] 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

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. [37]

The US NRC cancelled what would have been the first meaningful epidemiology study of health effects near US nuclear reactors, [38] despite the German epidemiology study of children living near nuclear plants having 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. [39] [40] [41]

The U.S. NRC refused to pay $8 million for the new study, and preferred the results from a National Cancer Institute study [42] that was designed to not find evidence of elevated health risks. Basically, the NCI study relied on comparing people living near nuclear power plants to people living near nuclear power plants. Unsurprisingly, they didn't detect excess risk from living near nuclear power plants.

How can a community make informed consent when the Department of Energy (and the Health Physics Society) refuse to acknowledge long known health risks below 10 rem?

And beyond cancer and leukemia health risks, at low doses, as low as 200 millirem that increase the risk of birth defects, increase the rates of infant mortality, and increase the rates of low-birth-weight babies and cause other adverse health impacts.

The DOE still refuses to acknowledge the harm of low dose and low dose rate radiation to human beings. The DOE is not protecting adult workers adequately, particularly since females

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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.

[37] 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.

[38] 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.

[39] 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

[40] 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

[41] 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.

[42] S. Jablon et al., *Cancer in Populations Living Near Nuclear Facilities*, Washington: National Cancer Institute, National Institute of Health, publication #90-874, July 1990.

are more vulnerable to radiation. And the DOE has long ignored what has been known about the increased harm to children and the child developing in utero.

In addition to increased rates of cancer and shortened life spans, elevated nuclear releases also coincide with increased infant mortality, increased rates of birth defects, low-birth weights, lowered intelligence in children, comprised immune systems and increases in other illnesses.

PAST NUCLEAR WASTE NEGOTIATOR EXPERIENCE

The presentation about seeking a community in Iowa to accept a consolidated interim storage facility showed some of the difficulties of gaining acceptance. Unfortunately, the presentation was based on the mistaken presumption that a few decades of successful dry storage means that there are no undue risks.

The longevity of the radionuclides that will be released from an accident is typically not discussed. The radiation doses to workers inspecting the dry storage are typically not discussed. The full range of adverse health impacts resulting from radiation exposure is typically not discussed. The likely inadequate compensation for lives, property and homes is typically not discussed. Exactly how is a community expected to provide "informed" consent?

The Department of Energy's current emphasis is on crafting a very filtered story to omit or downplay the down side of hosting a consolidated interim storage site. The presentation to the NWTRB about nuclear waste negotiator experience in Iowa showed one failed example but the failed effort in Utah for the Private Fuels Storage at the lands of the Skull Velley Band of Goshute Indians in Utah is another story of failure. And the years of effort to obtain consolidated interim storage has failed even after a community (or tribe) agrees to accept the short-sighted consolidated interim storage facility.

It was pointed out that consolidated storage, or a repository for that matter, does not generate tax income. It is also important to point out that the increasing tax breaks sought for nuclear reactors and their large requests for taxpayer bailouts also mean that nuclear reactors also may not be counted on for state tax income.

The risks to first responders in the event of an accident remains under appreciated. At the Idaho National Laboratory, fire fighters have on more than one occasion responded to a fire alarm and were completely unaware that a radiological event was in progress. This happened in 2018 at the Idaho Cleanup Project at the Idaho National Laboratory when four drums overpressurized and forcefully expelled their contents.

The training of first responders was mentioned at the meeting as people likely to convince the city mayor that a consolidated interim storage facility would be safe, and yet the adequacy of training and radiological instrumentation for first responders is likely to be far less than that of the fire fighters at the Idaho National Laboratory, who keep being put in harms way without adequate radiological monitoring. Transuranic waste shipments for contact-handled waste, and

for remote handled waste may differ from transportation of spent nuclear fuel. Timely and adequate radiation dose monitoring is not likely to be available to the first responders or the public in the event of an accident. And small naval fuel shipments may have different vulnerabilities than large commercial spent fuel shipments. The safety of certain specific shipments does not imply the safety of all radioactive material shipments. The variety of conditions that may result in criticality, or loss of neutron shielding, or cask or canister breach and gaseous and particle releases or compromised shielding involve different kinds of radiological monitoring and the situations can be dynamic.

In addition to potential accident radiation exposures, the elevated radiation doses from routine shipments are not trivial, especially for fertility and the developing unborn child. The potential brainwashing of first responders is not indicative of the adequacy of their training or the safety of storage and transportation of radioactive materials, as implied during the meeting.

Consolidated interim storage is vulnerable to having the spent fuel stranded there, with no place to go, far beyond the initial licensing period. Consolidated interim storage is vulnerable to terrorist attacks. Consolidated interim storage is vulnerable to canister breach events that may release radioactive gases and particles in lethal amounts and in amounts that can never be remediated.

The compensation to the public following an accident or act of terrorism at a consolidated interim spent fuel storage facility likely will not be sufficient to compensate those harmed. The level of compensation will depend on a court acknowledging the damages and on the federal government providing compensation. Similar to the Three Mile Island accident, the monitoring will be conducted by those who wish to withhold the true extent of the harm. The Price-Anderson Act compensation for dry storage of spent fuel accidents is likely to be inadequate and communities with at-reactor storage as well as at a consolidated interim spent fuel facility need to know this.

Overall, the August meeting's review of history and case studies was conducted as though the history and current events pertaining to consolidated interim storage were unknown to the presenters or were being actively ignored.

ONGOING PROBLEMS WITH DOE'S TRUSTWORTHINESS

The DOE's trustworthiness is an acknowledged problem. The past actions of DOE's predecessor, the Atomic Energy Commission, include nuclear weapons testing decades ago in New Mexico during the Trinity test, nuclear weapons testing in the Pacific Islands and at the Nevada Test Site. The DOE lied about the harm to Marshal Islanders, as well as the harm to U.S. citizens harmed by the wide-spread radioactive fallout from these tests. The AEC sought to withhold adverse epidemiological findings of the public and of radiation workers.

It is relevant now to point out the numerous ways that the Department of Energy, still, today, withholds information from the public on matters of safety and is not trustworthy. When the DOE holds environmental impact meetings, such as the one for the microreactor under Project

Pele. The DOE would not allow its own expert to take any questions from the public during the public meeting for the project.

In Idaho, the DOE pervasively withholds information from the public about violations it is cited with and about unsafe conditions such as those that required shipments of transuranic waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico, to be returned to the Idaho Cleanup Project (see DNFSB.org). The DOE's contractor withheld information from the public on these safety lapses and the DOE purposefully withheld information about these safety lapses to its own Idaho Cleanup Project Citizens Advisory Board.

The Department of Energy, in its environmental impact statements, lists pertinent DOE Orders and Regulations as explaining how the DOE conducts its operations safely. The truth of the matter is exemplified by the DOE's actions at the Los Alamos National Laboratory (LANL). **The DOE chose to not meet its own requirements and chose to put citizens in New Mexico at grave risk of health harm and permanent evacuation of their homes by refusing to make needed safety upgrades at the PF-4 facility at LANL.** The DOE conducted operations that allowed potential accident doses far exceeding 25 rem, and far exceeding DOE's own safety requirements. The DOE can and has, at whim, decided not to follow its own regulations and to allow egregiously high radiological risks to communities that may render vast areas permanently contaminated. And it has done so, saying that it had the taxpayer interests at heart while at the same time giving away billions of dollars to nuclear developers like Bill Gates' TerraPower.

That needed safety upgrades at LANL were largely delayed and then cancelled put citizens in New Mexico at risk, see the Defense Nuclear Facilities Safety Board meeting for 2022. The DOE's irresponsible failures over more than a decade to provide safety upgrades that DOE knew were needed is inexcusable and cost was the primary excuse.

The Department of Energy uses cost as the excuse to shortcut safety, putting workers, the public and the environment at risk, while simultaneously acting as though huge and growing taxpayer liability for managing spent nuclear fuel does not matter.

THE GROWING TAXPAYER LIABILITY FOR MANAGING SPENT NUCLEAR FUEL

No government agency and certainly not the Department of Energy or the Nuclear Regulatory Commission is disclosing serious taxpayer liability issues with the existing nuclear industry or expansion of nuclear energy.

The DOE needs to explain why it continues promoting creating more and more spent nuclear fuel when it has no permanent solution for the spent fuel, for reprocessing waste, and these reactors cannot possibly be deployed in time to combat climate change. Some NWTRB board members seem to be comfortable assuming the nuclear energy is required to solve climate change and this is allowed to go unchallenged, unfortunately. Nuclear energy cannot be deployed in time to combat climate change; but making more spent fuel digs the U.S. into a deeper and more expensive problem that it is making no progress solving.

The DOE has an unfunded spent fuel disposal liability for the repackaging, transportation and the disposal of spent fuel. The liability is so large that DOE refuses to estimate the cost. Because the DOE has no spent fuel disposal program, it had to cease collecting fees for disposal. The money collected for spent fuel disposal so far would likely not even pay for the repackaging of the spent fuel for disposal. The fact that small reactor fuels and advanced fuels are add research costs and also will take up more space in a repository needs to be discussed. Estimates show that the space in a repository needed for the proposed small reactors will require 2 to 30 times more space on an electricity generated basis. The U.S. already needs two repositories the size legally mandated for Yucca Mountain and it doesn't have one repository. With nuclear energy generating only about 20 percent of the electricity in the U.S., doubling the electricity generation from nuclear energy would not do much to combat climate change, but it will add to an already enormous taxpayer liability.

The compensation to the public for nuclear accidents from spent nuclear fuel during storage or transportation is also a taxpayer liability and will cost everyone while at the same time, not assuring compensation for lost lives, homes and homeland. The relevant case study in the 1986 Chernobyl accident which was so costly and disruptive that it broke apart the Soviet Union. The actual cost of the 2011 nuclear disaster at Fukushima shows that even though much airborne radioactivity blew toward the ocean, the contamination and the cost of dealing with the meltdowns are still mounting, over a decade after the accident.

Tami Thatcher of Idaho Falls, Idaho has studied and written about nuclear issues including nuclear facility safety, environmental contamination, radiation health issues for nuclear workers and the public for more than ten years. She has a degree in mechanical engineering (BSME) and worked at the Idaho National Laboratory as a radiation worker and as advisory engineer and nuclear safety analyst with specialty in nuclear reactor probabilistic risk assessment. Her articles and reports are available on the Environmental Defense Institute website at www.Environmental-Defense-Institute.org.