# Environmental Defense Institute

News on Environmental Health and Safety Issues

**February 2021** **Volume 32** **Number 2**

## INL provides marketing propaganda for TerraPower (and X-energy) and no mention of safety and waste disposal problems

The public was welcomed to tune in to an Idaho National Laboratory webinar promoting the recipients of Department of Energy nuclear research funding. But there was no discussion of nuclear waste disposal problems or nuclear reactor accident consequences. And with their stated goal of building reactors for other countries, to somehow solve ***energy poverty*** with the most expensive form of energy there is, their answer to nuclear weapons proliferation concerns was basically, "don't worry, be happy."

Idaho Representative Mike Simpson is a staunch supporter of the handouts of millions of dollars to TerrraPower, with founder Bill Gates, and GE Hitachi Nuclear Energy (GEH) and their Natrium reactor, a "cost-competitive" sodium-cooled fast reactor combined with a molten salt energy storage system. The fast reactors that have been built have been money pits, often spending more time being repaired than operational. [1]

The economics of sodium-cooled fast reactors have been awful. The U.S.-built Fast Flux Test Facility operational in 1980 at the Department of Energy's Hanford site, cost over $10,000 per kilowatt. Japan's Monju cost over $20,000 per kilowatt, according to IEER. [2]

Sodium-cooled reactor promotors are touting the low pressure that the reactor runs at but not mentioning that the sodium metal explodes upon contact with air or water. They also don't mention that fast reactors are the most ***inherently unsafe and unreliable reactors*** available. Boil the liquid sodium and the reactor may go prompt critical and explode. "Core disruptive accidents" are a particular problem for fast neutron plutonium fueled reactors. To build TerraPower's Natrium sodium-cooled reactor is to invite nuclear disaster.

**The high plutonium content of the fuel makes safety, transportation and disposal especially problematic.** The TerraPower cartoon schematic shows plenty of vulnerability to ocean or river flooding, which is referred to as "external flooding" in safety evaluations and all the other accident risks fast reactors are vulnerable to.

---

[1] Arjun Makhijani, Ph.D., Institute for Energy and Environmental Research, *Traveling Wave Reactors: Sodium-cooled Gold at the End of a Nuclear Rainbow?* September 2013. https://ieer.org/wp/wp-content/uploads/2013/09/TravelingWaveReactor-Sept20131.pdf

[2] Arjun Makhijani, Ph.D., Institute for Energy and Environmental Research, *Traveling Wave Reactors: Sodium-cooled Gold at the End of a Nuclear Rainbow?* September 2013. https://ieer.org/wp/wp-content/uploads/2013/09/TravelingWaveReactor-Sept20131.pdf

Perhaps Simpson believes, that despite the U.S. inability to be able to afford nuclear waste disposal and inability to achieve safe disposal, making more spent nuclear fuel waste, will somehow ***solve energy poverty***. Yet, the Department of Energy cannot bring itself to actually tally an estimate of the trillions of dollars it's going to cost for disposal of existing spent nuclear fuel. But, somehow the most expensive form of electricity generation, the unutterable costs of nuclear waste storage and disposal, and nuclear weapons proliferation issues which require security to protect the fuel — promotors claim, *will solve energy poverty*. It's like a bad plot in a 007 movie.

There is so little desire for these reactors in the U.S. that there seems to be an international pot of money, that when palms are greased, will allow these companies to tap into millions of dollars so they can profit as they attempt to build the very expensive nuclear reactors in places around the world. No one who actually cares about energy poverty would attempt to saddle these countries with nuclear waste and the risk of nuclear accidents.

Partnering with TerraPower is GE Hitachi, the company that has unsuccessfully promoted the GEH PRISM reactor, based on the design of the Experimental Breeder Reactor II (EBR-II) built at the Idaho National Laboratory. Since the 1990s privatization, no one has wanted to build one.

TerraPower and GE Hitachi are teaming up to design the Natrium reactor, a sodium-cooled fast reactor. After the Department of Energy blocked Bill Gates from working with China in 2018, [3] Congress stepped in with the Nuclear Energy Leadership Act, so Bill Gates could get the U.S. taxpayer to pay for his testing facility, the Versatile Test Reactor as well as get generous U.S. taxpayer grants to come up with glowing adjectives and perhaps a workable reactor design.

**TerraPower and GE Hitachi (GEH) are teaming up to present all the best adjectives to describe their nuclear reactor design research, while omitting all the downsides to their technology.** Similar glowing adjectives — ***Safe, Affordable, Flexible, Factory-built, Clean***, ***Stream-lined Licensing*** —accompany other nuclear reactor research efforts.

Both the Traveling Wave Reactor and the PRISM design are sodium-cooled fast reactors with fuels that involve liquid sodium inside the fuel rod as well as liquid sodium as the reactor coolant. The liquid sodium inside the fuel must be removed before disposal, adding costs to spent fuel handling and would require pyroprocessing facilities to remove. [4] The Traveling Wave Reactor was envisioned to produce plutonium in the core from uranium-238, rather than in a blanket of uranium-238 on the outer perimeter of the core, like the EBR-II.

---

[3] Ross Pomeroy, RealClear Science, "Why Aren't We Building a Traveling Wave Reactor in the U.S.?" November 26, 2019. https://www.realclearscience.com/blog/2019/11/26/why_arent_we_building_a_traveling_wave_reactor_in_the_us.html

[4] U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017. See Figure 5-8, Electrometallurgical treatment of sodium-bonded spent nuclear fuel at Idaho National Laboratory, for example. Very small batches of spent fuel can be treated in a facility and radioactive gases released poison people living nearby.

Many of the claims made in the past about the Traveling Wave Reactor were simply untrue and not feasible. The Traveling Wave Reactor design concept has evolved from claiming 100 percent uranium utilization to just 15 percent. And the Traveling Wave Reactor was claimed to not require reprocessing of the spent fuel, but that is also untrue. The spent nuclear fuel reprocessing via electrorefiner or "pyroprocessing" would be required to remove the sodium from the internal of the fuel assemblies, it can be fashioned to extract plutonium for weapons. The disposal issues present additional problems because of the high burn up of the fuel.

But there is no one to hold TerraPower accountable for its overly rosy or entirely fictional claims. Instead, vast wealth shifting from the U.S. taxpayer to TerraPower and others is happening based on unproven adjectives about proposed designs.

U.S. Nuclear Regulatory Commissioner Kristine Svinicky touts that more former Department of Energy employees are taking key roles at the NRC. Congressmen like Mike Simpson press for streamlined licensing of new reactor designs. And the experience with NuScale's U.S. Nuclear Regulatory Commission licensing shows that the time allotted and the outcome of the licensing review are both predetermined. The NRC approved the design on schedule while leaving important safety issues unresolved, putting off resolution of the issues for later. [5] This does not bode well for nuclear reactor safety in the U.S.

Fuel and materials testing to support Bill Gates venture will be conducted in the Versatile Test Reactor envisioned for the Idaho National Laboratory which will use surplus plutonium, rather than breed the plutonium-239. But all fast reactors are involved with fissioning plutonium, which does not require a moderator such as water to slow down the neutrons to fission uranium-235. The ability to fission without a moderator makes criticality during storage, transportation and after disposal a substantial problem.

## Department of Energy gives research money for high-temperature gas-cooled reactor designer X-energy

Not only are inherently unsafe sodium-cooled fast reactors being funded, the Department of Energy is also gifting research money to high temperature gas-cooled reactor designer X-energy. [6] Their Xe-100 is the only Gen IV reactor deployable within 5 years and they also foresee growth in foreign energy markets. X-energy is partnering with Energy Northwest to design a commercial-scale Xe-100 advanced reactor, a high temperature gas-cooled reactor by 2027. The Xe-100 would be 80 MW electric (MWe), and scalable to a 320 MWe four-pack. The Xe-100 would use TRISO fuel like the troubled Fort St. Vrain nuclear reactor.

---

[5] Environmental Defense Institute's November 2020 Newsletter article "U.S. Nuclear Regulatory Commission cautions that its recent NuScale approval does not mean NRC will approve a NuScale construction permit or an operating license" at http://www.environmental-defense-institute.org/publications/News.20.Nov.pdf

[6] X-energy, X-energy awarded $80 Million for the Department of Energy's Advanced Demonstration Program (ARDP), October 14, 2020. https://x-energy.com/media/news-releases/x-energy-awarded-80-million-department-of-energy-advanced-reactor-demonstration-program-ardp

There have been several gas-cooled reactors built. Germany operated the THTR, a 750 MW-thermal pebble-bed reactor (FRG) from 1985 to 1991. [7] In the U.S., the Department of Energy research included the Peach Bottom high temperature gas-cooled reactor (40 MWe) and the Fort St. Vrain (330 MWe) high-temperature gas-cooled reactor. [8] Fort St. Vrain was based on the Peach Bottom reactor design and used a fuel that was a mixture of carbides of uranium and thorium with TRISO coatings.

The Fort St. Vrain reactor was high-temperature gas-cooled reactor. It was helium-cooled, graphite-moderated, and *operated between unplanned repairs* between 1979 and 1989. The Fort St. Vrain reactor used TRISO fueled, using high enriched in uranium-235 and thorium-uranium carbide particles. The Fort St. Vrain reactor was plagued with problems. [9]

The high-temperature gas-cooled reactor Fort St. Vrain nuclear reactor suffered cost overruns in construction and operation, continuous breakdowns and was a huge financial failure. It had corrosion problems and it was shut down for repairs most of the time, with average capacity of only 14 percent. [10] Moisture in-leakage into the helium-cooled reactor degraded the control rod drives and reserve shutdown systems. [11] Six control rod pairs failed to scram during an event on June 23, 1984. This represented a significant safety hazard for the nuclear plant despite some claims to the contrary. Helium leaks were a challenge. Moisture in the helium coolant also degraded the nuclear fuel, caused by hydrolysis of the fuel particle coating of the TRISO fuel. [12]

Regarding waste disposal, something the Department of Energy is actively ignoring, according to the 2017 U.S. Nuclear Waste Technical Review Board report, [13] "Chemical reactivity of DOE SNF affects how some SNF is stored. For example, SNF from helium-cooled reactors that contains coated carbide fuel particles — such as that from the Peach Bottom Unit 1 Core at INL and FSV [Fort St. Vrain] SNF, which is at both INL and FSV — is stored in a gas environment (helium or nitrogen) within containers … because if the coatings on the carbide particles are damaged, the carbide will react with water to produce flammable gases."

---

[7] J. M. Beck and L. F. Pincock, Idaho National Laboratory, High Temperature Gas-cooled Reactors Lessons Learned Applicable to the next Generation Nuclear Plant, INL/EXT-10-19329, Revision 1, April 2011. https://inldigitallibrary.inl.gov/sites/sti/sti/5026001.pdf

[8] J. M. Beck and L. F. Pincock, Idaho National Laboratory, High Temperature Gas-cooled Reactors Lessons Learned Applicable to the next Generation Nuclear Plant, INL/EXT-10-19329, Revision 1, April 2011. https://inldigitallibrary.inl.gov/sites/sti/sti/5026001.pdf

[9] U.S. Nuclear Waste Technical Review Board (NWTRB, Factsheet Fort St. Vrain. https://www.nwtrb.gov/docs/default-source/facts-sheets/doe-snf-fact-sheet---fort-st-vrain-rev-1.pdf?sfvrsn=14

[10] Cathy Proctor, *Business Journal*, "Fort St. Vrain power plant reborn after checkered past," June 10, 2001. https://www.bizjournals.com/denver/stories/2001/06/11/story3.html (converted from nuclear to fossil fuel)

[11] D. A. Copinger and D. L. Moses, ORNL Prepared for U.S. NRC, "Fort Saint Vrain Gas Cooled Reactor Operational Experience," NUREG/CR-6839, September 2003. https://www.nrc.gov/docs/ML0403/ML040340070.pdf

[12] D. A. Copinger and D. L. Moses, ORNL Prepared for U.S. NRC, "Fort Saint Vrain Gas Cooled Reactor Operational Experience," NUREG/CR-6839, September 2003. https://www.nrc.gov/docs/ML0403/ML040340070.pdf

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

The NWTRB factsheet, however, says that Fort St. Vrain spent nuclear fuel does not require a storage with an inert gas (e.g., helium). [14] The Department of Energy never completed the design of proposed "standardized canister" and associated neutron absorbers required for the spent nuclear fuel stored at the Idaho National Laboratory to be repackaged. But DOE has estimated that all Fort St. Vrain spent nuclear fuel stored at the INL and in Colorado would require approximately 500 DOE canisters, **disproportionately high relative to the metric tons of the fuel because of the high enrichment of the fuel**, according to the NWTRB factsheet. The reason is the high enrichment, 93.5 percent uranium-235 and the breeding of uranium-233. Just one year of storage of the spent nuclear fuel from the unsuccessful decade between 1979 and 1989 of Fort St. Vrain reactor operation costs the U.S. taxpayer about $11 million dollars for dry storage in Colorado, according to recent Department of Energy budget estimates. Repackaging of the Fort St. Vrain spent nuclear fuel in Colorado is expected to require shipment to the Idaho National Laboratory, if and when a repackaging facility is built. The canisters that the spent nuclear fuel would be loaded into at the INL repackaging facility are the DOE "standardized" canisters which currently have not been designed or licensed.

It is important to note that the design of the spent nuclear fuel repackaging facility that would be built at the Idaho National Laboratory does not include the technology or capability to repackage the welded-closed canisters used in the majority of dry spent nuclear fuel from commercial nuclear power plants. That spent fuel repackaging technology has not been developed. But nonetheless and without concern for the cost to the U.S. taxpayer, the U.S. Nuclear Regulatory Commission assumes that the repackaging of spent nuclear fuel at 75 commercial nuclear sites around the country will be available, when needed, to repackage the waste repeatedly, until a repository is available. [15]

Gas-cooled reactors are prone to problems including air-ingress and material corrosion issues. But even if the X-energy nuclear accident risk is less (and anything would be safer than a sodium-cooled fast reactor), ***there remains the gaseous radiological releases during operation, radiological releases from accidents or sabotage and the so far unsolved and exorbitant cost of spent nuclear fuel disposal.***

Maximized spending appears to be the main but unspoken point of the Department of Energy's research spending on nuclear – **all while DOE is not doing the research to address the large, looming and growing spent nuclear fuel waste disposal problem**. Finally, to make a dent in gas and oil use would require so many nuclear reactors generating more spent nuclear fuel that a new Yucca Mountain repository would be needed every year [16] …. which alone is reason enough to stop this madness.

---

[14] U.S. Nuclear Waste Technical Review Board (NWTRB, Factsheet Fort St. Vrain. https://www.nwtrb.gov/docs/default-source/facts-sheets/doe-snf-fact-sheet---fort-st-vrain-rev-1.pdf?sfvrsn=14

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

[16] Edited by Allison M. Macfarlane and Rodney C. Ewing, *Uncertainty Underground Yucca Mountain and the Nation's High-Level Nuclear Waste*, The MIT Press, 2006. Page 4.

# West Valley Nuclear Fuel Reprocessing Plant Waste Disposal Costs Unknown, According to GAO

A January U.S. Government Accountability Office (GAO) report GAO states that the costs to complete cleanup at the West Valley Demonstration Project in New York are currently unknown. [17] The spent nuclear fuel reprocessing venture in New York operated for a short time between 1966 and 1972 by Nuclear Fuel Service, Inc. and reprocessed a scant 640 metric tons of spent nuclear fuel to recover plutonium and uranium. Approximately 60 percent of the fuel, including 33 percent of the plutonium, came from the Department of Energy's predecessor, the Atomic Energy Commission (AEC), and from N-Reactor at the Hanford site. The rest came from seven commercial nuclear power plants in the U.S. The DOE considers the wastes to be from civilian spent nuclear fuel reprocessing.

Here are things to remember about spent nuclear fuel reprocessing. Spent nuclear fuel reprocessing was very expensive, and has been estimated at about 10 times what nuclear utilities were required to pay into the Nuclear Waste Fund. [18] Spent nuclear fuel reprocessing releases radioactive contamination to air, water and soil that is rarely completely reported or monitored. And costs for even partial cleanup are billions of dollars — and as for every nuclear venture, the complete cost of cleanup and disposal is unknown (but will be high). And there is no disagreement: the consequences of not disposing of or forever repackaging the spent nuclear fuel will have devastating consequences on human health and the environment as the spent nuclear fuel remains radiotoxic for millennia.

Since 1972, the U.S. taxpayer has been saddled with treating the spent fuel and nuclear waste at the West Valley site. Nuclear Fuel Services, Inc. left behind 600,000 gallons of liquid high-level radioactive waste in two aging underground tanks; a highly contaminated Main Plant Process Building; and more than 2 million cubic feet of buried solid radioactive waste. Not mentioned in this GAO report, GAO-21-115, is the spent nuclear fuel that was left in the spent fuel pool, which has been moved to the Idaho National Laboratory for long-term storage, repackaging and perhaps, someday, disposal.

There are no facilities authorized to accept the solidified high-level waste from treating the liquid waste in the tanks and no facilities authorized to accept the non-defense transuranic wastes. The Department of Energy has identified the Waste Isolation Pilot Plant in New Mexico, as it does for virtually every waste stream it has, and a commercial facility in Texas. Currently, WIPP is not authorized to accept the commercial spent nuclear fuel waste, which DOE considers the waste to be. And Texas state regulations preclude disposal there.

---

[17] Government Accountability Office (GAO), *NUCLEAR WASTE – Congressional Action Needed to Clarify a Disposal Option at West Valley Site in New York*, GAO-21-115, January 2021. https://www.gao.gov/assets/720/711745.pdf

[18] Arjun Makhijani and Scott Saleska, A Report of the Institute for Energy and Environmental Research, *The Nuclear Power Deception – U.S. Nuclear Mythology from Electricity "too Cheap to Meter" to "Inherently Safe" Reactors*, " Apex Press, New York, 1999. P. 123. ISBN 0-945257-92-9

The West Valley reprocessing facility was licensed by the federal government's equivalent to the U.S. Nuclear Regulatory Commission, which was then also the AEC. Then, as now, where the nuclear waste is going to go, how it will be disposed of, just isn't worried about when the facility was licensed and put into operation. In addition to producing concentrated high-level waste, transuranic waste, the reprocessing plant's operations polluted air, water and soil that will never be remediated.

The GAO report states: "As of February 2020, the Department of Energy reported spending about $3.1 billion dollars on contracted cleanup activities, but it cannot estimate the cleanup's final cost until it decides how it will address the remaining waste."

The way that the GAO report words things indicates that its authors are trying to characterize the nuclear waste problem as a simple matter of indecision or a simple matter of Congress needing to pass some legislation.

The GAO reports on nuclear waste have been fooling a lot of people for a long time about the actual costs and consequences of dealing with spent nuclear fuel, high-level radiative wastes and other waste streams from nuclear reactor operations.

The Nuclear Waste Policy Act of 1982 limited the amount of spent nuclear fuel (and high-level waste) to be placed in the first repository to 70,000 metric tons heavy metal (MTHM). For Yucca Mountain, the Department of Energy allocated 63,000 MTHM for commercial spent nuclear fuel, 2,333 MTHM for DOE spent nuclear fuel and 4,667 MTHM for HLW. [19]

With the waste already generated and estimated spent nuclear fuel from operating existing nuclear reactors in the U.S., there is currently expected enough waste for **two** Yucca Mountain repositories.

The 2017 GAO report stated that "nearly 80,000 metric tons of this waste [spent nuclear fuel] is being stored at 75 reactor sites in 33 states. The Department of Energy (DOE) estimates the amount of commercial spent nuclear fuel will increase to about 140,000 metric tons over the next several decades." [20] The Department of Energy had already exceeded its allocated 2,333 MTHM and according to a 2017 report had 2,500 MTHM of spent nuclear fuel at Hanford, the Idaho National Laboratory, Savannah River Site and Fort St. Vrain. [21]

No fees have been collected from utilities operating nuclear plants, since 2014, and despite the cost of spent nuclear fuel disposal likely to be several trillion dollars, the Nuclear Waste Fund is estimated to have collected only $36 billion, according to a white-wash of the situation

---

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

[20] United States Government Accountability Office, Report to Congressional Requesters, COMMERCIAL NUCLEAR WASTE – Resuming Licensing of the Yucca Mountain Repository Would Require Rebuilding Capacity at DOE and NRC, Among Other Key Steps, GAO-17-340, April 2017. https://www.gao.gov/assets/690/684327.pdf

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

in GAO-17-340. It would cost roughly $30 billion dollars simply to repackage the waste for disposal.

The 2017 GAO report never mentions that a court found that the Department of Energy had no program for spent nuclear fuel disposal and also had no idea what it was going to cost to dispose of the spent nuclear fuel. [22] There is no cost estimate for the multi-trillion-dollar cost of repackaging and disposing of the nation's spent nuclear fuel and high-level waste.

In my assessment, the technical challenges associated with the Yucca Mountain repository virtually assure pre-closure accidents and early release of disposed of spent nuclear fuel. And the Department of Energy wants to make more spent nuclear fuel while refusing to acknowledge just how many trillions of dollars it will take to repackage, transport and dispose of the nuclear waste we already have.

## Existing spent nuclear fuel, including commercial SNF at the Idaho National Laboratory on track to miss Idaho Settlement Agreement milestones

There is a large variety of spent nuclear fuel at the Idaho National Laboratory, totaling approximately 325 metric tons of heavy metal, that is required by the 1995 Idaho Settlement Agreement to be shipped to a repository by 2035. [23]

Naval spent fuel is still being shipped to Idaho and is stored in pools or dry storage at the Naval Reactors Facility. Commercial spent nuclear fuel and DOE research fuels are stored at the Idaho Nuclear Technology and Engineering Center (INTEC, formerly CPP) facilities. Former Experimental Breeder Reactor II driver and blanket fuel and other fuels are stored at the Materials and Fuels Complex. DOE high-enriched aluminum clad fuel is stored at and still being generated at the Advanced Test Reactor Complex.

**Table 1**. Spent nuclear fuel stored at the Idaho National Laboratory.

| SNF Source | Description | Amount MTHM | Initial Enrichment | Storage System |
|---|---|---|---|---|
| Naval Reactors Facility | Submarine and aircraft carrier fuels | Over 14 MTHM NRF and over 14 MTHM had been at INTEC CPP-666. | 93 – 97 | Stainless steel canisters in concrete overpacks and degraded spent fuel pool. Also, INTEC pool CPP-666. |

---

[22] 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

[23] U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017. p. 75 says the INL has approximately 325 metric tons heavy metal (MTHM), but the recent MARVEL environmental assessment says INL has only 315 MTHM, p. 43.

| SNF Source | Description | Amount MTHM | Initial Enrichment | Storage System |
|---|---|---|---|---|
| Advanced Test Reactor Complex | Materials testing reactor regulated by DOE | Canal and reactor capacity, several billion curies | 93 | Reactor and fuel/experiment canal |
| Materials and Fuels Complex (MFC) (Group 31 fuel becomes HLW) | Hot Fuel Examination Facility | 0.01 | 0.2 and 0.7 | Sodium-bonded uranium-plutonium alloy in hot cell |
| | Radioactive Scrap and Waste Facility | ~2.3 | 67-78 | Carbon steel liners in soil, and INTEC pool |
| | Radioactive Scrap and Waste Facility | ~19.2 | 0.3 | Carbon steel liners in soil |
| Idaho Nuclear Technology and Engineering Center (INTEC) | TMI-2 Commercial Reactor Core Debris | ~81.6 | 2-3 | 12 stainless steel canisters per carbon steel dry storage container at CPP-1774 |
| | Shippingport Light Water Breeder Reactor | ~42.6 | 98.23 enriched with U-233, a fissile material | 47 vertical vaults (zirc-clad, thorium-uranium oxide) (CPP-749) |
| | Various commercial fuel | ~38.4 | 2-3 | Dry storage casks (VSC-17, TN-24P, CASTOR V/21, MC-10) (CPP-2707) |
| | Fermi-1 blanket, sodium-bonded stainless steel-clad U-Mo alloy (Group 31 fuel becomes HLW) | ~34.2 | 0.35 | Within 14 vertical vaults (CPP-749) |
| | SNF from West Valley, Big Rock Point and Robert E. Ginna commercial SNF | ~26.3 | 2-3 | 2 rail casks (TN-BRP and TN REG) (CPP-2707) |
| | Fort St. Vrain | ~8.6 | 93.5 | 186 clamped carbon steel canisters containing ambient air (CPP-603 in INL)<br>~15 MT remains in Colorado under DOE-EM |
| | Various DOE research fuel transferred | ~6.7 | ATR fuel 93 percent enriched and | Nu-Pac 125B transportation casks (CPP-666) |

| SNF Source | Description | Amount MTHM | Initial Enrichment | Storage System |
|---|---|---|---|---|
| | before 2006 | | others | |
| | Various including Loss-Of-Fluid-Test experiments and epoxied fuel | ~3.7 | Various | REA 2023 and Nu-Pac 125B dry storage casks (CPP-2707) |
| | Various | ~3.3 | Various | Unsealed stainless steel or carbon steel canisters containing ambient air (CPP-603) |
| | Advanced Test Reactor | ~1.6 | 93 | Wet pool (CPP-666) |
| | Peach Bottom Unit 1 Core | ~1.6 | 70-93 | 21 types of fuel canisters loaded in baskets within ~46 vertical vaults (CPP-749) |

Table Source: U.S. Nuclear Waste Technical Review Board (NWTRB), Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel. Arlington, December 2017. Table 5-2. Information has not been updated for subsequent spent fuel transfers from wet to dry, newly generated spent fuel or fuel shipments received.

Table notes: Enrichment is in uranium-235 unless otherwise specified. Higher enriched fuels require far more storage canisters for spent nuclear fuel disposal. The level of difficulty in preventing criticality during storage, transportation and disposal is far higher for enrichments over 3 percent. The level of difficulty in preventing criticality is also far higher for plutonium fuels and thorium (U-233) fuels compared to uranium-235 enriched fuel. Just 3.6 MTHM of Fort St. Vrain spent fuel will require over 200 DOE standardized canisters, and approximately 5 MTHM of Advanced Test Reactor SNF would require 290 DOE standardized canisters. The DOE has never completed design, licensing or construction of DOE standardized canisters.

The design life of the CPP and MFC facilities are to 2035, with the exception of CPP-1774, which had authorized storage until 2019.

Disposal canister design and neutron absorber design in the canisters depends on the fuel enrichment, burnup and other features of the fuel design. Each new fuel design requires design work that will need to be done eventually.

The repackaging of the spent fuel for transportation and disposal would require a facility that would take 15 years to design and build. Even if there was a spent fuel repository on the horizon, the Department of Energy would miss the deadline.

The Department of Energy was found to lack aging management programs for its spent nuclear fuel. [24] Spent fuel storage space is also running out at the INL. [25]

The Department of Energy's safety case for the proposed Yucca Mountain repository may have been swallowed by the U.S. Nuclear Regulatory Commission, but the problems with both

---

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

[25] Daniel A. Thomas, Idaho National Laboratory, *Initial DOE SNF Standardized Canister Storage Configuration Alternatives Study*, INL/EXT-19-55841, Revision 0, September 2019. https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_21726.pdf

pre-closure and post-closure of the repository were recognized by people who were paying attention. The State of Nevada officials were paying attention. They called out the fraudulent corrosion studies, the waffling on hot versus cold repository, the difficulty and cost of ever installing the titanium drip shields, and the fraudulent waste migration modeling.

No funding has been allocated for Yucca Mountain since 2010.  Efforts to spin the failure of Yucca Mountain on partisan issues have largely been successful, and ***discussion*** of the inability of the proposed repository to safety contain the wastes has been avoided.

The Idaho National Laboratory site includes the U.S. Naval spent nuclear fuel which is being packaged into dry storage, despite no disposal repository having been identified. Other than the naval spent nuclear fuel at the INL, the DOE research and assortment of commercial nuclear fuels at the INL have no repackaging facility for the shipment and disposal of the spent nuclear fuel at the INL.

It is estimated that it would take 15 years to design and build a repackaging facility for spent nuclear fuel at the INL. But the Idaho Settlement Agreement milestone of INL’s spent nuclear fuel being road-ready by 2035 is on track for failure. The Department of Energy is currently not funding a repackaging facility to meet one of the most important milestones for the Idaho Settlement Agreement.

## Idaho Cleanup Project Citizens Advisory Board January 2021 Virtual Meeting

The Idaho Cleanup Project (ICP) Citizens Advisory Board meeting was held virtually on January 28 and could be attended by the public by Zoom if signed up a few days in advance of the meeting. [26]

The COVID-19 pandemic has slowed cleanup work and some recent employee deaths from COVID and from suicide were weighing on employees and thought to be contributing to a rise in worker mishaps at the Radioactive Waste Management Complex (RWMC).

Transuranic waste in sludge waste that is being treated is also a difficult waste stream that is being worked on at the RWMC.

The “targeted” waste being exhumed from the burial ground is on the ninth and final phase, Accelerated Retrieval Project (ARP) IX. The deterioration of the buried drums in this ARP is making the work even more difficult than the past ARPs and this ARP has also had structural foundations from past ARP enclosures in the way of this exhumation.

**But unfortunately, removing all of the targeted waste will leave over 90 percent of the buried transuranic waste remaining buried.**

---

[26] Idaho Cleanup Project Citizens Advisory Board January 28, 2021 meeting agenda and presentations at https://www.energy.gov/em/icpcab/downloads/icp-cab-meeting-materials-january-2021

The remaining americium-241 dominates the estimated threat to the aquifer. The important metric is how much of the americium-241 that was buried (after a few initial or early retrievals) and how much will remain buried after the "targeted waste" is exhumed.

In fact, over 90 percent of the americium-241 is remaining buried. An estimated 215,000 curies will remain buried after targeted waste is removed according to composite analysis calculations of 230,000 curies of americium-241 having been buried. [27] [28] [29]

The buried americium-241 is not the only radionuclide that contributes to contaminant migration, but it was the dominant contributor according to the buried waste performance assessment. For simplicity and due to the significance of the americium-241 to the estimated migration of radionuclides from the burial ground, the amount of americium-241 that is not being exhumed from the burial ground is explained but the lion's share of other transuranic radionuclides, like plutonium-239, are also remaining buried.

The Department of Energy has submitted to the EPA a new 5-yr CERCLA report, just released January 20. Continuing issues with extensive groundwater contamination at Test Area North show that waste in the soil above the aquifer are still migrating to the aquifer. Not mentioned is that once the chemicals and radionuclides are in the aquifer, the water flows downgradient to communities south of the Idaho National Laboratory. If fact, the CERCLA cleanup goes to great lengths to give disinformation on this and the US Geological Survey goes to great lengths to not report the downgradient contamination. A never-used multi-level deep well and other decreased monitoring in deep wells means that relatively shallow aquifer monitoring will miss the Test Area North contamination as it flows south. Then near the Snake River when the aquifer is closer to the surface, elevated contamination levels are not attributed to the INL.

CERCLA vapor extraction has been discontinued at Test Area North in order to see what happens to aquifer contamination when the chemical vapor extraction is stopped. The RWMC also has used vapor extraction for the high levels of buried carbon tetrachloride.

---

[27] See the July 2017 EDI newsletter for a timeline for the burial ground at the Radioactive Waste Management Complex and other cleanup information at http://www.environmental-defense-institute.org/publications/News.17.July.pdf

[28] U.S. Department of Energy, 2008. Composite Analysis for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11244. Idaho National Laboratory, Idaho Falls, ID and U.S. Department of Energy, 2007. Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11243. Idaho National Laboratory, Idaho Falls, ID. Available at INL's DOE-ID Public Reading room electronic collection. (Newly released because of Environmental Defense Institute's Freedom of Information Act request.) See https://www.inl.gov/about-inl/general-information/doe-public-reading-room/

[29] See the CERCLA administrative record at www.ar.icp.doe.gov (previously at ar.inel.gov) and see also Parsons, Alva M., James M. McCarthy, M. Kay Adler Flitton, Renee Y. Bowser, and Dale A. Cresap, Annual Performance Assessment and Composite Analysis Review for the Active Low-Level Waste Disposal Facility at the RWMC FY 2013, RPT-1267, 2014, Idaho Cleanup Project. And see Prepared for Department of Energy Idaho Operations Office, Phase 1 Interim Remedial Action Report for Operable Unit 7-13/14 Targeted Waste Retrievals, DOE/ID-11396, Revision 3, October 2014 https://ar.inl.gov/images/pdf/201411/2014110300960BRU.pdf

The CERCLA cleanup of contaminated sites at the Idaho National Laboratory began in 1989 and there are ten waste area groups (WAPs). The contamination that is not safe for unrestricted use is put under institutional controls. In some cases, due to the radioactive decay of the contamination, the institutional controls may be lifted in 100 or 500 years. But in dozens of areas, the radioactive decay will not render the area safe after more than hundreds of thousands of years. In these cases, the institutional controls are said to continue "indefinitely." I call these sites forever contamination sites. [30]A status for the INL cleanup is provided in Environmental Defense Institute's September 2020 newsletter. [31]

The Department of Energy is continuing to investigate transfer of powdered calcine from an older storage bin set to a newer one. Calcine is a highly soluble radioactive granular waste resulting from calcining of liquid radioactive waste. The calcine is stored partially below grade in the flood plain of the Mackay dam and in seismically vulnerable bin sets of various vintages and designs.

The DOE had formally documented the selection of Hot Isostatic Pressing (HIP) as the way to package the calcine for shipment to a permanent repository. But the DOE continues to say they are not sure HIP is the best approach and said at the meeting that there is or soon will be available a new DOE report discussing disadvantages of calcine hot isostatic pressing (HIP).

The Integrated Waste Treatment Unit (IWTU) was discussed in one slide given during the meeting. The project that had been scheduled to be completed in 2012 continues to make modest progress. Once running to treat the liquid high-level waste called sodium-bearing waste, operations are now expected to continue for years in order to treat the waste and accommodate frequent expected outages to maintain the facility.

The DOE has extended Fluor Idaho's contract by at least a few months and stated it would not comment on cleanup contractor issues such as selecting a new contractor.

While it was not addressed by the Department of Energy, I mentioned in public comment during the meeting that Fluor Idaho had been fined by the $580,700 for four Severity Level I violations and other violations, for the four drums that ejected their radioactive powdery contents in April 2018 at the Radioactive Waste Management Complex. [32]

The Idaho CERCLA Disposal Facility (ICDF) is a CERCLA landfill at INTEC that was to dispose of CERCLA-related contaminated soil. The landfill purpose was expanded to take both

---

[30] See the list of "forever contamination" sites at INL Waste Area Group Institutional Controls Report. Dated February 16, 2016: https://cleanup.icp.doe.gov/ics/ic_report.pdf and from the EPA page: https://cleanup.icp.doe.gov/ics/

[31] See the September 2020 EDI newsletter article "Summary of Idaho National Laboratory Cleanup Status as of August 2020" at http://www.environmental-defense-institute.org/publications/News.20.Sept.pdf

[32] U. S. Department of Energy website "Department of Energy Cites Fluor Idaho, LLC for Nuclear Safety Program Violations, November 20, 2020 at https://www.energy.gov/articles/department-energy-cites-fluor-idaho-llc-nuclear-safety-program-violations See also https://www.energy.gov/sites/prod/files/2020/11/f80/Preliminary%20Notice%20of%20Violation%20for%20Fluor%20Idaho_0.pdf

soil and nuclear facility D&D waste. The landfill is being expanded again because the Naval Reactors Facilities has requested that DOE add their building D&D waste. This is adding 60 percent additional capacity with a new dump adjacent to the existing one. These lined landfills use evaporation ponds to dry the "leachate" from the line's dumps, to release radionuclides to Idaho skies. The ICDF along with the high-level waste calcine, and much of the INL's spent nuclear fuel storage lie in the flood plain near the Big Lost River and are vulnerable to a Mackay dam failure.

Moisture-damage compromised spent nuclear fuel storage has required moving Peach Bottom spent nuclear fuel stored in the early vintage underground "vaults" to still-old but newer vaults which are vertical pipes in the ground at the Idaho Nuclear Technology and Engineering Center (INTEC).

Briefly mentioned was the future need for repackaging not only the HLW calcine and the sodium-bearing waste once treated, but also the spent nuclear fuel at the INL. Construction and operation of a repackaging facility for the spent nuclear fuel at the INL is not included in DOE EM future budgets for the next 2 years. It has been estimated that it would take 15 years to build. The Idaho Settlement Agreement requires repackaging the spent nuclear fuel to ship to a repository by 2035. The DOE "standardized" canisters for transportation and disposal of spent nuclear fuel have never been designed, licensed or built.

DOE does not have a repository and I commented on the extent to which DOE is simultaneously pretending it has a repository but using the lack of a repository as an excuse to ignore the need to build one in order to meet the Idaho Settlement Agreement.

I reminded the CAB that while they had Richard Stallings come and speak to the CAB about Yucca Mountain, his involvement was over 20 years out of date. The CAB needed to understand that YM has not been funded for 10 years and that DOE could not continue to collect money into the Nuclear Waste Fund, because a court found that DOE has no repository program and DOE has no idea how many trillions one will cost. The roughly $30 billion collected by the Nuclear Waste Fund for utilities that generate electricity with nuclear power would not even pay to repackage the existing waste for disposal, left alone pay for a repository, which would be in the trillions of dollars. Unfortunately, not only is a repository expensive, the technology to safely confine the radio-toxic waste for millennia, so far, doesn't exist.

## Microreactor and gigantic waste disposal issues in the Environmental Assessment of the MARVEL project slated for the Idaho National Laboratory

Public comment on the Department of Energy's Environmental Assessment for the design and demonstration of the Microreactor Applications Research Validation and Evaluation Project (MARVEL). According to the Department of Energy, MARVEL is a sodium-potassium cooled, thermal microreactor with a power level of less than 100 kilowatts of electricity. The EA states the thermal power level is expected to provide only 20 kilowatts of electricity, which would light something like 300 light bulbs. This is tiny, yet the Department of Energy considers anything up to 20 megawatts-thermal (or 20,000 kilowatts-thermal) to be included in the category of "microreactor."

The Draft Environmental Assessment was issued for public comment on January 11 and comments were due January 26 but have been extended to February 9. [33] Tami Thatcher's public comment submittal on MARVEL is at http://www.environmental-defense-institute.org/publications/CommentDOEMARVELdea.pdf

In contrast, a large commercial nuclear reactor generates an average of about 3,000 megawatts of thermal energy and about 1000 MW of electricity. [34]

The fuel will be 150 kilograms of about 20 percent uranium-235 enrichment in 36 fuel pins and the fuel material will be uranium-zirconium-hydride in a stainless steel cladding. Each fuel pin is about 38-in. long and will be sodium-bonded.

In contrast, existing large commercial nuclear reactors use roughly 100,000 kilograms of fuel, but at less than 5 percent uranium-235 enrichment.

MARVEL is actually a micro-sized reactor, unlike what they likely may want to deploy. The real problem will be having one of these on the free-way next to you in a snowstorm pile up car accident or having one operating where you work or where you live.

But despite the deception in the MARVEL environmental assessment, the Department of Energy has no spent fuel disposal program.

The MARVEL EA states that the DOE's standardized canister will be used to package the MARVEL spent nuclear fuel for disposal at Yucca Mountain. And the wording is deceptive because the design of the standardized canister design and its neutron absorbers was never completed, never built and never licensed. But that is consistent for the spent nuclear fuel disposal facility, which it names as Yucca Mountain which does not exist, was never licensed for construction and has not been funded since 2010.

Beryllium used in the reactor will likely be buried over the Snake River Plain aquifer, as has long been the Department of Energy's practice for the Advanced Test Reactor's beryllium. The Department of Energy has also long used the its regulations to say that it can decide that any spent nuclear fuel used in experiments can be deemed "low level" radioactive waste with much less stringent disposal requirements. The Department of Energy practice is that low-level radioactive waste this is not accepted by commercial LLW facilities is buried over the Snake

---

[33] *Draft Environmental Assessment for the Microreactor Applications Research, Validation and Evaluation Project at Idaho National Laboratory (DOE/EA-2146)*, January 2021 at https://www.id.energy.gov/ or https://www.id.energy.gov/insideNEID/PDF/Final%20MARVEL%20Draft%20EA%20DOE%20EA-2146.pdf

[34] One thousand (1000) watts is equal to 1 kW and 1,000,000 watts is equal to 1 megawatt (MW).

River Plain aquifer at the Radioactive Waste Management Complex or its replacement facility near the Advanced Test Reactor.

MARVEL will be using High-Assay Low-Enriched Uranium (HALEU) and Stirling engines.

The INL's EBR-II fuel is the feedstock for its high-assay low-enriched uranium (HALEU), DOE/EA-2087, being pyroprocessed at INL's Materials and Fuels Complex and increasing the radiological airborne emissions from the INL 170-fold, see Table 2. DOE plans to treat at least 165 pounds of sodium-bonded EBR II driver fuel pins into material for high assay low enriched uranium fuel production (HALEU) each year until all pins have been treated, no later than the end of 2028.

**Table 2.** Estimated annual air pathway dose (mrem) to Idaho communities from normal operations to the maximally exposed offsite individual from proposed projects, including the estimated dose from expanding capabilities at the Ranges based on DOE/EA-2063.

| **Current and Reasonably Foreseeable Future Action** | **Estimated Annual Air Pathway Dose (mrem)** |
|---|---|
| | |
| National Security Test Range | 0.04[e] |
| | |
| Radiological Response Training Range (North Test Range) | 0.048[d] |
| Radiological Response Training Range (South Test Range) | 0.00034[a] |
| HALEU Fuel Production (DOE-ID, 2019) | 1.6[a] |
| Integrated Waste Treatment Unit (ICP/EXT-05-01116) | 0.0746[h] |
| New DOE Remote-Handled LLW Disposal Facility (DOE/ID 2018) | 0.0074[a] |
| Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling (DOE/EIS 2016) | 0.0006[c] |
| TREAT (DOE/EA 2014) | 0.0011[a] |
| DOE Idaho Spent Fuel Facility (NRC, 2004) | 0.000063[a] |
| Plutonium-238 Production for Radioisotope Power Systems (DOE/EIS 2013) | 0.00000026[b] |
| | |
| | |
| Total of Reasonably Foreseeable Future Actions on the INL Site | 1.77[g] |
| Current (2018) Annual Estimated INL Emissions (DOE2019a) | 0.0102[f] |
| Total of Current and Reasonably Foreseeable Future Actions on the INL Site [**DOE WOULD INCREASE INL'S AIRBORNE RELEASES BY OVER 170 TIMES**] | 1.78[g] |

**Table notes:**

a. Dose calculated at Frenchman's Cabin, typically INL's MEI for annual NESHAP evaluation.

b. Receptor location is not clear. Conservatively assumed at Frenchman's Cabin.

c. Dose calculated at INL boundary northwest of Naval Reactor Facility. Dose at Frenchman' Cabin likely much lower.

d. Dose calculated at INL boundary northeast of Specific Manufacturing Capability. Dose at

Frenchman's Cabin likely much lower.

e. Sum of doses from New Explosive Test Area and Radiological Training Pad calculated at separate locations northeast of MFC near Mud Lake. **Dose at Frenchman's Cabin likely much lower.**

**PLEASE NOTE THAT THE PUBLIC AT MUD LAKE IS CLOSER TO THE RELEASE THAN TO FRENCHMAN'S CABIN.**

f. Dose at MEI location (Frenchman's Cabin) from 2018 INL emissions (DOE 2019a). The 10-year (2008 through 2017) average dose is 0.05 mrem/year.

**PLEASE NOTE THAT MANY RADIOLOGICAL RELEASES ARE IGNORED AND NOT INCLUDED IN THE RELEASE ESTIMATES IN NESHAPS REPORTING.**

g. This total represents air impact from current and reasonably foreseeable future actions at INL. It conservatively assumes the dose from each facility was calculated at the same location (Frenchman's Cabin), which they were not.

h. Receptor location unknown, according to the Department of Energy, the agency that is supposed to know the receptor location.

## Department of Energy's Versatile Test Reactor Draft Environmental Impact Statement Relies on Inadequate EISs the DOE has Previously Conducted

Public comment is being sought on the *Draft Versatile Test Reactor Environmental Impact Statement* (DOE/EIS-0542).[35] The proposed materials testing reactor, the Versatile Test Reactor, would be a sodium-cooled, fast-neutron-spectrum test reactor to test how materials withstand intense neutron bombardment that would be encountered in fast-neutron reactors.

GE Hitachi Nuclear Energy is working with the Idaho National Laboratory on the VTR conceptual design based on its PRISM reactor, which was based on the Experimental Breeder II reactor.[36] The EBR II which was operated by Argonne National Laboratory – West at the Idaho site which is now the Materials and Fuels Complex at the INL, although the EBR II has been dismantled.

Fast reactors have high density core and require a coolant that doesn't slow the neutrons down, like liquid metals, molten salt or helium gas. In 1951, the EBR I, a small sodium-cooled fast reactor, operated at what is now the Idaho National Laboratory.[37] It experienced a core melt down. Fast reactors can fission plutonium, americium and curium as well as breed plutonium by neutron capture by uranium-238.

The U.S. fleet of commercial nuclear reactors are "slow" neutron reactors or thermal reactors that use fuel consisting of uranium-238 and less than 5 percent enrichment in uranium-235.

---

[35] Public Draft Versatile Test Reactor Environmental Impact Statement (DOE/EIS-0542) at https://www.energy.gov/ne/downloads/public-draft-versatile-test-reactor-environmental-impact-statement-doeeis-0542 (Announced December 21, 2020)

[36] Press Release, GE Hitachi, "GE Hitachi and PRISM Selected for U.S. Department of Energy's Versatile Test Reactor Program," November 13, 2018. https://www.ge.com/news/press-releases/ge-hitachi-and-prism-selected-us-department-energys-versatile-test-reactor-program

[37] Sonal Patel, *Power Magazine*, "Rapid Advancements for Fast Nuclear Reactors," March 1, 2019. https://www.powermag.com/rapid-advancements-for-fast-reactors/

These thermal neutron reactors are water-moderated to slow down the neutrons. These conventional nuclear reactors also produce plutonium, americium and curium. There is plentiful uranium-238 and when it absorbs a neutron, it will, following successive decays, create plutonium-239. The plutonium-239 that builds up in a conventional reactor may fission in conventional reactors or absorb a neutron without fissioning, producing plutonium-240, plutonium-241 etc. through successive neutron captures. Plutonium-239 is produced in and will fission in thermal reactors. All commercial nuclear spent fuel contains most of the original uranium-238 and uranium-235 plus a host of fission products and a large amount of actinides including plutonium-239 and other plutonium isotopes along with americium and curium.

Fast reactors fission plutonium-239 more efficiently, yet the VTR with its uranium-238, uranium-235, and plutonium (and zirconium) fuel actually results in only a slight reduction in the plutonium-239, about 10 percent less in the spent fuel than in the fresh fuel. Manufacture, storage and transportation of the 20 percent by weight plutonium fuel for the VTR creates a significant nuclear weapons proliferation risk. And because of the large stocks of weapons-usable plutonium-239 for the VTR fuel, the VTR and associated reactor research will promote nuclear weapons material proliferation.

The atomic bomb dropped on Nagasaki during WWII contained 6.2 kg Pu-239. The VTR will use 400 kg of Pu-239 annually. **The VTR increases the risk of nuclear weapons material proliferation.**

The Department of Energy’s Federal Register notice that is in Appendix A of the VTR EIS – actually quotes DOE as having an objective of the VTR to lead to **reduced nonproliferation concerns**. Translated this means DOE’s goal is to *increase the proliferation concerns* – Which may be an error by the DOE, but it is exactly the opposite of what we all want – which is to reduce proliferation concerns and keep nuclear weapons material like plutonium-239 out of nuclear weapons.

The Versatile Test Reactor cost estimates are likely to double several more times during design and construction. The Department of Energy’s project for far less complex conversion of 34 metric tons of surplus plutonium to mixed oxide fuel at the now cancelled Savannah River Site Mixed-Oxide Fuel Fabrication Facility was originally estimated to cost $1.4 billion to construct and be operating in 2004. By 2016, it was estimated to cost $17.2 billion and be completed by 2048. [38] [39] The Department of Energy sunk almost $8 billion into the MOX facility which was cancelled in 2018. The U.S. Government Accountability Office reports that the approaches for managing or disposal of Department of Energy’s roughly 57 metric tons (MT) of surplus plutonium has gyrated considerably over the last 20 years, and remains uncertain.

---

[38] Douglas Birch and R. Jeffrey Smith, *Center for Public Integrity*, “Nuclear Waste: A $1 Billion Energy Department Project Overshoots Its Budget by 600 Percent,” June 25, 2013. https://publicintegrity.org/national-security/nuclear-waste-a-1-billion-energy-department-project-overshoots-its-budget-by-600-percent/

[39] U.S. Government Accountability Office, Surplus Plutonium Disposition, GAO-20-166, October 2019. https://www.gao.gov/assets/710/702239.pdf

For the VTR project, the DOE now says it wants to fabricate over 24 MT over 60 years, of metal fuel for the Versatile Test Reactor, build a nuclear reactor, manage the spent nuclear fuel, and all for less money than the failed Savannah River MOX plant that was to make MOX pellets for nuclear fuel.

Fast Reactors such as the VTR are prone to have something called "core disruptive accidents" where the core explodes. Because monitoring these reactors is difficult, coolant stratification, coolant channel blockages, voids in the coolant or other unexpected situations can occur unpredictably. Partial melting and movement of the fuel can then result in the reconfiguration of the fuel in the core and a low yield explosion that destroys the reactor and releases a devastating amount of fission products and actinides like plutonium-239 to blow in the wind.

Even with light-water reactors, like Fukushima or Three Mile Island, the "experts" had much confusion as to what was going on, or what to do about it. The problem can be compounded for certain circumstances in sodium-cooled fast reactors and there won't be time to respond.

The VTR EIS asserts and with no evidence that the VTR will be safer than conventional reactors. We will be lucky if the VTR is as safe as conventional LWRs because of the unknowns about the new design and because a test reactor changes nuclear-fueled-experiments and other experiments frequently, leaving little time for analyzing the new core configuration's safety.

The VTR EIS relies on out-of-date, inappropriate, now known to be inadequate Department of Energy spent nuclear fuel disposal environmental impact statements. The fact is that the Department of Energy has no spent nuclear fuel disposal program. And interim storage is not a substitute for a permanent solution. The fact is that the Nuclear Waste Fund has been discontinued and the $30 billion or so that it collected is not even enough money to package spent fuel in disposal containers, let alone to license and construct a repository. The many trillions of dollars that this will cost the U.S. taxpayer is not being opening and honestly presented, either by the Department of Energy or by the Idaho National Laboratory as they promote nuclear power.

The completion of the VTR can be reasonably expected to have years of schedule delays. This means that the VTR and projects that would test nuclear materials will be too late to address climate concerns. And any meaningful increase in the use of nuclear energy would mean needing a new Yucca Mountain repository every year. [40]

The VTR takes the U.S. in the wrong direction of failed spent nuclear fuel disposal and subsequent nuclear reactors, like TerraPower's reactors, will proliferate nuclear weapons material wherever these reactors are operated or wherever their fresh or spent fuel is stored or transported. TerraPower and others are seeking to sell nuclear reactors outside the U.S. using loans orchestrated to help solve "energy poverty." Where will the spent nuclear fuel from those

---

[40] Edited by Allison M. Macfarlane and Rodney C. Ewing, *Uncertainty Underground Yucca Mountain and the Nation's High-Level Nuclear Waste*, The MIT Press, 2006. Page 4.

reactors end up? And who will pay for the continued storage and the hoped-for disposal of that spent nuclear fuel?

Environmental Defense Institute comments of the draft VTR EIS are on our home page or http://www.environmental-defense-institute.org/publications/CommentVTRdEIS.pdf

A copy of the Draft VTR EIS can be downloaded at https://www.energy.gov/nepa or https://www.energy.gov/ne/nuclear-reactor-technologies/versatile-test-reactor.

Comments are due February 16 and can be emailed to VTR.EIS@Nuclear.Energy.gov, depending on the timing of *Federal Register* notices.

## A 2021 Summary of the Dizzying Array of Department of Energy Involvement in Proposed Nuclear Reactors

Construction cost overruns and schedule delays for the 1000 MW-electric Westinghouse AP1000 nuclear reactors in Georgia hasn't damped the Department of Energy's appetite for nuclear reactors. From TerraPower's fast neutron sodium-cooled reactor Natrium, to X-energy's TRISO fueled high-temperature gas cooled reactors, there is a wide diversity of large nuclear reactor proposals.

Most nuclear reactors are designed to produce steam that runs steam turbines to convert to electricity and the rated electrical generating capacity is described in megawatts-electric (MWe). The AP1000 nuclear reactors are designed to have a nominal electrical output of 1117 megawatts electric (MWe) from the gross power rating of 3,415 megawatts thermal (MW-th).

Whether or not the nuclear reactor produces electricity, all reactors produce thermal energy described in megawatts-thermal (MW-th). The larger the nuclear reactor's thermal energy, the more fission products that may build up as the reactor operates. The more the reactor operates, the higher the "burnup," the higher the stresses in the fuel from the buildup of fission products and the higher the amount of radioactivity that could be released during an accident. Higher enriched fuels can be run longer in a reactor between refueling and can build up more fission products. Higher enrichment in U-235 also creates more storage and disposal challenges than low enrichment, say of 3 percent by mass U-235.

Nuclear fission depends on fissile materials uranium-235, uranium-233 or plutonium-239. Various materials are fissionable, but the fissile material kicks out more neutrons to sustain fission in the reactor. High enrichments of uranium-235 (above 2 percent) and fissile materials Pu-239 and U-233 create additional storage and spent nuclear fuel disposal challenges. Commercial spent nuclear fuel enrichments were about 3 percent when Yucca Mountain was first sought as a spent fuel repository, and the Department of Energy was reprocessing its higher enriched fuels. The need to dispose of more highly enriched fuels and fuels with higher burnup added to the difficulty of spent nuclear fuel disposal.

And in the broad category of “small” reactors, designers are working toward everything from the 720 MW-electric plant from a twelve-pack of 60 MW-electric NuScale small modular reactors to a 20 kW-electric (or 0.02 MW-electric) MARVEL micro reactor. This category of “small” nuclear reactors includes so-called “micro” reactors that range from 20 MW to 0.02 MW-electric, and NASA space exploration reactors. [41] [42] Space exploration is currently powered by radioisotope thermoelectric generators (RTGs) powered by plutonium-238 obtained from irradiating targets in the INL’s Advanced Test Reactor and the Oak Ridge National Laboratory’s (ORNL) High Flux Isotope Reactor. [43]

I’ve assembled a rough summary of some of the proposed reactors in Table 3.

**Table 3.** Summary of nuclear reactors currently receiving U.S. research dollars.

| **Reactor Category** *Reactor name* | **Reactor type/ Fuel type** | **MW-thermal** | **MW-electric** | **Fissile Material** | **Special notes** |
|---|---|---|---|---|---|
| **Materials Testing** *Versatile Test Reactor* | Fast neutron, sodium-cooled, U-Pu-Zr | 300 MW-th | 0 | Uranium-plutonium-zirconium metal | Existing materials testing at the Advanced Test Reactor is 250 MW-thermal, thermal neutron, light-water cooled |
| **Commercial electrical power** TerraPower & GE Hitachi *Natrium* | Fast neutron, sodium-cooled, U-Zr | ? | 345 MWe | Uranium-zirconium-hydride using HALEU | |
| **Commercial electrical power** X-energy’s *Xe-100* | High-temperature gas cooled, TRISO | ? | Xe-100, 80 MWe; 4-pack is 320 MWe | TRISO (tristructural isotropic) uranium fuel particles from HALEU | TRISO fuel used in Fort St. Vrain reactor (but FSV used U-233 fissile material) |
| **Commercial electrical power** | Light-water pressurized reactor, | ? | NuScale 50 MWe (hopes to | <4.95 percent enriched standard PWR fuel, hope | |

---

[41] Hale Stolberg, *American Institute of Physics*, “US Ramps Up Planning for Space Nuclear Technology,” July 31, 2020. https://www.aip.org/fyi/2020/us-ramps-planning-space-nuclear-technology

[42] Aaron Mehta, *Defense News*, “Pentagon awards contracts to design mobile nuclear reactor,” March 9, 2020. https://www.defensenews.com/smr/nuclear-arsenal/2020/03/09/pentagon-to-award-mobile-nuclear-reactor-contracts-this-week/

[43] Cory Hatch for INL Public Affairs, Idaho National Laboratory, National Labs Resume Plutonium Production for Space Exploration, December 17, 2019. https://inl.gov/article/national-labs-resume-plutonium-production-for-space-exploration/

| **Reactor Category**<br>***Reactor name*** | **Reactor type/ Fuel type** | **MW-thermal** | **MW-electric** | **Fissile Material** | **Special notes** |
|---|---|---|---|---|---|
| (Small Modular Reactor)<br>*NuScale* | standard PWR fuel with MOX and other fuels envisioned | | amend license to 60 MW);<br>12-pack 720 MWe | to use plutonium mixed oxide fuel (MOX) and/or higher enrichment fuels | |
| **Mobile reactors** | Variety | ? | < 20 MWe | variety | Wide range of sizes and accident consequences |
| **Micro**<br>*MARVEL* | Sodium-potassium-cooled, HALEU | 100 kW-th | “less than 100 kWe”<br>Expect 20 kWe (0.02 MWe) | 150 kg of 20 percent enriched U-235 (U-Zr-Hydride fuel in stainless-steel cladding | Testing planned at INL’s TREAT facility |

Table 3 notes: MW-th is megawatts-thermal energy, MWe or simply MW is megawatts-electric energy. HALEU is high assay low-enriched uranium, produced by the Idaho National Laboratory in a highly environmentally airborne polluting pyroprocessing operation. Note regarding past, current or under construction reactors: the nominally 1000 MWe Westinghouse AP1000 under construction is a light-water pressurized reactor, 1000 MWe, fuel of uranium oxide of 4.55 percent uranium-235 enrichment; existing Advanced Test Reactor, 250 MW-thermal, 93 percent enriched uranium-235; formerly operated Fort St. Vrain high-temperature gas-cooled reactor, 330 MWe, used TRISO fuel; formerly operated Peach Bottom reactor, 40 MWe; formerly operated Hanford’s Fast Flux Test Facility reactor was a 400 MW-thermal fast neutron sodium-cooled reactor; formerly operated INL’s Experimental Breeder Reactor II (EBR-II) was a fast neutron sodium-cooled pool-type reactor of 62.5 MW-thermal (19 MWe), see Perry et al., Seventeen Years of LMFBR Experience: Experimental Breeder Reactor II (EBR-II), CONF-820465—2, April 1982 at https://www.osti.gov/servlets/purl/6534205 .

*Articles by Tami Thatcher for February 2021.*