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Idaho Cleanup Project Citizens Advisory Board Meeting announces vitrification for calcine and other news

The Idaho Cleanup Project (ICP) Citizens Advisory Board (CAB) held an all-virtual (ZOOM) meeting on February 16. [1]

Key issues announced include that there are significant problems facing the future shipments of transuranic waste from Idaho to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Only 150 shipments of transuranic waste were shipped to WIPP last year, rather than the planned 257 shipments. Non-CERCLA waste is now destined for the Idaho CERLCA Disposal Facility but this only touches the surface of needed decommissioning disposal facilities that will be needed at the Idaho National Laboratory (INL). And the Integrated Waste Treatment Unit (IWTU), over a decade after it was planned to have completed processing liquid radioactive high-level waste, is still not processing liquid waste. The powdery calcine radioactive high-level waste resulting from spent nuclear fuel reprocessing and unsafely stored above the Snake River Plain Aquifer is to be vitrified rather than treated by the previously decided upon “hot isostatic processing.” And, at last, a plan is to be developed for addressing the Department of Energy-owned spent nuclear fuel repackaging at the INL.

- **Transuranic Waste Shipments to WIPP to Require $85 million in Drum Overpacks.** The Idaho Environmental Coalition (IEC) competed 150 of a planned 257 transuranic shipments to WIPP in 2022. Transuranic waste drum problems encountered last year that resulted in shipments of waste from IEC to be rejected by the Waste Isolation Pilot Plant (WIPP) in New Mexico. Several shipments were returned to the Idaho Cleanup Project in 2022, yet there was no discussion of this to the ICP CAB. WIPP may now be requiring drum overpacks for transuranic waste from Idaho. These drum overpacks encase 10 drums, reducing the typical number of drums (fourteen drums) that a TRUPACT shipment can ship. The overpacks may be difficult to procure and with the high number of drums remaining to be shipped, the overpacks are expected to cost $85 million. If needed drum overpacks become unavailable, this may cause a slowdown in sending shipments from Idaho to WIPP within a year.
- **High-Level Calcine Waste.** The high-level waste known as calcine is a powdery, soluble material stored partially above ground and partially below ground in a variety of vintages

[1] The Department of Energy’s Office of Environmental Management, Idaho Cleanup Project Citizens Advisory Board website is at https://www.energy.gov/em/icpcab/idaho-cleanup-project-citizens-advisory-board-icp-cab

of storage structures. The calcine solids storage facilities, or "bin sets" are seismically vulnerable and are subject to "floating" if water, enters the concrete structure from flooding. Flooding would be expected to breech the stainless-steel storage. The seismic properties of the concrete structures are difficult to know because of unknown properties of the concrete used in their construction. The current storage of the powdery and highly soluble calcine is unsafe and may be blowing in the wind and/or leaching into the Snake River Plain aquifer. The previous decision for treatment of the calcine was to use "hot isostatic pressing" or HIP. The Department of Energy announced at the February 16 meeting that the latest decision will be to use vitrification rather than HIP. Vitrification studies have begun with Catholic Universities. The calcine is to be treated to be "road ready" to ship to a repository although there is no repository to accept the calcine. The Department of Energy Operations Office will release a draft 3116 basis document and associated Performance Assessment for the calcine bin sets. The draft 3116 basis document will undergo a 45-day public comment period. A virtual public meeting will be held to answer questions from the public. I expect that DOE will try many tactics to allow the vitrified waste to forever stay in Idaho. But at least this plan might address the very unsafe of highly soluble and highly radioactive waste unsafely stored at INL now, especially since the calcine appears vulnerable to an increasingly likely failure of the Mackay Dam. The failure of the Mackay Dam is more likely than 1-in-100 years and was required to have been included in hazardous waste (RCRA) permits with the State of Idaho, but fraudulently was not despite the Department of Energy fully aware of Mackay Dam failure likelihood increases.

- **Integrated Waste Treatment Unit (IWTU).** The IWTU problem last December involving leakage of material has been resolved and hot operations are expected this year. Radiological emissions will not be monitored continuously and DOE-contractors and the State of Idaho Department of Environmental Quality have a habit of turning off air radiation monitors when airborne contamination levels get high. This is not the year to grow a vegetable garden within 50 miles of INL if IWTU starts radiological operations. (Other radiological airborne releases from the INL have already made for "hot lettuce" in southeast Idaho and are not worth the risk.) The DOE needs to explain the number canisters and vaults needed for solidified IWTU waste. The originally planned 37 vaults now needs to be 78 vaults and each vault holds many canisters.
- **Idaho CERCLA Disposal Facility.** DOE has decided to expand the Idaho CERCLA Disposal Facility (ICDF) that is located next to the Idaho Nuclear Technology and Engineering Center (INTEC). It is being expanded to accommodate non-CERCLA Naval Reactors decommissioning waste. The ICDF will be accepting the waste from the non-CERCLA waste from demolition of S1W and A1W prototypes and associated buildings and structures at the Naval Reactors Facility. This is only the tip of the iceberg when it comes to future decommissioning radioactive waste at the Idaho National Laboratory. Not to worry Idaho Falls, because these radionuclides will migrate down to the aquifer and then flow to the Magic Valley and Snake River south of the INL. And those folks, coupled with U.S. Geological Survey lies, still don't know what hit them, beginning by

the 1970s, increasing their cancers, from the INL spent nuclear fuel reprocessing liquid waste injected into the aquifer beginning around 1952.

- **DOE-owned Spent Nuclear Fuel.** The INTEC CPP-666 spent fuel basin is nearly emptied. The wet-to-dry transfer of spent nuclear fuel is about 98 percent complete as of January 22. The Department of Energy's unsafely stored, contaminated and uninspected for decades, spent fuel required the State of Idaho to demand work be done to phase out the unsafe spent fuel pools at the Idaho National Laboratory.

  An "Idaho Integrated Spent Nuclear Fuel Management Plan" is now included in 2023 appropriations, stating that *"The Department is directed to develop an integrated strategy between the Office of Nuclear Energy and the Office of Environmental Management to establish a road-ready, dry storage packaging configuration capability for Department-owned spent fuel" and "…As part of this integration effort, the Department shall develop an Idaho Sitewide Spent Nuclear Fuel Management Plan and shall analyze the use of the Naval Reactors spent fuel packaging facility to support EM's packaging needs in lieu of new construction."* This is encouraging news — albeit a couple decades late and is, hopefully, better than not having a plan.

- During public comment, I pointed out that Mackay Dam failure is not a 1-in-1000-yr failure probability, it is known and DOE knows that it won't withstand a less than 1-in-100-yr flooding event. This means that the RCRA permit excluding Mackay Dam failure, signed by the Department of Energy, is fraudulent. (See the Environmental Defense Institute website for more about the Mackay Dam vulnerabilities.)

Idaho Falls City Club hosts Idaho Environmental Coalition's Ty Blackford, on nuclear waste from nuclear reactors

The February 16 City Club luncheon in Idaho Falls had speaker Ty Blackford, of the Department of Energy's current cleanup contractor for the Idaho Cleanup Project, the Idaho Environmental Coalition. He proposed that the solution to nuclear energy waste is reprocessing of spent nuclear fuel — and that the US should follow the example set by the French. Questions to the speaker at the luncheon are carefully screened and limited. And no answer, however incomplete, is ever challenged. Idaho Falls City Club luncheons are intended to be pleasant pro-nuclear affairs, after all, typically sponsored by profiteering entities.

Blackford emphasized that the nuclear energy's problems are basically due to the wrong-headed perceptions of people who don't understand the technology and probably their minds cannot be changed.

The speaker's message was delivered with charm and swagger and was well received. Indeed, he claimed that many people wrongly associate the decades of leaking radioactive tank waste at Hanford for U.S. nuclear weapons production should not be associated with nuclear reactors to generate electrical energy. He did not mention that the same Department of Energy that has for decades failed to address the leaking radioactive high-level waste at Hanford from reprocessing of spent nuclear fuel associated with nuclear weapons production is the same Department of Energy that has no program for the disposal of spent nuclear fuel from commercial nuclear plants that generate electricity.

And Blackford stated that people who think a nuclear reactor can go off like a bomb are wrong.

In reality, nuclear reactors can explode as did the SL-1 reactor at the INL and the 1986 Chernobyl reactor. Does anyone remember the hydrogen explosions at the 2011 Fukushima disaster? But more importantly, the amount of airborne radiological releases from a reactor or its spent fuel pool can greatly exceed that of a nuclear weapons detonation, causing even greater harm to human health and the environment over wide areas.

The presentation was heavy on opinion and light on facts. Questions of the impact of small modular reactors on radioactive waste disposal and others were asked. But few facts, if any, were provided.

So, let me provide a few facts.

Small modular reactors (SMRs) and other smaller than 300 mega-watt-electric (MW) nuclear plants, according to a study of the disposal issues, will greatly increase spent nuclear waste disposal problems, whether small light-water reactors, sodium-cooled fast (neutron) reactors, or molten salt reactors. [2] It should be noted that the U.S. Nuclear Regulatory Commission, when licensing nuclear power plants, from micro- to small to large, **does not concern itself with the cost or feasibility of spent fuel disposal.**

Reprocessing of light-water spent fuel yields only modest improvements in uranium usage but creates very high costs, creates far higher volumes of radioactive waste, and immediately releases to the environment far more radioactivity. It does not significantly reduce the space needed in a deep geologic repository. It also creates huge nuclear weapons proliferation concerns for the vast buildup of separated plutonium.

The United Kingdom, that began reprocessing spent fuel in the 1950s has now ceased spent fuel reprocessing in 2022. It ceased its spent fuel reprocessing because of the high cost. Now, vitrified high-level waste is being returned to the countries that the UK reprocessed waste for. And the reprocessing has accumulated vast amounts of separated weapons-usable plutonium that there is no identified use for, about 116 metric tons plus plutonium belonging to Japan (24 metric tons). [3]

The UK reprocessed its own spent fuel and also the spent fuel of other countries, including Japan. Still, the UK also needs but does not have a geologic repository. The cost of "cleanup" of the reprocessing site called Sellafield is currently estimated as many tens of billions of British pounds and that estimate is likely to keep increasing. Windscale, after having radiological

[2] 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.

[3] Frank N. von Hippel and Masafumi Takubo, International Panel on Fissile Materials (IPFM), *Banning Plutonium Separation*, 2022.

airborne releases from a reactor accident was renamed Sellafield. [4] The extensive environmental contamination of air and sea and health harm from spent fuel reprocessing has largely been denied. The UK now has about 140 tons of separated civilian plutonium, which is 140,000 kg of plutonium and the nuclear weapon that the US dropped on Nagasaki, Japan during World War II was only 6.2 kg of plutonium. And more can be done with less plutonium in nuclear weapons designed following WWII.

France has also had a long history of reprocessing spent nuclear fuel for its own reactors and reprocessing for other countries and has not ceased reprocessing. France has over 79 metric tons of separated plutonium.

In France, the chemical extraction processes were used created liquid tank waste. France did use extracted the plutonium from light-water reactor spent fuel and fabricated into mixed oxide (MOX) fuel that is a mixture of uranium and plutonium. The concentration of plutonium used in MOX fuel used in nuclear reactors in France has increased over the years from 5.3 to 8.65 percent average plutonium content of the MOX fuel. The spent MOX fuel is hotter than low enriched light-water reactor fuel and now requires 30 years of cooling in a spent fuel pool. [5]

The higher 8.65 percent plutonium MOX fuel now requires about 30 years of cooling in a spent fuel pool, whereas MOX fuel with a 5.30 percent plutonium content requires only about 5 years of cooling, similar to conventional light-water reactor fuels. Now France's spent fuel pools are about full. So now in France, **an emergency effort is underway to build a new refrigerated pool for the hot MOX.**

Dry storage for the MOX has been studied and is considered feasible, but only after many years of cooling, again depending on the plutonium content in the MOX fuel. And, as of yet, no technology to reprocess the MOX fuel has been developed.

While France was able to fabricate and utilize MOX fuel, the UK and the US, however, were less successful at utilizing MOX fuel. And that appears to be a blessing. Had the US been successful in persuading US nuclear utilities to use the DOE-manufactured MOX fuel, we may have been stuck with years of MOX fuel in spent fuel pools and no dry storage developed for it. Then, we'd be stuck with having to try to evaluate the MOX fuel impacts to a disposal facility, with its high fissile content as well as high decay heat. Or perhaps even more expensive, we'd be trying to figure out how to reprocess MOX fuel and having to deal with the far higher volumes of radioactive waste from its reprocessing.

In addition to vast amounts of separated plutonium, France and the UK (like the U.S.) have vast amounts of recycled uranium for which there is no identified use. Fuel fabrication is greatly impeded by radioactive impurities in recycled uranium, such as result from the uranium-232 decay chain, yielding penetrating thallium-208 gamma radiation. However, in France, enriched uranium was recycled, see IPFM, 2022.

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[4] Samanth Subramanian, *The Guardian*, "Dismantling Sellafield Epic Task," December 15, 2022. https://www.theguardian.com/environment/2022/dec/15/dismantling-sellafield-epic-task-shutting-down-decomissioned-nuclear-site

[5] Institut de Radioprotection et de Surete Nucleaire (IRSN), "Assessment of dry storage possibilities for MOX or ERU [Enriched uranium] spent fuels," ISRN Report No. 2019-00903, French Issue April 2019.

In the U.S., testing of MOX fuel was conducted in various commercial nuclear power plants beginning in the 1960s. [6] After two cycles of testing beginning in 2005, MOX fuel was removed from Duke Power's Catawba nuclear reactor and Duke refused to continue testing of MOX fuel after 2008. [7] The inspection and test results and the full account of the reasons that no U.S. commercial reactor wanted DOE's MOX fuel remain vague.

What is clear, however, is that nuclear safety agencies, whether in the U.S. or in France, tend to fail to consider the impact on cost, storage cost and difficulty or disposal cost or difficulty when licensing higher burnup fuels. The higher the enrichment in uranium-235 (or plutonium-239), the longer the fuel can run in a reactor, and the greater the days operated in a reactor, the greater the amount of fission products and actinides than build up in the "used" fuel. Rather than 2 percent enrichment in U-235 like the first electrical generating nuclear reactors, enrichment up to 5 percent were licensed by the U.S. Nuclear Regulatory Commission, without regard to the cost and difficulty of pool or dry cask/canister storage or of disposal — even though the NRC was chartered to approve the licensing of the Department of Energy's proposed Yucca Mountain design.

As the U.S. NRC will be granting licenses to a wide variety of unusual nuclear reactors, so far, the increased cost and difficulty or even the lack of feasible disposal has not been a consideration by the NRC.

The term "recycling" implies far greater reuse and efficiency than spent nuclear fuel reprocessing currently provides. To suggest that the solution to the "back end" of the nuclear fuel cycle, as was suggested on February 16's Idaho Falls City Club luncheon, without discussing costs, environmental releases, proliferation concerns and the greatly increased volumes of multiple streams of radioactive waste and the modest, if any, reduction in the ultimately needed space for disposal of spent fuel waste, is understandable though. It simply would not convince anyone that reprocessing spent fuel was a sound idea.

Despite the enthusiasm for small modular reactors [8] being promoted by the Department of Energy and various companies, the small modular reactors (each core generating less than 300 MWe) will greatly worsen the spent nuclear fuel storage and disposal already faced by the U.S. According to a 2021 study of the challenges posed by disposal to the fuel and irradiated components of SMRs, the nuclear waste from the variety of small modular reactors (water-, molten-salt-, and sodium-cooled SMR designs) can be expected to "increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30." [9]

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[6] Department of Energy, Disposition of Surplus Plutonium, Appendix J, Evaluation of Select Reactor Accidents With Mixed Oxide Fuel Use at the Browns Ferry [Alabama, BWR] and Sequoyah [Tennessee, PWR] Nuclear Plants, 2015. This appendix gives a history of MOX fuel testing in the US up to 2015.

[7] *Friends of the Earth*, "Duke Energy Abandons Plutonium Fuel (MOX) Testing Program in South Carolina Reactor," circa 2008, https://foe.org/news/2009-11-duke-energy-abandons-plutonium-fuel-mox-testing-prog/ [accessed February 27, 2023]

[8] Jennifer McDermott, AP, *The Idaho Falls Post Register*, "Several universities to experiment with micro nuclear power," February 11, 2023.

[9] 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.

The U.S. already needs two deep geologic repositories that size of the legally mandated original size of the proposed Yucca Mountain repository, just to accommodate existing spent fuel, high-level waste and the spent fuel expected from currently operating reactors.

In 2010, the proposed 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.

The U.S. is no closer to achieving a solution of the "back end" of the nuclear fuel cycle now in 2023 than it was in 1980. The spent nuclear fuel from inadequately packaged waste creates the risk, or perhaps the certainty, of radiotoxic waste that remains posed to poison life from airborne or water or soil contamination for millennia.

NuScale Cost Estimates Rising, But Construction Has Not Begun; And NuScale Spent Fuel Disposal Problems Worse Than Existing Light-water Reactors

According to the January 2023 report by the Institute for Energy Economics and Financial Analysis, "More than two dozen of the 48 Utah Associated Municipal Power Systems (UAMPS) members have signed on to buy power from the NuScale SMR when the project is planned to come online in 2029. But a history of the project—and of nuclear energy projects in general—suggests the project is likely to end badly for utilities and worse for ratepayers." [10]

"UAMPS announced earlier this month that the cost per megawatt-hour (MWh), a unit of measurement roughly equivalent to the electricity used by the average U.S. home for a little more than a month, has risen from $58/MWh to $89/MWh, a 53 percent increase. Plus, the cost of power from the project would be much higher than $89/MWh without more than $4 billion in subsidies the project would receive from the U.S. government. Already, the total cost of the project has risen from $5.3 billion to $9.3 billion."

The costs for the full sized AP1000 pressurized light-water reactors being built at the Vogtle nuclear site in Georgia were originally claimed to cost $14 billion to construct and were to be completed by 2016. The two reactors in Georgia are still not completed and the costs of construction are expected to exceed $30 billion. And actually, would cost $34 billion if the $3.68

[10] David Schilssel, Institute for Energy Economics and Financial Analysis, Small modular reactor project likely to end badly for utilities and worse for taxpayers, January 24, 2023. https://ieefa.org/resources/small-modular-reactor-project-likely-end-badly-utilities-and-worse-taxpayers

billon that original contractor Westinghouse paid to the owners after going bankrupt is included. [11] Further delays and higher cost for the Vogtle project were announced this February. [12]

The projected startup date for Vogtle Unit 3 is May or June of this year, over six years late. The delay will add $201 million to the cost. Issues with vibrations in the passive cooling system and other problems are said to be the cause of the most recent delay. In 2017, an estimated levelized cost of electricity from Vogtle was from $105 to $112 per MWH, about twice as high as any other option. Read more about it, Georgia Conservation Voters, *Ratepayer Robbery – The True Cost of Plant Vogtle*, December 2021.

The NuScale "small modular reactors" would place twelve reactors (of approximately 60 MWe) in a facility — which is not a small radiological hazard nor a small amount of spent nuclear fuel to have to dispose of. The NuScale reactor module generating capacity is a changing value, and perhaps more importantly, the ultimately used fuel enrichment may be higher than initially licensed, which will further worsen spent fuel disposal problems.

The design of the NuScale fuel will require more space, by at least a factor of two, 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. [13]

Oregon Legislators Seeking Law Changes Currently Barring New Nuclear Energy Reactors

The Oregon State legislators are seeking to change laws that currently bar new nuclear reactors unless permanent disposition for the radioactive waste has been obtained. Also, Oregon's current law would require any proposed site certificate for a nuclear reactor to be submitted to electors of the state for approval or rejection. [14]

The Oregon public hearing on removing these sensible laws gave ample time to nuclear promotors and limited the speaking time to 2 minutes each for those opposed. The testimony of

[11] ANS Nuclear Cafe, *NuclearNewswire*, "Vogtle project update: Cost likely to top $30 billion," May 9, 2022. https://www.ans.org/news/article-3949/vogtle-project-update-cost-likely-to-top-30-billion/

[12] ANS Nuclear Cafe, *NuclearNewswire*, "Further delays, higher cost for Vogtle project announced," February 17, 2023. https://www.ans.org/news/article-4760/further-delays-higher-cost-for-vogtle-project-announced/

[13] 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.

[14] Oregon State Legislature, HB 2215 and SB 676, that "Removes requirement that adequate repository for terminal disposition of high-level radioactive waste be licensed as precondition for issuance of site certificate for nuclear-fueled thermal power plant" and "Removes requirement that proposed site certificate for nuclear-fueled thermal power plant be submitted to electors of this state for approval or rejection." Public hearings on February 13 and 20, 2023, see comment submittals and more at https://olis.oregonlegislature.gov/liz/2023R1/Testimony/HCEE?meetingDate=2023-02-13-15-00

those opposed to eliminating the laws were grouped together and there was no indication of legislators actually paying attention to the testimony.

According the testimony by Daniel Shay, there are twelve states with similar laws barring new nuclear reactors until the nuclear waste problem, largely that of the spent nuclear fuel, has been solved. And there are five states with laws requiring voter approval of new nuclear reactors.

With active lobbyists and short-sighted nuclear profiteers having access to the legislators, it appears that the "fix is in." A lot of effort is being focused on gutting these sensible laws, in Oregon, as well as in California and other states. And what an expensive and deadly mistake this will be.

The cost of disposal of spent nuclear fuel is currently unstated, but is likely to be many times that of the money collected is disposal fees. Reconditioning or reprocessing of the fuel will certainly be double the cost of constructing the reactor. The costs and the radiotoxic hazards will be placed on future generations as nuclear profiteers will disappear as soon as the inevitable problems occur and the money runs out and the companies go bankrupt like Westinghouse Nuclear, AREVA, BNFL and others.

See my comments about the Oregon law changes on the Environmental Defense Institute website. [15]

TerraPower's Natrium, a Sodium-cooled Fast Reactor, Facing Delays in Commencing Construction

The Bill Gates-backed sodium-cooled fast neutron reactor, Natrium, slated for Kemmerer, Wyoming is facing at least two years of delays because of difficulty getting its nuclear fuel from Russia. [16]

Construction has not yet started on the 325 mega-watt-electric (MWe) or 840 mega-watt-thermal (MWt) sodium-cooled fast reactor nuclear plant. Sodium-cooled fast reactors are the least safe to operate, create the comparatively far more radioactive waste disposal problems and will require costly conditioning to remove the salt before disposal. The fast neutron reactors create plutonium-239 that can be separated using pyroprocessing and increase the threat of separated plutonium-239 diverted to create the nuclear weapons. In other words, sodium-cooled reactors are unsafe, exacerbate nuclear fuel disposal problems and increase weapons proliferation concerns.

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[15] Tami Thatcher, "Public Comment Submittal on Oregon State Legislature, HB 2215 and SB 676, that "Removes requirement that adequate repository for terminal disposition of high-level radioactive waste be licensed as precondition for issuance of site certificate for nuclear-fueled thermal power plant" and "Removes requirement that proposed site certificate for nuclear-fueled thermal power plant be submitted to electors of this state for approval or rejection." February 13 and February 20, 2023 combined comments. http://www.environmental-defense-institute.org/publications/CommentNewSNF2023Feb20.pdf

[16] Catherine Clifford, CNBC, "Bill Gates-backed nuclear demonstration project in Wyoming delayed because Russia was the only fuel source," December 16, 2022. https://www.cnbc.com/2022/12/16/bill-gates-backed-nuclear-demonstration-delayed-by-at-least-2-years.html

The Natrium reactor is to use high-assay low-enriched uranium (HALEU) that is enriched to nearly 20 percent in uranium-235. Conventional light-water reactors use fuel enrichment below 5 percent. The invasion of the Ukraine by Russia has made it not feasible to obtain the HALEU fuel from Russia.

When used in the reactor, the HALEU will create more plutonium and that plutonium will be a weapons proliferation risk as well as a spent fuel disposal headache. The higher the fissile content in the spent fuel, the greater the criticality hazard for transportation, storage and disposal and for more than 10,000 years.

About half of the money to build the $ 4 billion Natrium reactor is coming from the Department of Energy. And now Natrium backers are seeking lawmakers to provide another $2.1 billion to support HALEU fuel production. A vast amount of misinformation is coming directly from the Department of Energy, like misleading claims that a sodium-cooled fast reactor can burn spent nuclear fuel, see https://www.energy.gov/ne/articles/3-advanced-reactor-systems-watch-2030 where DOE states that sodium-cooled fast reactors "can burn spent nuclear fuel from current reactors." With the vast amounts of spent nuclear fuel from US commercial nuclear reactors, then the inability to get HALEU fuel from Russia would not be much of a problem, would it?

HALEU fuel production releases airborne radiological contamination (see Table 1) and is expensive.

The Natrium sodium-cooled fast reactor is seeking approval from the U.S. Nuclear Regulatory Commission. [17] If the proposed reactor design wasn't already bad enough, TerraPower is seeking to allow the significant **release of radionuclides** during operating transients rather than meet fuel design limits (See ML23024A281) during plant upsets.

[17] U.S. Nuclear Regulatory Commission website at nrc.gov and NRC's ADAMS database. https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/natrium.html See also flow blockage issues at https://www.nrc.gov/pmns/mtg?do=details&Code=20220791 NRC Adams ML22227A058.pdf gives link to NATD-LIC-PRSNT-0026 which leads to NRC Adams ML222078814.pdf, a 2022 Gap analysis, including various safety exceptions for emergency planning and others. In ML23024A281.pdf TerraPower, January 24, 2023, Submittal of TerraPower Topical Report, "Principal Design Criteria for the Natrium Advanced Reactor" allowing radiological releases is being sought, rather than meeting fuel design limits in order to prevent radiological releases.

Table 1. 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.

TerraPower also seeking a Molten Salt Reactor, A 500-kilowatt demonstration project is planned for the INL

Despite the Natrium sodium-cooled fast neutron reactor not yet having been granted a license to construct, Bill Gates' TerraPower is seeking another reactor design, the Molten Chloride Reactor Experiment (MCRE). This would be a **fast-spectrum**, salt-fueled nuclear reactor, that circulates the nuclear fuel in the coolant. [18] The Idaho National Laboratory will be assisting with a demonstration project. Note that previous molten salt reactors were **thermal-spectrum** (or slow neutron) reactors. Fast-spectrum (fast neutron) reactors tend to have higher core power densities and be less easily controlled than thermal-spectrum reactors.

The 500-kilowatt demonstration project will not generate electricity and construction is planned by 2025. TerraPower is claiming this MCRE will be "low-cost clean energy." [19] [20]

According to a 2022 TerraPower factsheet, its molten salt reactor will be high temperature and "TerraPower's work focuses on a fast neutron spectrum, as opposed to the thermal neutron spectrum in which other [molten] salt reactors operate. The fast neutron spectrum minimizes the impact from fission contamination byproducts and allows the MCFR technology to avoid the need for the online reprocessing that is required in thermal spectrum and thorium concepts." [21] Also stated is that their proposed design allows "Refueling without the need for ongoing enrichment or reprocessing facilities effectively eliminates weapons proliferation risks."

Two experimental molten salt thermal breeder reactors were built in the U.S. over 50 years ago. [22] The 8 megawatt-thermal (slow neutron) Molten Salt Thermal Breeder reactor built at the Oak Ridge National Laboratory was the second at ORNL and operated from 1965 to 1969. That reactor entailed many radioactive waste decommissioning and disposal problems and the contaminated reactor is now entombed at the Oak Ridge National Laboratory. [23] It used enriched uranium-235 and fertile thorium as tetrafluorides, dissolved in a carrier salt of lithium and beryllium fluoride. Vessel internals included graphite. [24] The ORNL Molten Salt Thermal

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[18] See the TerraPower website and the factsheet for the Molten Chloride Fast Reactor project at https://www.terrapower.com/our-work/molten-chloride-fast-reactor-technology/ [accessed February 24, 2023]

[19] TerraPower web page, "TerraPower and Southern Company to demonstrate the world's first fast-spectrum salt reactor at Idaho National Laboratory," dated February 23, 2022 [accessed February 22, 2023]. https://www.terrapower.com/southern-terrapower-mcre-agreement/

[20] Idaho National Laboratory web page, "Southern Company Signs Agreement with U.S. Department of Energy to Demonstrate World's First Fast-Spectrum Salt Reactor in Collaboration with TerraPower, Idaho National Laboratory," dated November 18, 2021[accessed February 22, 2023]. https://inl.gov/article/southern-company-signs-agreement-with-u-s-department-of-energy-to-demonstrate-worlds-first-fast-spectrum-salt-reactor-in-collaboration-with-terrapower-idaho-national-laboratory/

[21] TerraPower, "TerraPower's Molten Chloride Fast Reactor Technology: Nuclear for a Changing Energy Sector," 2022, at www.terrapower.com. [Accessed February 24, 2023]

[22] Badawy M. Elsheikh, *Journal of Radiation Research and Applied Sciences*, "Safety Assessment of molten salt reactors in comparison to light water reactors," October 2013. https://www.sciencedirect.com/science/article/pii/S1687850713000101

[23] 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.

[24] Anthony V. Nero, Jr., *A Guidebook to Nuclear Reactors*, University of California Press, ISBN 0-520-03482-1, 1979.

Breeder reactor never generated any electricity and its waste management problems have not been solved.

Safety of the 1960's molten salt thermal breeder was thought to be improved from that of a fast neutron reactor by the use of uranium-233 rather than plutonium-239, by on-line removal of the fission products, and by prompt disposal of fission products transported to a repository. [25]

However, due to substantial design variations, these advantages may not apply to the proposed TerraPower project.

The earlier molten salt reactors had built-in reprocessing capability. But this capability will likely greatly increase the cost of building a molten salt reactor facility. Disposal of the fuel and the irradiated components of a molten salt reactor will also be expected to entail greater cost and difficulty and greater space in a repository than conventional light-water reactors, according to the 2021 study by Krall, Macfarlane and Ewing. [26]

Even without built-in reprocessing, the molten salt reactors lack adequate materials to withstand the corrosive environment, even thermal spectrum molten salt reactors. Even decades later, there is a lack of materials that can withstand the harsh environment of a molten salt reactor. More corrosion-resistant materials tend to be more brittle. Add a higher neutron flux and higher temperature, the molten salt fast reactor proposed by Bill Gates will likely be far less safe than conventional reactors, which are already unsafe.

A thermal spectrum molten salt reactor could use uranium-233, so why make it a fast spectrum reactor? TerraPower's proposed molten salt fast spectrum reactor will use or breed U-233, but is ultimately very different than earlier molten salt reactors.

Some nuclear power promoters claim molten salt reactors will be cheaper to run. But there are many unsolved problems with molten salt reactors. [27]

The Bill Gates-backed research of molten salt reactors will divert money from real solutions and require so many years of research that it cannot be helpful in the urgent need to address climate change. The experimentation involving molten salt reactors is in the early stages and cannot be expected to be deployed within decades or within time to make a difference for climate change.

Articles by Tami Thatcher for March 2023.

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[25] Karl Z. Morgan and Ken. M. Peterson, *The Angry Genie – One Man's Walk through the Nuclear Age*, University of Oklahoma Press, 1999.

[26] 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.

[27] M.V. Ramana, *The Bulletin*, "Molten salt reactors were trouble in the 1960s – and they remain trouble today," June 20, 2022. https://thebulletin.org/2022/06/molten-salt-reactors-were-trouble-in-the-1960s-and-they-remain-trouble-today/