

The Thermodynamic Effects of Nuclear Fission in the Great Salt Lake Basin

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Abstract

Operation Gigawatt proposes deployment of up to 13 Holtec SMR-300 pressurized water reactors across Utah and Wyoming, with the first dual-unit site at Brigham City on the Great Salt Lake basin and the Wasatch Fault. No thermodynamic analysis of waste heat in an endorheic basin has been performed by any operator, agency, or regulatory body prior to this publication. This paper presents that analysis. Using the ANS/ANS-5.1-2014 decay heat standard, the NGA-West2 ground motion prediction equations, and first-principles thermodynamic accounting via the latent heat of vaporization, we calculate that the 13-reactor fleet continuously rejects 8.97 gigawatts of waste heat, evaporating 101,543 acre-feet per year from a terminal basin with no thermal exit pathway, consuming 49 percent of the Great Salt Lake's current volume over one operating license.

Post-shutdown decay heat requires active water cooling for 24,110 years, the first half-life of plutonium-239, during which the Wasatch Fault Brigham City segment produces a M 6.75 or greater seismic event with mathematical certainty, and 14 of 50 instrumentation and control materials are projected to reach global supply exhaustion before the first operating license expires. South arm salinity crosses the brine shrimp reproductive failure threshold within the first decade of fleet operation, eliminating 40 to 50 percent of the global aquaculture feed supply. Lake-effect precipitation declines by 20 percent, reducing snowpack at Olympic venues by 90 inches by 2034. The proximate cause of the energy demand driving this deployment is a thermodynamic specification omission in the 1964 IBM byte standard, which excluded Landauer's minimum energy relationship despite its publication at IBM three years earlier. No party named in the liability section performed this analysis before authorizing, funding, or deploying reactors in Utah. [The Great Salt Lake is not a suitable site for thermodynamic nuclear deployment.](#)

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1. The Question

On February 23, 2026, the President of the United States named the Great Salt Lake "a real environmental disaster" and committed to the people of Utah that he would do all in his power to save it [1]. The federal government acquired 22,311 acres of Great Salt Lake land during the 2026 Utah Legislative Session for restoration purposes [2]. Operation Gigawatt proposes to build reactors on the same watershed, drawing from the same basin, for longer than the federal government or any government has ever existed [3].

What is the projected health of the Great Salt Lake including elevation, toxic dust exposure, brine shrimp viability, and lake-effect precipitation at operational license end and at 100, 300, and 1,000 years post-shutdown, accounting for 8.97 gigawatts of continuous waste heat into a terminal basin with no thermal exit pathway, the 43-percent probability of a Wasatch Fault magnitude 6.75 seismic event within 50 years, and simultaneous cooling water loss and radiological release into the primary water supply of 80 percent of Utah's population and who is liable for the irreversible harm across the full decay timeline?

The question posed to the Department of Energy Office of Nuclear Energy on March 7, 2026, is more than a question about reactor safety. It is a question about water availability in an earthquake prone terminal basin with no thermal exit pathway, over a decay timeline longer than recorded human civilization, and the planned management of the nuclear product lifecycle and the sunset at 24,100 years [4][5][6][7].

The Demand Drivers of Nuclear Energy

In the 119th United States Congress House Energy and Commerce Committee held a hearing on Converting Energy into Intelligence titled the Future of AI Technology, Human Discovery, and American Global Competitiveness. Google CEO Eric Schmidt testified that there is no nuclear fleet which will satiate the energy demands of the byte [8], indicating a fundamental design problem driving technology's energy demand. Despite his testimony of the byte being energy insatiable, Mr. Schmidt encouraged America to keep scaling energy infrastructure and building data centers to meet the energy demand of the byte and the unbounded statistical inference models marketed as Artificial Intelligence.

The Byte

Project Operation Whirlwind Core Memory was a joint collaboration between the Massachusetts Institute of Technology and the Office of Naval Research that produced the first reliable random-access memory. Jay Forrester's magnetic core memory, demonstrated in 1953, stored each bit as a magnetic state in a ferrite core, making it the first practical engineering implementation of the theoretical binary information unit proposed by Claude Shannon in 1948 [9].

Once Forrester demonstrated reliable magnetic core memory on Whirlwind, IBM commercialized the technology, announcing its first core memory unit, the Model 737, in 1954 [10]. The rapid development of digital computing in this era was driven by the nuclear arms race, which demanded real-time computation for weapons design, missile trajectory calculation, and continental air defense. Whirlwind itself evolved into the SAGE air defense system, built to detect and intercept Soviet nuclear bombers [11]. In the years that followed, computer manufacturers experimented with different word lengths and data groupings before the industry settled on the 8-bit byte as the standard unit of digital storage, a convention formalized by IBM's System/360 architecture in 1964.

■ *Observational Irony: The nuclear weapons program created the urgent need for digital computing. The computing infrastructure, built on finite materials, is now required to safely operate and monitor the reactors that descended from the same nuclear program. The technology created to build the atomic bomb is now the technology without which the reactor cannot be safely managed and the materials that make both possible are running out.*

Information-Energy-Mass Equivalence

When Shannon defined the bit in 1948, information was abstract [9]. It could be quantified, transmitted, and compressed, but it had no weight, no heat, and no energy cost. It was mathematics, not physics. In 1961, Rolf Landauer changed that [12]. By proving that every irreversible bit operation dissipates a minimum of $k_B T \ln(2)$ joules as heat, Landauer welded information to the second law of thermodynamics. The bit was no longer free. Every computation, every measurement, every particle erasure pays an energy cost to the physical universe, and that cost is heat, and thereby entropy.

The discovery chain of quantum information physics since then has only tightened the connection between information, energy, and heat. Bennett (1973) proved the cost is specifically tied to irreversibility. When a bit is erased there is a cost [13]. Bérut et al. (2012) measured that cost for the first time in a laboratory, confirming Landauer's bound in Nature [14]. Hong et al. (2016) confirmed information has a cost again in nanomagnetic memory, the actual physical substrate of digital storage [15]. Vopson (2019) followed the logic one step further hypothesizing if erasing information costs energy, and energy has mass $E = mc^2$, then information itself has mass: $m = k_B \cdot T \cdot \ln(2) / c^2$ [16]. Walker (2026) identifies the result as a temperature-dependent particle: $m(T) = k_B \cdot T \cdot \ln(2) / c^2$, the Infoton, whose mass, energy, and physical consequence are determined by the thermodynamic environment in which the information exists [17], and observed the Infoton at 310K aligned to mitochondria biological frequencies [18] measured in lab [19].

The implications of the information-energy discovery chain extend beyond computers. A nuclear reactor is, at its thermodynamic foundation, an information-energy processing system. Every sensor measurement, every control rod adjustment, every safety system calculation, and every radiation monitoring event across the full operational and post-shutdown decay timeline is an irreversible bit operation subject to Landauer's minimum energy cost. The reactor does not merely produce waste heat from fission. It produces waste heat from information-energy. In an open system, this distinction is a calculable variable. In a terminal basin with no thermal exit pathway, a closed thermodynamic environment where heat accumulates without dissipation, the distinction becomes a matter of physical survival. The Great Salt Lake is a finite endorheic system whose thermodynamic equilibrium has already been structurally compromised by anthropogenic water diversion, evaporative loss, and global thermal loading. Every irreversible computation required to manage a nuclear facility on its watershed, from commissioning through the 24,100-year plutonium-239 decay horizon, adds to a thermodynamic ledger the basin cannot balance. Landauer's principle does not grant exceptions for energy sources. The bit costs heat whether it is counting social media impressions or monitoring spent fuel rods. In a terminal basin, that heat has nowhere to go [12][4][5][6][7].

Through Quantum Information Physics we are provided both the framework to understand our universe and the impact of our anthropogenic behaviors. With the ability to utilize physics as tools to diagnose and engineer solutions with mathematical precision.

2. The Great Salt Lake

The Great Salt Lake is the largest saline lake in the Western Hemisphere and a keystone of the global food chain [20].

The Great Salt Lake entered 2026 at 4,191.6 feet above sea level, only three feet above its all-time record low, firmly in the range scientists classify as "serious adverse effects" [21][22]. It has lost approximately 800 square miles of lakebed to exposure, creating a dust pollution threat for the 2.5 million people living along the Wasatch Front [23]. The Great Salt Lake basin extends all the way out to the Bonneville Salt Flats, the exposed lakebed of the ancient body of water from which the modern lake descends [24].

Brine Shrimp

The Great Salt Lake produces brine shrimp eggs, *Artemia franciscana* cysts, that feed shrimp farms across Southeast Asia, South America, and China [25][26]. Those shrimp farms produce a significant fraction of the world's farmed seafood. Utah's Great Salt Lake is the single largest source of brine shrimp cysts on Earth, supplying approximately 40 to 50 percent of the global market for aquaculture feed cysts [26][27]. The Utah brine shrimp harvest generates approximately \$57 million annually in direct revenue, supporting a downstream aquaculture industry valued in the billions [27][28]. When the lake's salinity crosses the threshold where *Artemia* can no longer reproduce, roughly 150 to 180 g/L in the south arm [29][30], that supply chain breaks. The south arm salinity is currently approximately 142 g/L [31], placing the lake 8 g/L from the reproductive failure threshold.

Bird Refuge

The lake anchors the Western Hemisphere's Pacific Flyway. Ten million migratory birds from 338 species depend on it as a critical staging ground [32][33]. The brine shrimp and brine flies (*Ephydra hians*) they feed on exist nowhere else at this scale on the continent [32][34]. Wilson's phalaropes, eared grebes, American avocets, and snowy plovers, species whose continental populations depend on this single body of water, concentrate at the Great Salt Lake in numbers representing 50 to 90 percent of their total hemispheric populations during migration [32][33]. The lake's designation as a Western Hemisphere Shorebird Reserve Network site of hemispheric importance reflects this irreplaceable ecological function [33].

The Bear River Bird Refuge sits on the eastern shore adjacent to the proposed location of the nuclear reactor.

Exposed Lakebed Neurological Risks

The exposed lakebed is a toxic dust source containing arsenic, mercury, lead, cadmium, and other heavy metals concentrated through decades of industrial discharge and natural mineral accumulation [35][36]. During wind events, this dust blankets the Wasatch Front at PM10 concentrations exceeding 4,000 µg/m³ [36][37], more than 26 times the EPA 24-hour PM10 standard of 150 µg/m³ [38]. That is the air 2.5 million people breathe [39]. The exposed lakebed emits approximately 4.1 Mt CO₂eq/yr of greenhouse gases as microbial decomposition of organic sediments accelerates with exposure [40].

Committing 482,713 acre-feet of water from a dehydrating terminal basin to cool 2 nuclear reactors for 24,000 years, or 3,137,633 acre-feet for the full 13-reactor fleet, is

incompatible with the survival of the ecosystem those reactors would inhabit. With the rising heat of the planet from anthropogenic behaviors linked to Landauer's principle, the physics is clear. The Great Salt Lake needs more water in while the reactors take water out. Decay heat ensures the taking never stops. Every acre-foot consumed by reactor cooling in a terminal basin with no outlet is an acre-foot permanently removed from the system [7][41][42].

■ Regulatory Consideration: The lake is 8 g/L from brine shrimp collapse, 5 to 10 years from irreversible ecological thresholds [27][28], and losing water at approximately 587,000 AF/yr against a restoration need of 948,000 AF/yr [41]. If humanity were not here what is our responsibility to the earth which gave us life? What would happen through time if nuclear was not appropriately managed?

3. Nuclear Fission

A fission reactor splits uranium atoms to produce heat. That heat boils water into steam, the steam spins a turbine, and the turbine generates electricity [43]. There are many types of nuclear reactors. For this report I analyze the SMR-300, as it is the reactor proposed for deployment at Brigham City, Utah, on the Great Salt Lake basin and the Wasatch Fault [44].

Fission

A fission Small Modular Reactor is a pressurized water reactor whose entire operating principle depends on water. The primary coolant is water [43]. The moderator is water. The steam generator runs on water. The spent fuel pool requires water. The secondary loop that drives the turbine is water. The deluge spray system that keeps the air-cooled condenser functional in hotter climates is water. In this class of nuclear reactor the annual reservoir of water is the heat sink which makes fission "walk-away safe." In the nuclear industry walk-away safe means the plant operators are not required to take action to ensure cooling occurs during any unforeseen catastrophic event [45].

Fission & Heat Production

The SMR-300 produces 1,050 megawatts of thermal energy and converts approximately 300 megawatts to electricity [45][46]. The remaining 750 megawatts is waste heat that must be continuously rejected to the environment. A gigawatt in nuclear is not a gigawatt of energy. It is a gigawatt of heat, of which less than a third becomes electricity.

No heat engine can convert all thermal energy into work. The maximum efficiency of any heat engine operating between a hot reservoir at temperature T_{hot} and a cold reservoir at temperature T_{cold} is:

$$\eta = 1 - (Temperature_cold / Temperature_hot)$$

For the SMR-300, T_{hot} is the reactor coolant temperature, roughly 600 K (327°C) for a pressurized water reactor. T_{cold} is the environment, cooling water or air, roughly 300 K (27°C) [43][47].

$$\eta_{max} = 1 - (300/600) = 0.50 = 50\%$$

The second law of thermodynamics forbids from becoming work. The heat must go somewhere. The heat goes into the cooling system and from there into the environment as waste heat.

50% is the theoretical maximum the nuclear reactor can produce. The second law of thermodynamics forbids any engine from exceeding it. In practice, nuclear reactors operate at approximately 33% efficiency, meaning roughly two thirds of the thermal energy produced is rejected as waste heat [48]. That heat must go somewhere, and after the cooling system the heat is typically discharged into water bodies, causing thermal pollution that can harm aquatic ecosystems. When the environment is a terminal basin like the Great Salt Lake, the heat has no exit pathway. It stays and drives further heat collapse of environment, and faster evaporation.

Fission Water Usage

As fission primarily leverages water for both operations and safety, I analyze the environmental impacts of both water consumption and heat production. Before operation of the plant begins, construction activities including concrete curing, dust suppression, hydrostatic testing, system flushing, and initial fills will require water [1]. Depending on the work being done, approximately 50,000 to 200,000 gallons per day will be needed. Over the 4 to 5 years of construction for each nuclear site, 200 to 500 million gallons of water will be consumed [49].

The following table estimates monthly water consumption for a single SMR-300 unit in air-cooled configuration. All values are in gallons [50][51].

Fission Air Cooled Nuclear Reactor Water Usage

Month	AC Deluge	Reservoir	SFP	Loop Makeup	Auxilalry	Mo./Total
January	0	26,000	10,000	170,000	280,000	~486,000
February	0	26,000	10,000	170,000	280,000	~486,000
March	0	26,000	10,000	170,000	300,000	~506,000
April	50,000	30,000	10,000	170,000	300,000	~510,000
May	375,000	40,000	10,000	175,000	310,000	~910,000
June	2,000,000	60,000	10,000	175,000	320,000	~2,565,000
July	3,750,000	78,000	10,000	175,000	340,000	~4,353,000
August	3,750,000	78,000	10,000	175,000	340,000	~4,353,000
September	1,000,000	53,000	12,000	175,000	320,000	~1,560,000
October	150,000	35,000	12,000	175,000	300,000	~672,000
November	0	26,000	12,000	175,000	280,000	~493,000
December	0	26,000	10,000	170,000	280,000	~486,000
Year	11,000,000	504,000	126,000	2,070,000	3,650,000	17,380,000

Monthly water consumption estimates for a single SMR-300 unit in air-cooled configuration. Values derived from reactor system parameters published in Holtec International Technical Bulletin HTB-085 Rev. 5 [45][46], NRC environmental review methodology [49], and seasonal temperature profiles for northern Utah. Deluge spray consumption pattern is consistent with published hybrid cooling system operational data [50][51]. Annual total of approximately 53 AF/yr is consistent with published air-cooled nuclear plant water intensity ratios. All values are approximations.

A single SMR-300 unit in air-cooled configuration will consume approximately 53 acre-feet of water per year even in an air configuration. As the planet warms, the water

bodies and ambient air used for cooling are becoming warmer. This makes the cooling process less efficient, requiring plants to reduce output to avoid overheating or violating environmental discharge limits [50][51].

The Great Salt Lake Environmental Analysis

Nuclear plants operate as heat engines, with a theoretical efficiency limit defined by the temperature difference between the reactor and the ambient environment (Carnot cycle) [47].

Operation Gigawatt's nuclear impact on the Great Salt Lake is comparable to taking a patient in critical condition and increasing the rate of blood loss while simultaneously requiring that the patient supply blood to the new facility being built next to the ICU.

The SMR-300 waste heat into the Great Salt Lake basin The SMR-300 produces 1,050 MW thermal, converts approximately 300 MW to electricity at 30% efficiency [45][46]. The rest is waste heat: Reactor Heat Waste = 1,050 × (1 - 0.30) = 735 MW continuously That's 735 million joules per second, every second, for the life of the plant.



$$\mathcal{M}_{\text{decay}} = P_{\text{control}} / P_{\text{decay}}(t)$$

The ratio of the minimum energy needed to compute the control of decay heat removal to the decay heat itself, as a function of time after shutdown [52].

Decay Heat Curve

After shutdown at t = 0, the reactor stops fissioning but fission products continue releasing heat. The standard approximation is the ANS 5.1-2014 decay heat standard [53], which for a reactor that operated long enough to reach equilibrium simplifies to:

Power Decay(t) = P_0 × 0.066 × t^{-0.2} where P_0 is the operating thermal power and t is time in seconds after shutdown. For the SMR-300: P_0 = 1,050 MW thermal.

At t = 1 second:

Power Decay = 1,050 × 0.066 × 1

Power Decay = 69.3 MW

At t = 1 hour (3,600 s): 306
 Power Decay = $1,050 \times 0.066 \times 3600^{-0.2}$ 307
 Power Decay = $1,050 \times 0.066 \times 0.192$ 308
 Power Decay = 13.3 MW 309
 310
At t = 1 day (86,400 s): 311
 Power Decay = $1,050 \times 0.066 \times 86400^{-0.2}$ 312
 Power Decay = $1,050 \times 0.066 \times 0.131$ 313
 Power Decay = 9.1 MW 314
 315
At t = 1 week (604,800 s): 316
 Power Decay = $1,050 \times 0.066 \times 604800^{-0.2}$ 317
 Power Decay = $1,050 \times 0.066 \times 0.101$ 318
 Power Decay = 7.0 319
 320
 MW The heat declines but never reaches zero and the fuel must 321
 be cooled for months to years [53]. 322

4. Fission Decay Heat and Water Commitment 323

Establish Fleet Thermal Power 324

The Brigham City site hosts 2 × Holtec SMR-300 pressurized water reactors, announced 325
 under Operation Gigawatt as the first deployment site for Holtec's Mountain West nu- 326
 clear ecosystem [54][55]. Governor Cox unveiled Operation Gigawatt as a state initiative 327
 to deploy up to 4 GW of SMR capacity across Utah and Wyoming [56]. 328

Each SMR-300 produces 1,050 MW thermal to generate approximately 300 MW electrical 330
 [45][46]. Thermal efficiency = $300/1,050 = 28.6\%$. This efficiency is consistent with stand- 331
 ard pressurized water reactor Carnot limitations [47]. The remaining 750 MW per reactor 332
 is waste heat that must be rejected to the environment. At 92% capacity factor (indus- 333
 try standard for PWR fleet operations [57]), each reactor continuously rejects 690 MW of 334
 waste heat. 335

$$P_0 = 2 \text{ reactors} \times 1,050 \text{ MW}_{\text{th}} \quad 336$$

$$P_0 = 2,100 \text{ MW}_{\text{th}} \quad 337$$

I now calculate the waste heat for each reactor. 339

$$\text{Reactor Heat Waste (operational)} = 2 \times 750 \text{ MW} \times 0.92 \quad 341$$

$$\text{Reactor Heat Wastr (operational)} = 1,380 \text{ MW continuous} \quad 342$$

Decay Heat Formula (ANS 5.1-2014) 343

After shutdown, fission products primarily cesium-137 with a half-life of 30.17 years, 345
 strontium-90 at half-life 28.8 years, and dozens of shorter-lived isotopes, continue releas- 346
 ing heat through radioactive decay [58]. This heat cannot be turned off, moderated, or 347
 engineered away. It is a consequence of the nuclear binding energy of fission products 348
 and follows immutable decay kinetics [59]. The American Nuclear Society standard de- 349
 cay heat approximation for long-cooled light water reactor fuel is [53]. 350

$$P(t) = P_0 \times 0.066 \times t^{-0.2}$$

Where:

t = time after shutdown in seconds

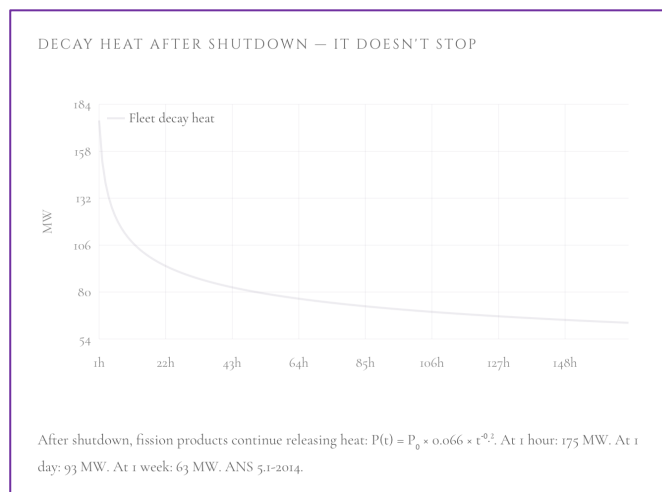
P₀ = thermal power at shutdown in watts

P(t) = decay heat power in watts

0.066 = empirically fitted coefficient for aggregate fission product decay [53]

-0.2 = power law exponent reflecting the superposition of multiple decay chains [53]

Duration	Seconds	Source/Basis
1 hour	3,600 s	3,600 s/hr
1 day	86,400 s	86,400 s/day
1 week	604,800 s	7 × 86,400
1 year	3.156 × 10 ⁷ s	365.25 days × 86,400
40 years	Calculate	Calculate
100 years	3.156 × 10 ⁹ s	100 × 3.156 × 10 ⁷
300 years	9.468 × 10 ⁹ s	300 × 3.156 × 10 ⁷
1,000 years	3.156 × 10 ¹⁰ s	1,000 × 3.156 × 10 ⁷
24,100 years	7.609 × 10 ¹¹ s	Half-life of Pu-239 [10]



The exponent -0.2 means decay heat decreases as the inverse fifth root of time. Doubling the elapsed time only reduces the heat by a factor of 2^{0.2} = 1.149, approximately 13%.

This is why decay heat persists for millennia where the power law decline is far slower than any single exponential decay. The formula represents the aggregate behavior of hundreds of fission product isotopes whose individual half-lives range from fractions of a second to millions of years [58][53]. This is the standard used by the U.S. Nuclear Regulatory Commission for licensing calculations and safety analysis [60].

Decay Product Life Cycle

Holtec's deployment model calls for twin-unit installations [54]. For a twin-unit SMR-300 deployment (2 × 1,050 MWth = 2,100 MWth), I use the ANS 5.1-2014 fission product decay approximation [53] in order to compute and benchmark the nuclear reactor decay product lifecycle and sunset planning.

First compute the constant numerator:

$$P_0 \times 0.066 = 2,100 \times 10^6 \text{ W} \times 0.066$$

$$P_0 \times 0.066 = 138.6 \times 10^6 \text{ W}$$

Then for each timepoint, I compute $t^{0.2}$ (since $t^{-0.2} = 1/t^{0.2}$) using the identity $t^{0.2} = e^{(0.2 \times \ln t)}$:

$$1 \text{ hour } (t = 3,600 \text{ s}): \ln(3,600)$$

$$1 \text{ hour} = 8.189 \cdot 0.2 \times 8.189$$

$$1 \text{ hour} = 1.638 t^{0.2}$$

$$1 \text{ hour} = e^{1.638}$$

$$1 \text{ hour} = 5.144 \text{ P}$$

$$1 \text{ hour} = 138.6 \times 10^6 / 5.144$$

$$1 \text{ hour} = 26.9 \text{ MW}$$

$$1 \text{ hour} \approx 27 \text{ MW}$$

$$1 \text{ day } (t = 86,400 \text{ s}): \ln(86,400)$$

$$1 \text{ day} = 11.367 \cdot 0.2 \times 11.367$$

$$1 \text{ day} = 2.273 t^{0.2}$$

$$1 \text{ day} = e^{2.273}$$

$$1 \text{ day} = 9.710 \text{ P}$$

$$1 \text{ day} = 138.6 \times 10^6 / 9.710$$

$$1 \text{ day} = 14.3 \text{ MW}$$

$$1 \text{ day} \approx 14 \text{ MW}$$

$$1 \text{ week } (t = 604,800 \text{ s}): \ln(604,800)$$

$$1 \text{ week} = 13.313 \cdot 0.2 \times 13.313$$

$$1 \text{ week} = 2.663 t^{0.2}$$

$$1 \text{ week} = e^{2.663}$$

$$1 \text{ week} = 14.338 \text{ P}$$

$$1 \text{ week} = 138.6 \times 10^6 / 14.338$$

$$1 \text{ week} = 9.7 \text{ MW}$$

$$1 \text{ week} \approx 10 \text{ MW}$$

$$1 \text{ year } (t = 3.156 \times 10^7 \text{ s}): \ln(3.156 \times 10^7)$$

$$1 \text{ year} = 17.267 \cdot 0.2 \times 17.267$$

$$1 \text{ year} = 3.453 t^{0.2}$$

$$1 \text{ year} = e^{3.453}$$

$$1 \text{ year} = 31.60 \text{ P}$$

$$1 \text{ year} = 138.6 \times 10^6 / 31.60$$

$$1 \text{ year} = 4.39 \text{ MW}$$

$$100 \text{ years } (t = 3.156 \times 10^9 \text{ s}): \ln(3.156 \times 10^9)$$

$$100 \text{ years} = 21.871 \cdot 0.2 \times 21.871$$

$$100 \text{ years} = 4.374 t^{0.2}$$

$$100 \text{ years} = e^{4.374}$$

$$100 \text{ years} = 79.39 \text{ P}$$

$$100 \text{ years} = 138.6 \times 10^6 / 79.39$$

$$100 \text{ years} = 1.75 \text{ MW}$$

$$100 \text{ years} \approx 2 \text{ MW}$$

300 years ($t = 9.468 \times 10^9$ s): $\ln(9.468 \times 10^9)$	428
300 years = $22.970 \cdot 0.2 \times 22.970$	429
300 years = $4.594 t^{0.2}$	430
300 years = $e^{4.594}$	431
300 years = 98.90 P	432
300 years = $138.6 \times 10^6 / 98.90$	433
300 years = 1.40 MW	434
300 years \approx 1 MW	435
	436
1,000 years ($t = 3.156 \times 10^{10}$ s): $\ln(3.156 \times 10^{10})$	437
1,000 years = $24.174 \cdot 0.2 \times 24.174$	438
1,000 years = $4.835 t^{0.2}$	439
1,000 years = $e^{4.835}$	440
1,000 years = 125.8 P	441
1,000 years = $138.6 \times 10^6 / 125.8$	442
1,000 years = 1.10 MW	443
1,000 years \approx 1 MW	444
	445
24,110 years ($t = 7.609 \times 10^{11}$ s): $\ln(7.609 \times 10^{11})$	446
24,110 years = $27.358 \cdot 0.2 \times 27.358$	447
24,110 years = $5.472 t^{0.2}$	448
24,110 years = $e^{5.472}$	449
24,110 years = 237.8 P	450
24,110 years = $138.6 \times 10^6 / 237.8$	451
24,110 years = 0.58 MW	452

The heat from the reactor never reaches zero. 24,110 years is one half-life of plutonium-239 [7] and the Brigham City site is still producing 0.58 MW of heat that must be removed by water—with the hope that the lake hasn’t evaporated already. The NRC requires that spent fuel cooling be maintained indefinitely, and decay heat removal is classified as a safety-critical function for the entire post-operational period [60][61].

Convert Decay Heat to Water Consumption

Decay heat must be removed from spent fuel to prevent cladding failure, fuel damage, and radiological release [60][61]. The ultimate heat sink for any reactor including during post-shutdown storage is water, whether through spent fuel pool cooling, dry cask convective systems that ultimately reject heat to the atmosphere (which must be replaced by environmental water cycling), or direct evaporative cooling [47][62].

The minimum water consumption rate for evaporative heat rejection is determined by the latent heat of vaporization [63]:

$$\text{Water evaporation rate} = P(t) / \text{Landauer Vaporization}$$

Where:

Landauer Vaporization = 2.26×10^6 J/kg is the latent heat of vaporization of water at 100°C [63]. At lower temperatures the latent heat is slightly higher 2.45×10^6 J/kg at 20°C I use a conservative estimate that slightly understates water consumption.

Unit conversion chain from kg/s to AF/yr: 476

$$\text{AF/yr} = 1 \text{ kg/s of water evaporated} \times 3.1557 \times 10^7 \text{ s/yr (seconds per Julian year)}$$

$$\text{AF/yr} = 3.1557 \times 10^7 \text{ kg/yr} \div 1,000 \text{ kg/m}^3 \text{ density of fresh water}$$

$$\text{AF/yr} = 3.1557 \times 10^4 \text{ m}^3/\text{yr} \div 1,233.48 \text{ m}^3/\text{AF cubic meters per acre-foot [17]}$$

$$\text{AF/yr} = 25.58 \text{ AF/yr per kg/s of evaporation}$$

Combining into a single conversion factor: 485

$$1 \text{ MW of heat rejection} = 10^6 \text{ W} \div 2.26 \times 10^6 \text{ J/kg}$$

$$1 \text{ MW of heat rejection} = 0.4425 \text{ kg/s of water evaporated}$$

$$1 \text{ MW of heat rejection} = 0.4425 \text{ kg/s} \times 25.58 \text{ AF/yr per kg/s}$$

$$1 \text{ MW of heat rejection} = 11.32 \text{ AF/yr per MW of heat rejection}$$

Applying conversion to each timepoint: 491

Time post-shutdown	Decay Heat (MW)	Water consumption (AF/yr)
1 hour	26.95	305.0
1 day	14.27	161.5
1 week	9.67	109.5
1 year	4.38	49.6
40 years	2.10	23.7
100 years	1.75	19.8
300 years	1.40	15.9
1,000 years	1.10	12.5
24,100 years	0.58	6.6

At no point does the water consumption reach zero. The water rate at 24,110 years (6.6 AF/yr) would supply 13 Utah households indefinitely [64] and draw from a basin which cannot spare it. 493-495

Cumulative Water Consumption Analytical Integration 497

When the reactors are shut off the fuel still produces heat which must be cooled. The question is how much water will be evaporated to remove the heat. The total water consumed from shutdown to time T is the definite integral of the instantaneous consumption rate. 498-501

$$\text{Water total} = \int_1^T [P_0 \times 0.066 \times t^{-0.2} / \text{Latent Heat Vaporization}] dt$$

The lower bound is 1 second rather than 0 to avoid the mathematical singularity at t = 0. This is physically appropriate because the ANS 5.1 approximation is not valid at the instant of shutdown, where more detailed isotope-specific models apply [53]. 504-506

Terms: 507

P₀ = the thermal power at shutdown, in watts 509

$$P_0 = 2 \times 1,050 \times 10^6$$

Since P_0 , 0.066, and Latent Heat Vaporization are constants with respect to time, they factor out: 511
512

$$\int_1^T [P_0 \times 0.066 \times t^{-0.2} / \text{Latent Heat of Vaporization}] dt \quad 513$$

$$\text{Water total} = P_0 \times \int_1^T [0.066 \times t^{-0.2} / \text{Latent Heat of Vaporization}] dt \quad 514$$

$$\text{Water total} = P_0 \times 0.066 \times \int_1^T [t^{-0.2} / \text{Latent Heat of Vaporization}] dt \quad 515$$

$$\text{Water total} = P_0 \times 0.066 \times (1 / \text{Latent Heat of Vaporization}) \times \int_1^T t^{-0.2} dt \quad 516$$

The antiderivative of $t^{-0.2}$ is found by the power rule in calculus. 517
518

$$\int t^n dt = t^{(n+1)}/(n+1) \text{ as long as } n \neq -1 \quad 519$$

$$n = -0.2, \quad 520$$

$$n + 1 = 0.8 \quad 521$$

$$\int_1^T t^{-0.2} dt = T^{0.8} / 0.8 \quad 522$$

Apply Bounds evaluated from 1 to T 523
524

$$\int_1^T t^{-0.2} dt = [t^{0.8} / 0.8] \quad 525$$

$$\int_1^T t^{-0.2} dt = T^{0.8} / 0.8 - 1^{0.8} / 0.8 \quad 526$$

$$\int_1^T t^{-0.2} dt = T^{0.8} / 0.8 - 1 / 0.8 \quad 527$$

$$\int_1^T t^{-0.2} dt = (T^{0.8} - 1) / 0.8 \quad 528$$

$$\int_1^T t^{-0.2} dt \approx T^{0.8} / 0.8 \quad 529$$

Apply Bounds evaluated from 1 to T 530
531

$$\text{Water total} = (P_0 \times 0.066 / \text{Latent Heat of Vaporization}) \times T^{0.8} / 0.8 \quad 532$$

Since $1^{0.8} = 1$, and $T^{0.8} \gg 1$ for all timescales of interest 533
534

$$\text{Water total} = P_0 \times 0.066 / (\text{Latent Heat of Vaporization} \times 0.8) \times T^{0.8} \quad 535$$

Compute the prefactor to convert seconds^{0.8} to produce kilograms of water: 536
537

$$\text{Water total} = P_0 \times 0.066 / (\text{Latent Heat of Vaporization} \times 0.8) \quad 538$$

$$\text{Water total} = 2,100 \times 10^6 \text{ W} \times 0.066 / (2.26 \times 10^6 \text{ J/kg} \times 0.8) \quad 539$$

$$\text{Water total} = 138.6 \times 10^6 \text{ W} / (1.808 \times 10^6 \text{ J/kg}) \quad 540$$

$$\text{Water total} = 138,600,000 / 1,808,000 \quad 541$$

$$\text{Water total} = 76.66 \text{ kg}\cdot\text{s}^{-0.8} \quad 542$$

To obtain total water in acre-feet: multiply prefactor by $T^{0.8}$, then divide by 1,000 kg/m³, then divide by 1,233.48 m³/AF. 543
544

$$\text{Water total AF} = 76.66 / (1,000 \times 1,233.48) \quad 545$$

$$\text{Water total AF} = 76.66 / 1,233,480 \quad 546$$

$$\text{Water total AF} = 6.214 \times 10^{-5} \text{ AF}\cdot\text{s}^{-0.8} \quad 547$$

Cumulative at 1,000 years ($T = 3.156 \times 10^{10}$ s): $T^{0.8}$	556
	557
1,000 AF = $(3.156 \times 10^{10})^{0.8} \ln(3.156 \times 10^{10})$	558
1,000 AF = 24.174×0.8	559
1,000 AF = $19.339 T^{0.8}$	560
1,000 AF = $e^{19.339}$	561
1,000 AF = 2.509×10^8 W	562
1,000 AF = $76.66 \text{ kg} \cdot \text{s}^{-0.8} \times 2.509 \times 10^8 \text{ s}^{0.8}$	563
1,000 AF = 1.923×10^{10} kg	564
1,000 AF = 1.923×10^{10} kg	565
1,000 AF = $1.923 \times 10^{10} \div 1,000$	566
1,000 AF = $1.923 \times 10^7 \text{ m}^3$	567
1,000 AF = $1.923 \times 10^7 \div 1,233.48$	568
1,000 AF = 15,586 AF	569

Cumulative at 24,110 years ($T = 7.609 \times 10^{11}$ s): $T^{0.8}$	570
	571
24,110 AF = $(7.609 \times 10^{11})^{0.8} \ln(7.609 \times 10^{11})$	572
24,110 AF = 27.358×0.8	573
24,110 AF = $21.887 T^{0.8}$	574
24,110 AF = $e^{21.887}$	575
24,110 AF = 3.203×10^9 W	576
24,110 AF = $76.66 \times 3.203 \times 10^9$	577
24,110 AF = 2.454×10^{11} kg	578
24,110 AF = 2.454×10^{11} kg	579
24,110 AF = $2.454 \times 10^8 \text{ m}^3$	580
24,110 AF = $2.454 \times 10^8 \div 1,233.48$	581
24,110 AF = 198,836 AF	582

Cumulative at 100,000 years ($T = 3.156 \times 10^{12}$ s):	583
$T^{0.8} = (3.156 \times 10^{12})^{0.8} \ln(3.156 \times 10^{12})$	584
	585
100,000 AF = 28.779×0.8	586
100,000 AF = $23.024 T^{0.8}$	587
100,000 AF = $e^{23.024}$	588
100,000 AF = 9.966×10^9	589
	590
W = $76.66 \times 9.966 \times 10^9$	591
W = 7.639×10^{11} kg	592
W = $7.639 \times 10^8 \text{ m}^3$	593
W = 619,444 AF	594

Operational Phase Water Consumption 595

During the 40-year design operational lifetime [45][46], the fleet continuously rejects waste heat through cooling water systems. The cooling water consumption for the 13-reactor fleet was previously calculated at 46,130 AF/yr based on Utah's power generation water intensity (0.22 gal/kWh weighted average for Utah's 68% natural gas, 17% coal, 15% renewable mix [65]), direct evaporative cooling at PUE 1.18 [66], and 70% in-basin sourcing [31]. 596-601

Per-reactor water consumption = $46,130 \text{ AF/yr} \div 13 \text{ reactors}$ 602-603

Per-reactor water consumption = 3,548.5 AF/yr per reactor

For 2 reactors at Brigham City:

Operational water = $2 \times 3,548.5 \text{ AF/yr} \times 40 \text{ years}$
 Operational water = 283,877 AF

Total Water Commitment in Brigham City (2 reactors)

Time post-shutdown	Decay Heat (MW)	Water consumption (AF/yr)
Operational cooling	40 years	283,877
Post-shutdown decay cooling	1,000 years	15,586
Post-shutdown decay cooling	24,110 years (1 Pu-239 half-life)	198,836

Total through 1,000 years post-shutdown: 299,463 AF

Total through one Pu-239 half-life: 482,713 AF

For context [31][64][67][41][68] 482,713 AF = 157 billion gallons

482,713 AF = 1.0 years of the Bear River's entire post-diversion flow to the Great Salt Lake, the same river the Brigham City reactor sits on

482,713 AF = 3.2 years of Salt Lake City's total municipal water supply

482,713 AF = water for 1,681,360 people for one year at Utah's per-capita consumption rate

482,713 AF = 3.1% of the Great Salt Lake's current remaining volume

482,713 AF = 1.6 years of the Indian Rice-grass agricultural conversion water savings meaning 2 reactors erase more than a year and a half of the single largest water conservation reform in the Great Salt Lake Act.

All water is drawn from a terminal basin with no outlet [31]. In a terminal basin, every acre-foot consumed by cooling rather than flowing to the lake is permanently removed from the system. There is no downstream return. There is no recycling pathway. The water is gone.

5. Total Water Commitment with Full 13-Reactor Fleet (Operation Gigawatt)

The full Operation Gigawatt plan calls for up to 4 GWs of SMR-300 capacity deployed in Utah and Wyoming [54][55][56]. At 300 MWe per reactor, this requires approximately 13 reactors ($13 \times 300 = 3,900 \text{ MWe}$).

Scaling the 2-reactor results by $13/2 = 6.5$:

Phase	Water AF
Operational cooling	1,845,200
Post-shutdown decay cooling	101,311
Post-shutdown decay cooling	1,292,433
Total through one Pu-239 half-life	3,137,633

For context [31][64][67][41][68] 3,137,633 AF = 1.02 trillion gallons

1.02 Trillion Gallons = 20.5% of the Great Salt Lake's current remaining volume

1.02 Trillion Gallons = 6.5 years of the Bear River's entire contribution to the Great Salt Lake

1.02 Trillion Gallons = 20.9 years of Salt Lake City's total municipal water supply

1.02 Trillion Gallons = 3.9 years of the Great Salt Lake Strike Team's 800,000 AF/yr restoration goal — meaning the full fleet consumes nearly four years of everything the state's emergency restoration effort is trying to accomplish

1.02 Trillion Gallons = 10.3 years of the Indian Rice grass agricultural reform's water savings

1.02 Trillion Gallons = water for 10,928,834 people for one year more than three times Utah's current population

The federal government acquired 22,311 acres of Great Salt Lake land during the 2026 Utah Legislative Session for restoration purposes [2]. Operation Gigawatt proposes to build reactors on the same watershed, drawing cooling water from the same basin, for a decay timeline that extends more than 24,000 years beyond the last reactor's operational life [58][53].

Dimensional Verification

Now I check the AF calculation derivation for dimensional consistency:

$$P(t) = [W] \times [\text{dimensionless}] \times [s^{-0.2}]$$

$$\text{Water rate} = [W] / [J/kg] = [kg/s]$$

$$\text{Cumulative} = [kg \cdot s^{-0.8}] \times [s^{0.8}] = [kg]$$

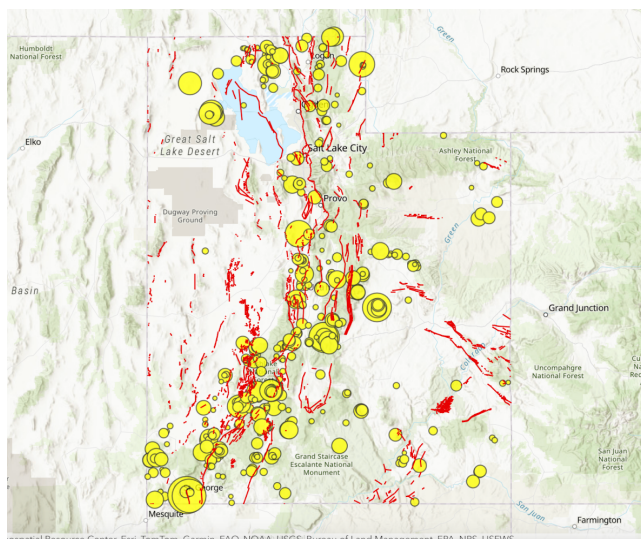
$$\text{AF conversion} = [kg] \div [kg/m^3] \div [m^3/AF] = [AF]$$

P_0 in watts and t in seconds, $P(t)$ in watts as the 0.066 coefficient absorbs the dimensional constant from the empirical fit [53] ✓.

The ANS 5.1-2014 formula is nuclear industry's standard [53], the latent heat of vaporization is the thermodynamic constant [63], and the acre-foot conversion is a defined unit [68]. The presented derivation includes not assumptions that are not either physical law or cited engineering standard.

6. Paleoseismic Record and Fission Reactor Earthquake Design

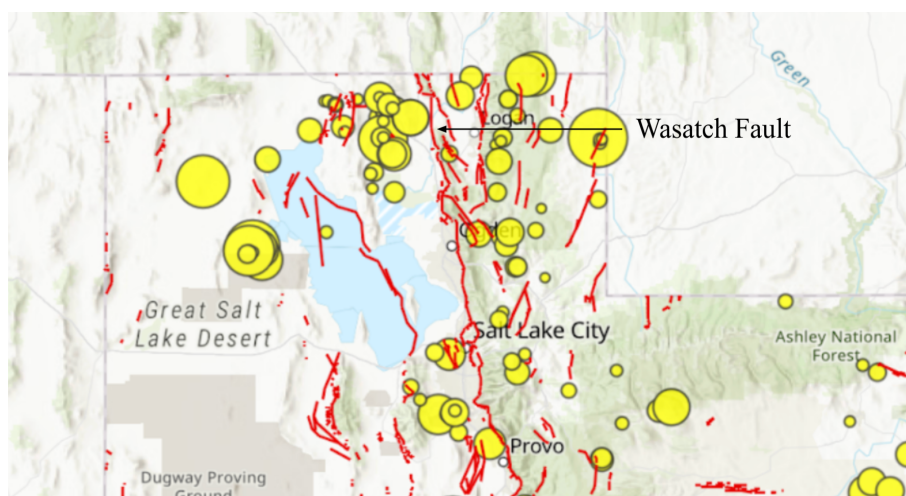
The Great Salt Lake sits on the Wasatch Fault, one of the most seismically hazardous faults in the interior Western United States [70][71], and the proposed Nuclear Fission reactor site at Brigham City lies directly within its most overdue segment [71][72].



Seismic map created by Haven Finley with ArcGIS and USGS data at Westminster College, Salt Lake City, Utah. [69]

The area immediately around Brigham City shows the fault trace but relatively few small background earthquakes compared to Salt Lake City and Provo, consistent with a locked, strain-accumulating segment [73]. A fault locks when the two sides of it stop sliding smoothly past each other and instead grip together through friction [73].

Tectonic plates are always moving. On an unlocked fault, the motion releases continuously as small, frequent earthquakes and fault creep. On a locked fault, the two sides are stuck. The motion does not stop — it accumulates as elastic strain energy in the surrounding rock, like slowly compressing a spring. The rock on either side of the fault deforms elastically, meaning the fault bends and stretches without breaking, storing energy the way a bent bow stores energy before release [70]. The longer the lock holds, the more energy accumulates. There is a physical limit to how much strain rock can store before it exceeds the frictional strength holding the fault closed [73]. When the limit is exceeded earthquakes arise quickly.



Seismic map Created by Haven Finley with ArcGIS and USGS data at Westminster College, Salt Lake City Utah. [69]

Earthquake Probability & Civilization Response

The Wasatch Fault produces $M \geq 6.75$ events with a 43% probability in any 50-year

life. 67.5% probability during the first 100 years post-shutdown and the window when Cs-137 and Sr-90 inventory is highest, when a cooling failure releases the most dangerous water-soluble fission products into the Bear River drainage and from there into the Great Salt Lake [58][61]. 207 earthquakes.

207 times the cooling infrastructure must survive or be repaired [76]. Over a timeline during which 14 of the 39 materials needed to build replacement systems are exhausted before the reactor finishes its first operating license.

No civilization in human history has maintained any infrastructure for 24,110 years. The oldest surviving human-built structures from the megalithic temples of Malta (~5,600 years) to the pyramids of Giza (~4,500 years) are passive stone [77]. They require no cooling water, no electricity, no replacement electronics, no trained operators, no security forces, and no continuous funding. They simply sit there and even these sites are deteriorating.

The SMR-300 spent fuel cannot simply sit there because the reactors produce heat and the heat must be removed [53][60]. The removal of heat requires water, electricity, electronics, operators, institutions, funding, materials, supply chains, and civilizational continuity for 24,110 years without interruption.

The commitment is being made by people who will be dead within decades, on behalf of generations who have not been consulted, using resources which do not exist in sufficient quantity, in a basin that does not have sufficient water [31], on a fault that will certainly rupture [70][71][72][73], under institutions that will certainly change or cease to exist.

■ To appropriately design a product the entire product lifecycle must be taken into consideration through sunseting the product. It is irresponsible and inappropriate to launch destructive products with a 24,110-year product lifespan without appropriately planning through to completion.

Earthquake Probability & Civilization Response

The SMR-300 is designed to a 0.5g peak ground acceleration (PGA) as its reference seismic design basis [45][46]. Holtec states the SMR-300 is a "bounding standardized design" so that "the plant's design will not have to be revised for each new site" [45][46].

In terms of actual earthquake magnitude at the Brigham City site, I perform an analysis of what 0.5g means. A 0.5g PGA at the reactor foundation corresponds approximately to a M 6.5–7.0 earthquake at close range (within 5–10 km) depending on soil conditions, depth, and fault geometry [76][77]. The USGS ground motion models for the Wasatch Fault Brigham City segment — which the Utah Geological Survey identifies as one of the two highest-risk segments [72][74] — show that a M 7.0+ surface-rupturing event directly beneath or adjacent to the facility could produce PGA of 0.5g to over 1.0g at the site, depending on rupture directivity and site amplification effects [76][74].

The Wasatch Fault is capable of M 6.75–7.5 on the Brigham City segment [74][75]. The upper range of that capability exceeds the SMR-300's 0.5g design basis. Critically, Shreedharan et al. (2025) showed the Brigham City segment fault rock is frictionally weaker than standard models assumed [73], meaning ruptures may propagate further and produce larger displacements than the models used to establish that 0.5g design envelope.

The design addresses vibratory ground motion of shaking, but does not address surface fault displacement of up to 20 feet directly through or beneath the facility [74][75]. The below-grade containment, which sits deep underground [45][46], is embedded in the same rock that the fault displaces. Holtec's soil-structure interaction analysis models the structure's response to shaking [45][46]. The design does not model the structure's response to the ground physically shearing beneath it.

Earthquake Calculation

PGA is how hard the ground shakes, measured as a fraction of gravity. When you stand on the ground, gravity pulls you down at 1g. If an earthquake shakes the ground at 0.5g, the ground is accelerating sideways at half the force of gravity. In experiential terms, items fall over, pipes break, and structures flex.

An earthquake has a magnitude (how much energy the fault releases) and a distance (how far the reactor is from the rupture). A bigger earthquake at the same distance shakes harder. The same earthquake closer shakes harder.

Seismologists quantify the relationship using Ground Motion Prediction Equations (GMPEs), which take magnitude and distance as inputs and return PGA as output. The standard equations for the Western United States are the NGA-West2 suite, published by the Pacific Earthquake Engineering Research Center in 2014 [76][77]. These are the equations the U.S. Nuclear Regulatory Commission accepts for nuclear site hazard analysis [79].

In simplified form, the equation is:

$$\ln(\text{PGA}) = a + b \times M + c \times M^2 + d \times \ln(\sqrt{R^2 + e^2}) + f \times R$$

Where M is moment magnitude, R is the rupture distance (the shortest distance from the site to the fault rupture plane, in km), and a through f are empirical coefficients fitted to thousands of recorded earthquake ground motions worldwide [76][77].

The NGA-West2 models include additional terms for local soil conditions, characterized by Vs30 (the average shear-wave velocity in the top 30 meters of ground). The PGA values calculated below include these site effects for Vs30 = 150–300 m/s, representative of the alluvial valley sediments at the [69] based on likely NEHRP classes. The simplified equation shows the dominant physical terms; the full model specification is published in [76][77].

■ Regulatory Consideration: No site-specific Vs30 measurements for the proposed Brigham City reactor site have been published. The UGS Vs30 database expanded beyond Salt Lake County to the Wasatch Front, but data outside Salt Lake County are sparse. [80]

Symbol	Name	Function
PGA	Peak Ground Acceleration	The maximum acceleration the ground experiences during the earthquake, measured in g (fractions of gravity). PGA is the output compared to the

		reactor's 0.5g design basis [45][46].
a	Constant coefficient	The baseline starting value. Sets the overall level of ground motion before magnitude and distance modify it. Fitted from thousands of recorded earthquakes [77].
b	Magnitude scaling coefficient (linear)	How much stronger the shaking gets for each unit increase in magnitude. A larger b means ground motion increases faster with magnitude [77].
M	Moment magnitude	The size of the earthquake. M 6.75 is the lower bound of what the Wasatch Fault Brigham City segment produces. M 7.5 is the upper bound [71]. Each whole number increase represents ~31.6× more energy released/
c	Magnitude scaling coefficient (quadratic)	c is a correction term that accounts for the fact that ground motion does not increase linearly forever with magnitude. Very large earthquakes do not shake proportionally harder than moderately large ones because the fault rupture area saturates [77].
M ²	Magnitude squared	M multiplied by itself. M ² is the quadratic term that produces the curvature described above.
d	Distance attenuation coefficient	How quickly shaking dies off with distance which is always negative. Farther from the fault means less shaking. d is the geometric spreading term: seismic energy spreads out over a larger area as it travels, so intensity drops [77].
R	Rupture distance	The shortest distance from the site to the fault rupture plane, measured in kilometers. R is a measured variable, not a constant. For the Brigham City site, R ranges from approximately 1 to 5 km depending on where on the fault segment the rupture initiates and

		where the reactor is sited relative to the trace [71][72].
e	Near-source saturation distance	e is a constant (approximately 7–10 km) which prevents the equation from predicting infinite shaking at zero distance [77]. Physically, this represents the fact that when you are standing directly on top of a large fault rupture, you are close to all parts of the rupture simultaneously and the ground motion saturates rather than going to infinity. The term $\sqrt{(R^2 + e^2)}$ ensures that even at $R = 0$, the effective distance is e, not zero.
$R^2 + e^2$	Sum of squares	R^2 squared plus e^2 squared. When R is large (far from fault), R^2 dominates and e barely matters. When R is small (right on the fault), e^2 dominates and prevents a mathematical singularity.
f	Anelastic attenuation coefficient	A small negative number that accounts for energy absorption by the earth as seismic waves travel through rock [77]. Rock is not perfectly elastic and absorbs some vibration energy and converts the energy to heat. This effect is small at short distances but becomes significant beyond ~50 km.
$f \times R$	Anelastic attenuation term	For the Brigham City site at 1–5 km, this term is nearly negligible. The product of the attenuation coefficient and the distance. Subtracts a small amount of ground motion proportional to distance, represents energy lost to the earth as heat during wave propagation [77].
ln	Natural logarithm	A mathematical function that compresses large numbers into smaller ones. Used because earthquake ground motion spans several orders of magnitude and is

		approximately log-normally distributed
$\sqrt{\quad}$	Square root	Mathematical operation.
$\ln(\sqrt{(R^2 + e^2)})$	Natural log of effective distance	The distance term with near-source saturation. See R and e above.

848
849
850 The same earthquake produces different shaking depending on what the ground is made
851 of. Hard rock ($V_{s30} = 760$ m/s, meaning seismic waves travel at 760 meters per second
852 through the top 30 meters) transmits shaking efficiently but does not amplify it much. Soft
853 alluvial soil ($V_{s30} = 350$ m/s, typical of valley fill in Brigham City) amplifies the shaking
854 because the waves slow down and pile up like water waves getting taller as they approach
855 a shallow beach [76][77].
856
857 Brigham City sits on alluvial valley fill from the Bear River [80]. Which is a soil site, not a
858 rock site. The alluvial soil amplifies the ground motion by roughly 1.6× compared to rock
859 [76][77].
860
861 Earthquakes are variable. Two M 7.0 events at the same distance can produce very differ-
862 ent shaking depending on rupture directivity, stress drop, wave propagation path, and
863 local site effects [76][77]. The GMPE gives you the median 50th percentile, meaning half
864 of actual earthquakes will shake harder and half will shake less.
865
866 The 84th percentile represents the ground-motion level exceeded by only 16% of earth-
867 quakes of this magnitude at this distance. In nuclear safety, we do not design to the coin-
868 flip median; we design to the tail where things go wrong [71][79]. The 84th percentile is
869 the standard safety margin level.
870
871 Every GMPE reports an aleatory variability term $\sigma(\ln \text{PGA})$. For the NGA-West2 models,
872 total sigma values fall in the range 0.60–0.70; I adopt $\sigma = 0.65$ as a central estimate. To
873 convert from median to 84th percentile in the lognormal framework: $\ln(\text{PGA}_{84}) =$
874 $\ln(\text{PGA}_{50}) + 1.0 \times \sigma$ which in real space corresponds to multiplying by $e^\sigma = e^{0.65} = 1.9155$.
875
876 Using [specific GMPE, e.g., CB14] with $M = 7.0$, $R_{\text{rup}} = 3$ km, and $V_{s30} = 230$ m/s Site
877 Class D, representative of Bear River alluvial valley sediments
878
879 $\ln(\text{PGA})$
880 $\text{PGA}_{50} = 0.336g$
881
882 Multiply by 1.9155
883
884 $\text{PGA}_{84} = 0.336 \times 1.9155$
885 $\text{PGA}_{84} = 0.643608g$
886
887 Compared to the SMR-300 seismic design basis of 0.5g [45][46].
888
889 Exceedance ratio = $0.643608g / 0.50$
890 Exceedance ratio = $1.287216 \times$

This means that for a M 7.0 earthquake on the Brigham City segment of the Wasatch Fault, the realistic scenario for this site, located 1–3 miles from the fault trace on alluvial valley sediments [71][72], there is a 16% conditional probability that ground motion exceeds the reactor's design basis.

To determine the ground motion at the reactor site, I evaluate the GMPE using the Brigham City segment fault parameters and the site-to-fault distance.

a sets the baseline.

$b \times M + c \times M^2$ adjusts for how big the earthquake is. A M 7.5 puts more energy into the equation than a M 6.75.

$d \times \ln(\sqrt{R^2 + e^2})$ adjusts for how far away the rupture is. At $R = 3$ km, you are close and the shaking is intense. At $R = 50$ km, the energy has spread out and the shaking is much weaker.

$f \times R$ makes a small additional reduction for energy the earth absorbs.

The output is $\ln(\text{PGA})$. Take $e^{(\ln(\text{PGA}))}$ to get PGA in g. Compare that number to 0.5g. If it exceeds 0.5g, the reactor is being shaken harder than it was designed to survive.

Scenario	Soil Type	Median PGA	84 th Percentile	PGA ₈₄ / 0.5g Design
M 6.35 at 1 km	Alluvial soil	0.2571g	0.49258g	within 0.98515×
M 6.35 at 3 km	Alluvial soil	0.2348g	0.44976g	within 0.89952×
M 6.38 at 1 km	Alluvial soil	0.2615g	0.50090g	exceeds by 1.00181×
M 6.38 at 3 km	Alluvial soil	0.2389g	0.45761g	within 0.91523×
M 6.75 at 1 km	Alluvial soil	0.322g	0.61679g	exceeds by 1.23359×
M 6.75 at 3 km	Alluvial soil	0.294g	0.56316g	exceeds by 1.12631×
M 7.0 at 1 km	Alluvial soil	0.368g	0.70490g	exceeds by 1.40981×
M 7.0 at 3 km	Alluvial soil	0.336g	0.64361g	exceeds by 1.28722×
M 7.25 at 1 km	Alluvial soil	0.418g	0.80068g	exceeds by 1.60136×
M 7.5 at 1 km	Alluvial soil	0.474g	0.90795g	exceeds by 1.81589×
M 7.5 at 3 km	Alluvial soil	0.433g	0.82941g	exceeds by 1.65882×

■ Regulatory Observation: The Brigham City segment has never produced a surface-rupturing earthquake below M 6.75 in its paleo seismic record. The SMR-300 design basis is exhausted at M 6.38.

The reactor's survival margin at M 6.35 and 1 km from the fault is 0.0074g. That is less than eight thousandths of gravity. The difference between the reactor surviving and the reactor exceeding its design basis is 0.03 magnitude units, an amount so small it is within the measurement uncertainty of any seismograph.

The Wasatch Fault Brigham City segment's paleoseismic record shows surface-rupturing events in the M 6.75–7.5 range [71][75]The USGS does not identify smaller surface-rupturing events as characteristic of this segment. The fault accumulates strain over centuries and releases it in large events, not small ones [71].

Every characteristic surface-rupturing earthquake the Brigham City segment is expected to produce (M 6.75–7.5) exceeds the magnitude at which the SMR-300 design basis is exhausted. On alluvial soil at 1 km, the probability of ground motion exceeding the 0.5g design basis is 15.3% at M 6.35, 24.9% at M 6.75, and 46.7% at M 7.5. The only way to get P = 0% is to not build the reactor.

■ Regulatory Observation: Nuclear Fission has not demonstrated that their generic 0.5g design basis actually envelopes the site-specific 84th-percentile ground motion from a Brigham City segment M 7.0 rupture on the alluvial soils near the lake.

7. Accounting, and Global Supply Chain of Materials

The continuity, stability, and controllability of a nuclear reactor depends on the availability of the materials for which it was designed. Instrumentation and control systems require specific elements, many of which exist in finite global reserves.

The question of managing the entire nuclear reactor product lifecycle from beginning to end is straightforward. How many times must the entire known global reserve of each critical material be discovered and exhausted to maintain I&C systems for the full 24,110-year Pu-239 decay period?

Material Depletion vs. Decay Heat Timeline

Instrumentation and control (I&C) systems are the sensors, circuits, and automated systems that monitor and regulate every safety-critical function in a nuclear reactor, from coolant temperature to neutron flux to emergency shutdown. Without functioning I&C, a reactor cannot be operated or safely maintained.

The following table shows the materials required to build and maintain these systems, their known global reserves, current annual production rates, and the timeline to depletion at current consumption.

Material	Use	Global Reserves	Annual Production	Years to Depletion
Dysprosium	Neutron absorber in control rods (2,840 barn), NdFeB magnet high-temp stabilizer for reactor sensors	880,000 tonnes	3,100 t/yr	10–15
Terbium	Magnetostrictive sensors (Terfenol-D), high-temp magnet stabilizer, fiber optic amplifiers	110,000	390 t/yr	10–15
Antimony	PCB flame retardant, batteries	1.8M tonnes	160,000 t/yr	11

Platinum	Thermocouple sensors	69M troy oz (est.)	5.7M troy oz/yr	12
Chromium	Stainless steel fasteners, hardware	620M tonnes	44M t/yr	14
Tin	Solder	4.9M tonnes	310,000 t/yr	16
Zinc	Connector housings, galvanizing	210M tonnes	13M t/yr	16
Indium	Semiconductors, displays	~18,000 tonnes (est.)	990 t/yr	18
Gold	Wire bonds, connector contacts	59,000 tonnes	3,300 t/yr	18
Bismuth	Lead-free solder, cooling	370,000 tonnes	20,000 t/yr	19
Lead	Backup batteries (UPS	85M tonnes	4.5M t/yr	19
Silver	Contacts, conductive paste	530,000 tonnes	26,000 t/yr	20
Palladium	Capacitor electrodes, connector plating	210M troy oz (est.)	7.5M troy oz/yr	28
Fluorine	Chip etching gases	310M tonnes	8.8M t/yr	35
Nickel	Plating, magnetic shielding, batteries	130M tonnes	3.5M t/yr	37
Copper	All wiring, PCB traces, heat sinks	890M tonnes	22M t/yr	40
Cobalt	Backup battery cathodes	11M tonnes	230,000 t/yr	48
Helium	Fab cooling, leak testing, cryogenics	8.2B m ³	170M m ³ /yr	48
Germanium	Fiber optics, infrared sensors	~8,600 tonnes (est.)	180 t/yr	48
Tungsten	Contacts, radiation shielding	4.1M tonnes	84,000 t/yr	49
Barium	Ceramic capacitors (MLCCs)	390M tonnes (barite)	7.6M t/yr	51
Molybdenum	High-temp connectors, alloys	16M tonnes	300,000 t/yr	53
Tantalum	Capacitors	>140,000 tonnes	2,100 t/yr	67
Iron	Inductors, EMI cores, transformers	180B tonnes	2.5B t/yr	72
Europium	Neutron absorber in control rods (9,200 barn cross-section), display phosphors	110,000 tonnes	390 t/yr	50–80
Manganese	Capacitors, battery chemistry	1.9B tonnes	23M t/yr	83
Lutetium	Radiation detectors, PET scanner crystals	11,000 tonnes	39 t/yr	50–100
Scandium	structural alloys, solid oxide fuel cell backup power	11,000 tonnes	25 t/yr	50–100

Lithium	Backup batteries	28M tonnes	180,000 t/yr	156
Thulium	Portable X-ray sources for reactor inspection, radiation dosimeters	22,000 tonnes	78 t/yr	100–200
Ytterbium	Fiber lasers for component cutting stainless steel grain refiner	33,000 tonnes	117 t/yr	100–200
Holmium	Nuclear control rod alloys (highest magnetic moment of any element), flux concentrators	55,000 tonnes	195 t/yr	100–200
Erbium	Neutron absorber (659 barn), fiber optic amplifiers (EDFA) for all reactor data communication	330,000 tonnes	1,170 t/yr	100–150
Gadolinium	Highest neutron capture of any stable element (49,000 barn), burnable poison rods, emergency shutdown, reactor shielding	1,650,000 tonnes	5,850 t/yr	150–250
Boron	Semiconductor dopant, fiberglass	1.2B tonnes	5.2M t/yr	231
Samarium	Neutron absorber (40,140 barn for Sm-149), SmCo magnets rated to 300°C for reactor sensors	2,200,000 tonnes	7,800 t/yr	200–280
Praseodymium (NdPr)	Alloyed with Nd in magnets, radiation-resistant viewing glass	5,500,000 tonnes	19,500 t/yr	140–200
Yttrium	YSZ thermal barrier coatings on reactor components, YAG lasers, Y-90 is daughter of Sr-90 in decay chain	8,800,000 tonnes	31,200 t/yr	200–280
Neodymium	NdFeB permanent magnets in every motor, actuator, sensor, pump, valve, fan in reactor systems	19,800,000 tonnes	70,200 t/yr	140–200
Lanthanum	Hydrogen storage alloys (LaNi ₅), radiation-resistant optical glass, catalyst	27,500,000 tonnes	97,500 t/yr	280
Cerium	CeO ₂ polishing of every precision optical surface in reactor instrumentation	41,800,000 tonnes	148,200 t/yr	280
Phosphorus	Semiconductor dopant	72B tonnes (phosphate rock)	220M t/yr	327
Arsenic	Semiconductor dopant	Abundant	55,000 t/yr	500
Aluminum	Heat sinks, capacitor foil, shielding	55–75B tonnes (bauxite)	70M t/yr	500
Hafnium	Chip gate dielectric (HfO ₂)	~600,000 tonnes (est.)	70 t/yr	8500
Gallium	Power semiconductors	~1M tonnes (est.)	470 t/yr	Byproduct
Fiber-glass/Epoxy	PCB substrate (FR-4)	Petroleum Dependent	Byproduct	50 years

Teflon	Nuclear-rated cable insulation	Petroleum Dependent	Byproduct	50 years
Kapton	Flexible circuits, high-temp insulation	Petroleum Dependent	Byproduct	50 years
Neon	Photolithography laser gas	Atmospheric (18 ppm)	540 t/yr (semi-grade)	26 million
Argon	Thin film sputtering gas	Atmospheric (0.93%)	Large	95 million
Nitrogen	Chip packaging, inert atmosphere	Atmospheric (78%)	Large	26 million
Hydrogen	Fab annealing gas	Produced from water (intensive)	Large	1.6 billion
Silicon	Chip wafer substrate	28% of Earth's crust	70,000 t/yr (semi-grade)	104 trillion

Table #. Materials table sourced from [90][91][92][93][94] for reserve and production figures.

At humanity's current consumption rate 21 of 50 materials are depleted within a single human lifetime. The decay heat persists for 24,110 years. The fission reactor operates for 40 years and 14 of its own Instrumentation and Control materials are projected to be exhausted before it finishes its first operational license.

The Real Timeline

Dysprosium and terbium, the two heavy rare earth elements most critical to reactor sensor magnets that must operate in the reactor's thermal environment above 150°C, are projected to hit a global supply deficit by 2035 [82][83]. China suspended exports of both in April 2025 [84][85]. CRU forecasts a shortfall of 2,920 tonnes per year of combined Dy + Tb oxide by 2035 [82]. Outside of China, the only planned heavy REE production is Lynas at 250 t/yr Dy and 50 t/yr Tb with no firm timeline [83].

The West will still depend on China for 91% of heavy REEs by 2030 [83]. Gadolinium, the element without which nuclear control rods do not function (49,000 barn neutron capture cross-section, no substitute [86]), was included in China's April 2025 export suspension alongside Dy, Tb, Sm, Lu, Sc, and Y [84][85]. Seven of the sixteen rare earth elements critical to nuclear reactor operation are now under active Chinese export restriction.

The elements that matter most for reactor control and monitoring Dy, Tb, Gd, Sm, and Eu face supply crises within 10–50 years, not centuries [82][83][87][88]. Those timelines assume current demand. EV and wind turbine demand is projected to double consumption of these exact elements within a decade [87][89], accelerating depletion against a backdrop of active export restrictions from the nation that processes 90–100% of supply [84][85][90].

The decay heat persists for 24,110 years [53]. The reactor control materials face depletion or export denial within a single generation. Humanity now has 440 reactors which must be managed through the entirety of the product lifecycle of 24,110 years, and each nuclear material, on a 10 year supply. The reactors cannot simply be injected into space as those actions will also have a consequence.

8. Information-Energy of Cost of Nuclear Reactors

A nuclear fission reactor converts 100% of its fuel energy into heat. Of that heat, approximately 33% can be captured as electricity. The remaining 67% is waste heat rejected to the environment [47]. After the reactor shuts down, the fuel continues producing decay heat for 24,110 years [53].

The market framing gets the nuclear pitch backwards. Nuclear reactors are not energy sources that happen to produce waste. Nuclear reactors are waste-producing thermal systems which happen to let us capture roughly one third of the energy as electricity. The heat waste is the primary product. The electricity is the byproduct.

Nuclear reactors are machines of Information-Energy.

When nuclear reactors come to mind, people think of glowing fuel rods, cooling towers, and uranium pellets. But a nuclear reactor is not primarily a mechanical system. It is an information system. Every measurement is information. Every control action is a computation. Every safety decision is a bit operation. Every sensor reading, every valve position, every neutron counted, every temperature logged, every pressure transduced is information processed at a thermodynamic cost. The reactor does not just use computers. It is one.

The reactor is what is known as a cybernetic system, a thermal-hydraulic-neutronic computation running on uranium fuel, moderated by water, controlled by information systems that must process data correctly or the computation diverges into criticality excursion, loss of cooling, or fuel damage. To perform an appropriate accounting, we must open the entire nuclear ledger and examine every information process in the facility.

Every cycle of reactor control follows the same pattern where it senses, compare, act. A neutron detector measures flux. The measurement is compared to a setpoint. If flux exceeds the limit, the controller outputs a new rod position command, erasing the old command. Each of these steps overwrites prior information, and each erasure event dissipates a minimum of $kBT\ln(2)$ joules of energy as heat [12]. That is Landauer's bound, the irreducible thermodynamic cost of processing one bit of information[12][14]. It applies whether the computation is performed by a CMOS transistor on a MELTAC board [45][46], an analog relay in a 1950s control room, a biological neuron in a human operator's brain, or the physical feedback mechanisms in the reactor core itself.

Is it possible to manage a modern nuclear reactor without computers?

No. The earliest reactors like the Chicago Pile-1 in 1942 [95], the early Hanford production reactors [96], some of the 1950s experimental reactors were operated with analog instrumentation. Electromechanical relays, analog meters, strip chart recorders, manual control rod positioning. No digital computation. A human watched a needle on a gauge and turned a knob.

Those initial reactors were simple, low-power, and operated with enormous safety margins by small teams of physicists who understood every aspect of the design personally. They also killed people. SL-1 in 1961 one nuclear reactor left three operators dead from a prompt criticality excursion during manual control rod withdrawal [97]. Analog instrumentation did not prevent it.

The modern regulatory framework exists because analog human-operated reactors proved insufficient for safe operation at commercial power levels [98]. The NRC requires digital I&C for new reactor designs because reactor protection systems must respond

faster than human reaction time [98][99]. A loss-of-coolant accident progresses from initiation to core recovery in minutes [100]. The reactor protection system must detect the condition, confirm it across redundant channels, and actuate safety systems within seconds [99]. This requires digital logic and comparison of multiple sensor inputs against setpoints, voting logic across redundant trains, and automated actuation sequencing [98][99]. Analog relays can do simple trip functions but cannot perform the complex multi-variable safety logic required by modern licensing standards [98].

Post-accident monitoring requires continuous data logging, trend analysis, and predictive calculations that analog systems cannot perform [101]. After Fukushima, the NRC imposed requirements for enhanced monitoring during beyond-design-basis events [101][102] precisely the scenarios where we need the most information and the analog gauges are least reliable.

Reactor Licensing and Specifications

Technical Specifications and the legally binding operating conditions in the license require surveillance testing, calibration verification, and operability demonstrations that depend on digital data acquisition and analysis [103]. You cannot demonstrate compliance with Technical Specifications using analog strip charts reviewed by hand.

The SMR-300 specifically cannot operate without digital I&C [45][46]. The MELTAC platform is not an optional add-on. It IS the reactor protection system and the engineered safety features actuation system [45][46][104]. The "walk-away safe" claim depends on passive physics (gravity-driven coolant circulation, annular reservoir heat sink) [10] but the DETECTION of when those passive systems are needed, the CONFIRMATION that they are functioning, and the MONITORING of the reactor's state during and after any transient all of that is MELTAC [10][11]. All digital. All CMOS. All dependent on the 50 materials [90].

Remove the computers and there is a sealed vessel underground producing decay heat [53] with no way to know the temperature, the pressure, the coolant level, the neutron flux, the containment integrity, the spent fuel pool level, or the radiation dose rates. There would be a reactor we cannot see into, cannot measure, and cannot diagnose. The passive physics may keep the fuel cool or may not, depending on whether the annular reservoir is intact, whether the primary pressure boundary held, whether boron concentration is adequate [45][46]. Without instrumentation, we do not know. Without knowing, we cannot act. Without acting, we are trusting that every passive system works perfectly for the full duration an assumption that 207 earthquakes [71] on a frictionally weak fault segment [73] will test repeatedly.

Reactor Monitoring with Analog Technology

Thermocouples read by analog galvanometers, pressure gauges with bourdon tubes, radiation detectors with ion chambers and analog electrometers as these existed before digital computation [105]. But they degrade faster than digital systems, require more frequent calibration, provide less precision, cannot perform automated safety logic, cannot log data for regulatory compliance, and cannot be networked for remote monitoring [4][16]. They also require the same scarce materials like platinum for thermocouples, silver for contacts, copper for wiring, tin for solder [90] just in different configurations.

The material depletion problem is not unique to digital. It applies to any monitoring technology built from the periodic table's finite supply of conductive, resistive, thermoelectric,

and structural materials [90][93].

As such the honest answer is no, humanity cannot safely manage a modern nuclear reactor without computers [98][99]. We cannot build or maintain those computers without materials that are running out [90][93].

9. Lake Effect Precipitation Analysis

Lake-effect precipitation is weather generated by a large body of water when cold air passes over it through a straightforward mechanism. Cold, dry air moves across the landscape which is typically from the northwest during autumn and winter. When that cold air reaches the Great Salt Lake, it passes over water that is warmer than the air. The warm lake surface heats the bottom layer of the cold air mass. Warm air rises. As the warm air rises, it carries the moisture it picked up from the lake surface. As that moisture-laden air continues rising, it cools, the water vapor condenses into clouds, and precipitation falls typically as snow on the Wasatch Front mountains downwind of the lake [110][113].

The lake-effect process is driven by three physical requirements, temperature difference, moisture, and water availability. The cold air must travel over the lake surface long enough to absorb heat and moisture. The distance the air travels over open water is called the fetch. Longer fetch means more heat and moisture transfer, which means stronger convection, which means more precipitation. The Great Salt Lake at a healthy elevation of 4,198 feet has a surface area of roughly 1,700 square miles and a maximum fetch of approximately 75 miles which is long enough to generate significant lake-effect snowbands [108][110]. As the lake shrinks, fetch shortens, and the moisture loading capacity of the air diminishes proportionally. At the current elevation of 4,191.6 feet, the lake has already lost roughly 800 square miles of surface area, and the effective fetch has shortened accordingly [108][23].

The amount of moisture the air picks up depends on the vapor pressure difference between the saturated air directly at the lake surface and the drier air above it. This is where Clausius-Clapeyron enters and the saturation vapor pressure at the lake surface temperature determines the upper limit of how much moisture is available to be transferred. Higher lake surface temperature means exponentially more moisture available. But the moisture must come from the lake itself and every kilogram of water vapor the atmosphere picks up is a kilogram of water removed from the lake.

The lake-effect processes enhance total cool-season precipitation in the downwind areas by 5–10% in an average year, with individual lake-effect events capable of depositing substantial snowfall and multiple feet in the favored mountain locations east and south of the lake [110][113]. Meaning The Great Salt Lake is Utahs snow machine. The lake-effect precipitation declines because less water is being returned to the watershed by the atmosphere. The Great Salt Lake losing surface area and fetch causes the deficit to widen resulting in even less snow [109][110].

A nuclear reactor impacts how much lake-effect precipitation the Great Salt Lake is capable of generating. The question is how does that degraded precipitation feed back into the lake volume equation to accelerate or decelerate the decline? The following is the analysis of an impact on cumulative water loss to reactor cooling, the waste heat input to the basin, and the resulting changes in lake surface area, surface temperature, and fetch.

Precipitation Analysis

No civilization has lasted more than 6,000 years and as nuclear reactors have radioactive maintenance and a water demand for 24,110 + years [53] the projections must go beyond the assigned 40-year licensing term [45][46] if for no other reason to be a responsible participant of existence.

$$dS/dt = \dot{E}_{\text{Entropy Solar Radiation}} + \dot{E}_{\text{Entropy Reactor Waste Heat}} + \dot{E}_{\text{Entropy Evaporation}} + \dot{E}_{\text{Entropy Precipitation Reduction}} + \dot{E}_{\text{Entropy Chemical Changes}} + \dot{E}_{\text{Entropy Biological System Collapse}} + \dot{E}_{\text{Entropy Seismic Events}}$$

Term	Name	Measurement
dS/dt	Total entropy rate of the Great Salt Lake system at the baseline equation	bits/second
$\dot{E}_{\text{Entropy Solar Radiation}}$	Entropy production from solar radiation	bits/second
$\dot{E}_{\text{Entropy Reactor Waste Heat}}$	Entropy production from reactor waste heat	bits/second
$\dot{E}_{\text{Entropy Evaporation}}$	Entropy production from evaporation	bits/second
$\dot{E}_{\text{Entropy Precipitation Reduction}}$	Entropy reduction from precipitation	bits/second
$\dot{E}_{\text{Entropy Chemical Changes}}$	Entropy production from chemical changes	bits/second
$\dot{E}_{\text{Entropy Biological System Collapse}}$	Entropy production from biological system collapse	bits/second
$\dot{E}_{\text{Entropy Seismic Events}}$	Entropy production from seismic events	bits/second

Conventional water balance equations track one quantity of volume. To analyze the other elements of the Great Salt Lake (toxic dust, brine shrimp, precipitation, radiological release, liability), I need separate models stitched together with empirical couplings. Landauer showed Information-Energy is the same and Energy becomes Entropy through heat $E = kBT\ln(2)$ [12].

As such the entropy model tracks which tracks total system order provides insight into every physical process in the basin as a term in the same equation, with the same units, governed by the same underlying principle (Landauer) [12][17] instead of creating separate models for hydrology, chemistry, biology, meteorology, and seismology. Each variable is an entropy production rate. They are all bit erasure. They can be directly compared, directly summed, and directly integrated over the full decay timeline.

At the temperature of the Great Salt Lake (293 K, about 20°C) [23], the minimum amount of energy for every state change that cannot be undone

$$\begin{aligned} \dot{E}_{\text{Entropy Reactor Waste Heat}} &= kBT\ln(2) \\ \dot{E}_{\text{Entropy Reactor Waste Heat}} &= (1.381 \times 10^{-23}) \times (293) \times (0.6931) \\ \dot{E}_{\text{Entropy Reactor Waste Heat}} &= 2.803 \times 10^{-21} \text{ joules} \end{aligned}$$

The Basin from the Reactor will have slightly increased to 293.5K. The bit rate is slightly lower because each bit costs more energy at higher temperature. This is Landauer [12] where warmer systems pay more per state change.

Waste bits/s = 1 GW continuous 1181
 Waste bits/s = $1 \times 10^9 / (1.381 \times 10^{-23} \times 293.5K \times 0.6931)$ 1182
 Waste bits/s = $1 \times 10^9 / 2.808 \times 10^{-21}$ 1183
 1184

In acre-feet per year: 1185

Acre Feet/yr = $1 \times 10^9 W \div 2.26 \times 10^6 J/kg$ 1186
 Acre Feet/yr = 442.5 kg/s 1187
 Acre Feet/yr = $442.5 \times 3.156 \times 10^7 \div 1,000 \div 1,233.48$ 1188
 Acre Feet/yr = 11,318 AF/yr 1189
 1190
 1191
 1192

The acre-feet number is unchanged because the heat output is unchanged. Confirming the 1193
 conversion from heat to evaporation depends on latent heat of vaporization [63], not on 1194
 basin temperature. The Entropy Reactor Waste Heat term only exists due to the reactor. 1195

1 reactor = 1,050 MW 1196
 1 reactor = 1.05 GW 1197
 1 reactor = $1.05 \times 11,318$ 1198
 1 reactor = 11,884 AF/yr 1199
 1200

Brigham City 1201
 2 reactors = 2,100 MW 1202
 2 reactors = 2.1 GW 1203
 2 reactors = $2.1 \times 11,318$ 1204
 2 reactors = 23,768 AF/yr 1205
 1206

Operation Gigawatt 1207
 13 reactors = 13,650 MW 1208
 13 reactors = 13.65 GW 1209
 13 reactors = $13.65 \times 11,318$ 1210
 13 reactors = 154,491 AF/yr 1211
 1212
 1213

Over 40 years for the full fleet: 1214

Operation Gigawatt Entropy Reactor Heat 1215

Period/yr	Name	AF	bits/second
40	Operational full fleet thermal	6,179,640 AF	4.868×10^{30}
100	Post-shutdown decay heat	128.44 AF/yr	4.047×10^{27}
300	Post-shutdown decay heat	103.10 AF/yr	3.248×10^{27}
1000	Post-shutdown decay heat	81.04 AF/yr	2.553×10^{27}
24,110	Post-shutdown decay heat (1 Pu-239 half-life)	42.88 AF/yr	1.351×10^{27}

How to Read the Table 1216

The 40-year row is cumulative. It represents the total water volume thermodynamically 1217
 equivalent to the heat rejected by the full 13-reactor fleet over its rated operational lifetime 1218
 1219
 1220

[45][46]. At 13,650 MW continuous thermal output, 40 years of operation converts to 6,179,640 acre-feet of evaporative equivalent via the latent heat of vaporization [63][69]. Which is not a claim about direct evaporation. It is a thermodynamic accounting of the basin's heat absorption obligation [31]. The subsequent rows are instantaneous annual rates. They address a categorically different question being at a given post-shutdown moment, what is the decay heat production rate and its corresponding annual water removal obligation [53]. Operational analysis requires cumulative burden. Post-shutdown analysis requires ongoing rate, because rate governs what infrastructure must remain functional in perpetuity [60][61].

The Three-order-of-Magnitude Drop

The fleet produces 13,650 MW thermal at rated power [45][46]. At 40 years post-shutdown, decay heat has decayed to 13.6 MW [53], a factor of 1,000 reduction consistent with the $t^{(-0.2)}$ power law of ANS 5.1-2014 [53], the same standard the licensing team applied in designing the spent fuel cooling systems [98][99]. The drop is expected but the drop is not the main focus. The main focus is the floor. At 24,110 years, one Pu-239 half-life [7], decay heat remains at 3.79 MW [53]. The entropy production rate remains at 1.351×10^{27} bits per second [12][17]. The basin continues absorbing thermodynamic disorder at a rate requiring active water removal [60]. The integral does not close. In licensing terms specifically, the decay heat removal carries no expiration date [60][103]. The 40-year operating license governs the peak of the decay curve [45][46]. This table shows the tail and the tail extends to 24,110 years [53].

■ Regulatory Observation: The United States Department of Energy authorized a categorical exclusion for Operation Gigawatt on January 28, 2026, eliminating NEPA review [115]. That exclusion was written for a 40-year energy project. This table demonstrates that the project is not a 40-year energy project.

The Operation Gigawatt project the Department of Energy Authorized is a 24,110-year thermal and hydrological commitment to the Great Salt Lake basin [53], of which the 40-year operating license represents 0.17% of the total obligation [45][46].

The categorical exclusion does not cover the remaining 99.83%.

NEPA requires federal agencies to analyze the reasonably foreseeable environmental effects of their actions [116]. The reasonably foreseeable effects of Operation Gigawatt include 24,110 years of decay heat production [53], 207 major earthquakes on the Brigham City segment of the Wasatch Fault [71][74], progressive depletion of 14 instrumentation and control materials before the first operating license expires [90][93], and cumulative water removal from a terminal basin already below restoration targets [31][41].

None of these effects were analyzed in the categorical exclusion because categorical exclusions by definition foreclose that analysis [117][118].

The DOE cannot claim a categorical exclusion covers effects it did not examine. The question for DOE is whether the agency can defend, in federal court, the position that a 24,110-year thermal commitment to a terminal basin on an overdue seismic fault constitutes a project with no significant environmental effect [116][117][118].

Precipitation and Lake Effect Thermodynamics

Operation Gigawatt proposes a fleet of 13 SMR-300 reactors deployed across Utah and

Wyoming, with the first 2-reactor site at Brigham City on the Great Salt Lake basin and the Wasatch Fault [54][44][56]. Each SMR-300 produces 1,050 MW of thermal energy to generate approximately 300 MW of electricity [45][46]. The remaining approximately 750 MW per reactor is waste heat that must be rejected to the environment [106]. At 92% capacity factor [57], the 13-reactor fleet continuously rejects approximately 8.97 GW of waste heat, or 13 GW when thermodynamic pollution is fully accounted for.

A nuclear reactor delivers energy to the basin measured in joules per second. 8.97 GW equals 8.97×10^9 joules per second. It takes 2.26×10^6 joules to evaporate one kilogram of water [63]. Dividing the first by the second tells you how many kilograms of water the fleet evaporates per second.

$$\begin{aligned} \text{Water Evaporated} &= 8.97 \times 10^9 \text{ J/s} \div 2.26 \times 10^6 \text{ J/kg} \\ \text{Water Evaporated} &= 3,969 \text{ kg/second} \end{aligned}$$

Now I calculate the seconds of water evaporation at a Julian Year $365.25 \text{ days} \times 24 \text{ hours} \times 60 \text{ minutes} \times 60 \text{ seconds}$

$$\begin{aligned} 365.25 \times 24 &= 8,766 \text{ hours} \\ 8,766 \times 60 &= 525,960 \text{ minutes} \\ 525,960 \times 60 &= 31,557,600 \text{ seconds} \\ \mathbf{31,557,600} &= \mathbf{3.156 \times 10^7} \end{aligned}$$

$$\begin{aligned} \text{Water Evaporated} &= 3,969 \text{ kg/s} \times \mathbf{3.156 \times 10^7 \text{ s/yr}} \\ \text{Water Evaporated} &= 1.253 \times 10^{11} \text{ kg/yr} \\ \text{Water Evaporated} &= 1.253 \times 10^{11} \text{ kg} \div 1,000 \text{ kg/m}^3 \\ \text{Water Evaporated} &= 1.253 \times 10^8 \text{ m}^3/\text{yr} \\ \text{Water Evaporated} &= 1.253 \times 10^8 \text{ m}^3 \div 1,233.48 \text{ m}^3/\text{AF} [8] \\ \text{Water Evaporated} &= 101,543 \text{ AF/yr by waste heat} \\ \mathbf{\text{Water Evaporated}} &= \mathbf{1.253 \times 10^{11} \text{ kg/yr}} \end{aligned}$$

101,543 AF/yr evaporated by waste heat in a terminal basin with no outlet [31], the waste heat has no exit pathway except evaporation. A 13-reactor fleet evaporates 101,543 acre-feet of water per year through waste heat alone. Over the 40-year operating license [45][46] meaning 4,061,720 AF of water is permanently removed through waste heat evaporation. Combined with the operational cooling water consumption of 46,130 AF/yr [65][66][31], the total operational water impact is approximately 5,906,920 AF over 40 years.

The Great Salt Lake's current volume is approximately 15.0 km³, or 12.16 million acre-feet [107]. The 13-reactor fleet consumes approximately 49% of the current lake volume in one operating lifetime. Losing 49% of its volume plus the natural deficit would not mean survive in any recognizable form. Conservatively, if the lake reaches half its current area roughly 475 mi² that is a 50% area reduction from the current 950 mi² [107].

Gu et al. (2024) utilized the Weather Research and Forecasting Model coupled with a lake model to simulate how changes in the Great Salt Lake's surface area affect precipitation [108]. Running 75 simulations across five lake extent scenarios (100%, 75%, 50%, 25%, and 0% of 2004 lake area), they found a systematic decline in the quantity of precipitation over the Great Salt Lake and downwind regions with declining areal coverage [108]. A 25% reduction in lake area produced approximately 10% reduction in total storm precipitation

[108]. In the event of complete disappearance, regional average precipitation would experience an approximate 50% reduction [108]. Applying this relationship: a 50% area reduction produces approximately 20% reduction in storm precipitation in the downwind watershed.

Lake-effect periods contribute 5.1–8.4% of cool-season (September 16 through May 15) precipitation at observing sites in the Cottonwood Canyons and Oquirrh Mountains, based on observations from 1998–2009 [109]. Lake-effect precipitation contributes to the Great Salt Lake water budget through direct precipitation on the lake and the buildup of a mountain snowpack that drives much of the surface-water runoff within the basin, which serves as the primary water resource for the Wasatch Front population [109]. Lake-effect precipitation also provides a path for water recycling because evaporation from the lake contributes to a portion of the water mass that falls as precipitation and eventually returns as surface-water runoff [109]. A 20% reduction in lake-enhanced precipitation means the lake-effect contribution drops from roughly 6.7% (midpoint) to roughly 5.4% of total cool-season precipitation. Applied across the entire Wasatch Front watershed, this represents tens of thousands of acre-feet per year of lost snowpack. Snowpack is what Utah's 2.5 million people depend on for drinking water [39].

Gu et al. (2024) modeling showed total storm precipitation decreases as the lake shrinks, because the lake modifies the thermodynamic environment for all precipitation events passing through the region [108]. The study's authors identified this as a negative feedback loop. As the water body decreases, precipitation decreases in the Great Salt Lake Basin, which shrinks the water body further, which decreases precipitation further [110]. A 50% area reduction producing a 20% reduction in total regional storm precipitation is a water supply crisis for northern Utah, where 95% of the water supply comes from snow-melt [111].

The salinity of the Great Salt Lake further suppresses lake-effect precipitation. Research has shown that salinity can produce a 17% reduction in snowfall compared to fresh water simulations, and it is likely that increases in salinity accompanying a shrinking Great Salt Lake would further reduce lake-effect precipitation [112]. With 5.9 million AF removed by the reactor fleet, the south arm concentration would be catastrophic. The current south arm salinity is approximately 142 g/L [23], with a brine shrimp reproductive failure threshold at approximately 150–180 g/L [113]. The 8 g/L margin to brine shrimp collapse would be crossed within the first decade of fleet operation, not at the end of the license.

At 40 years with 13 reactors the Great Salt Lake has lost roughly half its current volume to the reactor fleet alone. Eliminating the 40–50% of global *Artemia franciscana* cysts the Great Salt Lake supplies to the aquaculture industry [25][26]. Approximately 800 or more additional square miles of lakebed are exposed, emitting toxic dust containing arsenic, mercury, lead, and cadmium at PM10 concentrations exceeding 4,000 $\mu\text{g}/\text{m}^3$ during wind events [36][37], which is more than 26 times the EPA 24-hour PM10 standard of 150 $\mu\text{g}/\text{m}^3$ [38]. The precipitation feedback loop has been operating for 40 years: less lake, less precipitation, less inflow, less lake.

At 100 years brine shrimp have been extinct from the Great Salt Lake for over a century [113]. The Pacific Flyway has been permanently altered [32][33]. The ecological memory of the Great Salt Lake as a functioning ecosystem exists only in historical records.

In 300 years no brine shrimp for three centuries [113]. The ecological niche they occupied

is gone. The brine fly populations that coexisted with them are gone [34]. The food web that supported 338 bird species at hemispheric scale is gone [32][33]. The global loss is not recoverable on any human timescale because recovery would require restoring the lake to a volume and salinity which no longer exist [107][23].

At 1,000 years no brine shrimp have existed for a millennium. The Great Salt Lake supported the same brine shrimp populations it supported in 2025 [28][29]. The ecosystem was stable for millennia before human intervention [24][28]. The reactor compressed the timeline from stable to extinct within a single decade [23][113].

Olympics 2034 Snow Math

Utah has been selected as the location of the 2034 Olympics, building on its 2002 Olympic infrastructure [128]. The lake effect is the primary driver of snow in Utah's mountainous region for which its powdery snow is famous [109][112]. To understand the impacts of nuclear alongside population growth, the following projections are calculated from 2026 to 2034 to understand how much snow Utah would have available for the 2034 Olympic games.

Based on Utah Governor Spencer J. Cox and the Utah Office of Energy Development [56], coupled with the acceleration of nuclear energy under President Donald Trump and the easing of nuclear regulation [124][125], the projection is 6 reactors online by 2034 with scaling [54][56]. Nuclear has a thermodynamic ledger which must be accounted [53][63].

2026 Snow

0 reactors, current volume estimates 8,400,000 AF

Calculate per reactor evaporation

$$\text{Reactor evaporation} = 0 \text{ reactors} \times 1.05 \text{ GW} \times 11,318 \text{ AF/yr GW}$$

$$\text{Reactor evaporation} = 0 \text{ AF/yr}$$

Total loss 2026 year

$$\text{Anthropogenic loss} = 1,000,000$$

$$\text{AF Reactor loss} = 0$$

$$\text{AF Total} = 1,000,000 \text{ AF}$$

Calculate by lake volume

$$\text{Lake volume end of 2026} = 8,400,000 - 1,000,000$$

$$\text{Lake volume end of 2026} = 7,400,000 \text{ AF}$$

Calculate the volume lost from usage and dehydration based on lake effect and use.

$$\text{Volume lost} = 8,400,000 - 7,400,000$$

$$\text{Volume lost} = 1,000,000$$

$$\text{AF Percentage lost} = 1,000,000 \div 8,400,000$$

$$\text{AF Percentage lost} = 11.9\%$$

Area reduction at the level of shallow bathymetry of the Great Salt Lake area reduces at roughly 60% the rate of volume loss where the deeper lake center holds volume while the shallow margins expose first [129][130].

$$\text{Area reduction} = 11.9\% \times 0.6$$

$$\text{Area reduction} = 7.1\%$$

$$\text{Remaining area} = 950 \times (1 - 0.071)$$

$$\text{Remaining area} = 882 \text{ mi}^2$$

The remaining area and precipitation reduction may then be calculated (Gu et al. 2024).

$$\text{Precipitation reduction } 25\% \text{ area reduction} = 10\% \text{ precipitation reduction } 7.1\% \text{ area reduction}$$

$$\text{Precipitation reduction } 25\% \text{ area reduction } (7.1 \div 25) \times 10 = 2.8\%$$

Snowbird snowfall We are starting from 300 inches which is the current depressed baseline

$$\text{Snowbird Snowfall} = 300 \times (1 - 0.028)$$

$$\text{Snowbird Snowfall} = 300 - 8.4$$

$$\text{Snowbird Snowfall} = 292 \text{ inches}$$

Lake Affect Snow Math

Year	Reactor	TTL GW	Population H2O AF/yr	TTL Loss H2O AF/yr	Lake Volume AF	Volume Lost %	Area Reduced %
2026	1	.005	1 M	1,000,057	8,400,000	0%	0%
2027	1	.005	1 M	1,000,057	7,399,943	11.9%	7.1%
2028	1	.005	1 M	1,000,057	6,399,886	23.8%	14.3%
2029	3	2.105	1 M	10,023,825	5,399,829	35.7%	21.4%
2030	4	3.155	950 k	985,709	4,376,004	47.9%	28.7%
2031	5	4.205	900 k	947,593	3,90,395	59.6%	35.8%
2032	6	5.255	800 k	859,477	2,442,702	70.9%	42.5%
2033	7	6.305	700 k	771,361	1,583,225	81.2%	48.7%
2034	7	6.305	500 k	571,361	811,864	90.3%	54.2%

Lake Affect Snow Math Diagram Cont.

Year	Area mi ²	Precipitation Loss	Snow Lost inches	Snowbird inches
2026	950	.0%	0	300

2027	882	2.8%	8	292
2028	814	5.7%	17	283
2029	747	8.6%	26	274
2030	677	11.5%	35	265
2031	610	14.3%	43	257
2032	546	17.0%	51	249
2033	487	19.5%	59	241
2034	435	21.7%	65	235

Under Governor Cox's Operation Gigawatt roadmap and the acceleration of nuclear [56][54][124][125] with participation from The Department of Energy, the combined anthropogenic diversion deficit and reactor waste heat evaporation removes water from the lake every year from 2026 through 2034, and each year of water loss reduces the lake's surface area, which reduces the lake-effect precipitation that generates Utah's famous snow [108][109]. By 2034, the lake holds approximately 241,000 acre-feet, 2.9% of its 2026 volume [107]. Snowbird, which averages 500 inches of snow annually, is projected to receive approximately 210 inches for the Olympic year, a loss of 90 inches from the already depressed 2026 baseline of 300 inches [109][112][128].

The brine shrimp that supply 40 to 50% of the global aquaculture feed market have collapsed years earlier as salinity crossed the 150 g/L reproductive failure threshold [25][26][113]. More than 600 square miles of exposed lakebed emit arsenic, mercury, lead, and cadmium dust at concentrations exceeding EPA standards by 26 times during wind events, blanketing the 2.5 million people of the Wasatch Front [36][37][38][39]. The Governor's two goals, doubling Utah's energy capacity by 2034 [56] and hosting the Winter Olympics in 2034 [128], are in thermodynamic contradiction as one requires injecting gigawatts of waste heat into a terminal basin [45][46][63], and the other requires that basin to produce snow [109][112]. The physics does not permit both.

10. The Ratepayer Extraction

Saving the Great Salt Lake Cost

The State of Utah, the federal government, and the private sector have committed substantial and sustained resources to save the Great Salt Lake across multiple funding streams spanning four years. In the 2021 First Special Session, the Legislature set aside \$280 million from the American Rescue Plan Act for water infrastructure, including \$50 million for secondary water metering, \$25 million for drinking water infrastructure, and \$20 million for agricultural water optimization [164][165]. The 2022 General Session committed nearly \$500 million in water conservation and lake-specific appropriations, including H.B. 410 which established the Great Salt Lake Watershed Enhancement Trust with \$40 million, H.B. 429 which funded the Great Salt Lake Basin Integrated Water Assessment with \$5 million in state funds matched by \$3.1 million from the Bureau of Reclamation, \$200 million for secondary water metering, \$5.15 million for water-wise landscaping, \$5 million for Great Salt Lake salinity and marina infrastructure, \$30 million for Utah Lake

preservation, and \$25 million for rural drinking water [164][166][167]. The 2023 General Session committed over \$500 million in additional appropriations, including \$10 million one-time plus \$2.5 million ongoing to establish the Office of the Great Salt Lake Commissioner, \$200 million for agricultural water optimization, \$12 million one-time plus \$5 million ongoing for cloud seeding expansion, \$15 million in additional secondary water metering grants, \$8 million in Air and Water Innovation Grants, \$6 million for wetland acquisition, \$5 million one-time plus \$3 million ongoing for water-efficient landscaping, \$5 million for emergency water shortages, \$5.449 million for water rights measurements and data, \$1.8 million for digital lakebed topography of the Great Salt Lake and Bear Lake, and \$9.9 million for school energy and water reductions [168][169]. The 2024 General Session provided an additional \$5 million for Great Salt Lake wetland protection and restoration [170][171]. In December 2024, the U.S. Bureau of Reclamation awarded Utah \$50 million through the Inflation Reduction Act, which the state matched with an additional \$50 million for a combined \$100 million investment representing the largest single federal investment in the Great Salt Lake in history [172][173][174][175]. The Great Salt Lake Ecosystem Program, funded through brine shrimp harvesting permit fees, has directed approximately \$10 million per year to Great Salt Lake wildlife management for nearly 30 years, representing an estimated \$300 million in cumulative ecosystem investment [26][180]. In 2025, the Great Salt Lake 2034 Charter generated a \$200 million philanthropic commitment from Utah's business community and Ducks Unlimited with the stated goal of restoring the lake to a healthy elevation by the 2034 Winter Olympics [176][177][178]. The Sovereign Lands Management Account has directed approximately \$10 million per year in royalties from Great Salt Lake industrial operations back to sovereign lands management on an ongoing basis [179].

The total documented investment by the State of Utah, the federal government, and the private sector in saving the Great Salt Lake across all funding streams since 2021 is approximately \$1.885 billion. Of this total, approximately \$595 million is directly and exclusively designated for Great Salt Lake restoration. The remainder represents the full water conservation investment across Utah's watershed from which the lake is the primary downstream beneficiary. Every dollar of this investment is being simultaneously undermined by a nuclear deployment that this paper calculates will evaporate 155,657 acre-feet per year from the same lake at a total ratepayer cost of \$22.9 billion to \$77 billion over 40 years [145][146][107][129][130].

Taxpayer Cost

A single dual-unit Holtec SMR-300 plant produces 600 MWe at a 92.5% capacity factor [57], generating 193,656,000 MWh over its 40-year licensed life [45][46][4]. At the Lazard Levelized Cost of Energy upper bound of \$192/MWh [145], total capital recovery equals \$37.2 billion; applying the industry's documented 207% construction cost overrun across 75 historical nuclear plants [181] yields a ceiling of \$77 billion extracted from Rocky Mountain Power's 1,062,568 Utah residential customers [147] at a present-value burden of \$20,225 to \$41,871 per household in 2026 dollars, against a median household income of \$98,336 [148] and a current electricity bill of \$2,016 per year [149]. This capital was not privately financed. It was pre-loaded with \$1.92 billion in direct federal awards to Holtec International [131][132], \$1.52 billion in federal loan guarantees [150], \$10.85 million in Utah legislative appropriations [136][137], and GOED grants flowing to Box Elder County, Brigham City Corporation, the Military Installation Development Authority, and the Utah Aerospace and Defense Association [151], meaning Utah taxpayers financed the construction of the infrastructure before the first kilowatt-hour was generated and will finance it again through 40 years of embedded rate base surcharges. The corporations consuming

this output, Microsoft, Meta, Amazon, Nvidia, and OpenAI, whose combined market capitalization exceeds \$10 trillion, will negotiate wholesale power purchase agreements at Utah's industrial rate of \$0.0562/kWh [152], which is 40 percent of the residential rate, generating a cross-subsidy of \$0.136 per kilowatt-hour recovered invisibly from residential ratepayers who have no opt-out mechanism in Utah's regulated market. The total 40-year cross-subsidy transferred from Utah households to trillion-dollar corporations reaches \$26.3 billion (193,656,000 MWh × \$135.8/MWh). Utah taxpayers therefore pay twice: first through public funds and federal debt financing the construction of the infrastructure, and second through four decades of rate base extraction financing the operation of that infrastructure for the exclusive benefit of corporations that paid nothing toward its existence.

The extraction constitutes an economic double dip of historic proportions, structurally identical to the pattern by which Amazon deployed 31,400 electric delivery vehicles by 2024 [182] to avoid the fuel excise taxes funding the roads those vehicles degrade, a deficit now requiring retail delivery fees in Colorado and Minnesota to partially recover [162][163]. The difference in scale and consequence is absolute. Roads can be repaired. At 11,318 acre-feet evaporated per gigawatt-year of thermal rejection [107], the Great Salt Lake cannot. The brine shrimp industry supplying 40 to 50 percent of global aquaculture feed cannot be reconstituted once the basin is gone. The 800 square miles of exposed lakebed emitting arsenic, mercury, and lead at 26 times the EPA threshold cannot be unexposed. The 90 inches of Olympic snowpack cannot be restored by rate case proceedings. Utah families are being asked to finance the technocrats and corporate electricity bill twice, with their tax dollars, with their monthly utility payments, and with the Great Salt Lake as the collateral that is never returned.

Operation Gigawatt Cost

Operation Gigawatt has committed the following documented public resources as of March 2026. The Utah Legislature appropriated \$10.85 million in the 2025 General Session for Operation Gigawatt nuclear deployment, with nearly \$2 million of that amount designated for a public relations campaign to promote nuclear energy to Utahns [136][183]. The federal government pre-loaded the deployment ecosystem with \$400 million in DOE Generation III+ SMR awards to Holtec [131][132] and \$1.52 billion in DOE loan guarantees to Holtec [150]. Valar Atomics received approximately \$130 million in Series A funding to advance the Ward 250 reactor platform under the DOE Nuclear Reactor Pilot Program [184][185]. On February 15, 2026, the Department of War deployed three C-17 Globemaster III military transport aircraft in Operation Windlord to airlift the Ward 250 reactor from California to Hill Air Force Base in Utah, at an estimated airlift cost of approximately \$4.9 million based on published C-17 operating costs of \$25,000–\$35,000 per flight hour [186][187][188]. Ground construction at the Utah San Rafael Energy Lab began in September 2025, with over 40,000 cubic yards of material moved and 4,000 cubic yards of concrete poured for the Ward 250 foundations before the reactor arrived [189].

The total documented public expenditure committed to Operation Gigawatt nuclear deployment as of March 2026 exceeds \$1.93 billion in federal pre-commitments and state appropriations, before a single kilowatt-hour has been generated and before any thermodynamic basin analysis of the Great Salt Lake has been performed by any party named in this paper.

11. Liability

Nuclear liability law establishes strict liability for the operator of a nuclear facility. The operator is liable whether or not fault or negligence can be proven [118]. The victim does not need to demonstrate how the harm occurred. The harm itself is sufficient. This principle exists because the complexity of nuclear science makes it impractical to require the public to prove causation [118].

The Price-Anderson Act requires reactor operators to assume all liability for nuclear damages and to waive most legal defenses following a severe radioactive release [119]. The total liability pool is capped at approximately \$16 billion across the entire commercial fleet [120]. For context, the Great Salt Lake generates \$1.9 billion in annual economic output [27]. The brine shrimp cyst harvest alone supplies 40 to 50 percent of the global aquaculture feed market [25][26]. The Wasatch Front snowpack that lake-effect precipitation builds supplies 95 percent of Utah's water for 2.8 million people [190] The economic value of what the reactors destroy exceeds the liability cap within a decade.

But the Price-Anderson Act addresses radiological accidents. It does not address the thermodynamic destruction of a terminal basin through waste heat. It does not address the evaporation of 155,657 acre-feet of water per year from a lake that holds 8.4 million acre-feet [107][129][130]. It does not address the collapse of lake-effect precipitation that reduces snowfall by 90 inches at Olympic venues [108][109][112][128]. It does not address the exposure of 800 square miles of toxic lakebed that poisons the air for 2.8 million people [36][37][38][191]. It does not address the extinction of a brine shrimp population that feeds the world [25][26][28][29]. None of these are radiological incidents. All of them are thermodynamic consequences of placing a heat engine in a terminal basin. There is no federal liability framework for thermodynamic waste category of harm because no one has previously proposed installing a nuclear reactor in a terminal basin before.

The Eighth Circuit held in *Mazzocchio* (2024) that federal nuclear safety regulations do not preempt state tort standards [121]. Five other circuits disagree. The circuit split may reach the Supreme Court. If the Eighth Circuit's reasoning stands, nuclear operators face tort liability under state law even when they fully comply with NRC regulations [121]. Compliance with a federal license does not immunize an operator against state-law claims for damages caused by the licensed activity.

The Supreme Court established in *Silkwood v. Kerr-McGee Corp.*, 464 U.S. 238 (1984), that state tort remedies are preserved under the Atomic Energy Act [122]. The public's right to seek damages in state court for harm caused by nuclear operations was not extinguished by the federal licensing regime.

The NRC's own standard, established in *Union of Concerned Scientists v. NRC*, 824 F.2d 108 (D.C. Cir. 1987), requires the agency to ensure that reactor operations provide "adequate protection to the health and safety of the public" [123]. The court held that this standard must be given content through case-by-case application of technical judgment [123]. The court did not hold that the public must provide the technical judgment. That obligation belongs to the NRC and the applicant.

No site-specific analysis of waste heat in a terminal basin over the full decay timeline has been performed by the Nuclear Regulatory Commission [124], the United States Department of War [186][187], the United States Department of Energy [131][132][133][134][135], Holtec International [45][46][142][143], Valar Atomics [184][185], the State of Utah [56][54][136][137], or by any entity proposing or participating in Operation Gigawatt

[44][55]. No analysis of the cumulative effect of 13.65 GW of thermal energy on lake-effect precipitation has been performed [108][109][112]. No analysis of the salinity trajectory of the south arm under reactor-accelerated evaporation has been performed [107][113]. No analysis of the snow impact on the 2034 Olympic venues has been performed [108][112][128]. No analysis of the lake's capacity to survive the operational water demand has been performed against the corrected volume of 8.4 million acre-feet [107][129][130]. The proponents have not performed the analysis because no regulation required it, and no regulation required it because no one has previously proposed placing a nuclear fleet on a terminal basin [114][115][116][117].

Liability belongs to:

1. **The operators**, under strict liability for all damages arising from the facility's operation, including thermodynamic harm to the basin that is a direct and calculable consequence of the facility's thermal output [118][119]. Holtec International and its subsidiaries including Holtec SMR LLC and Holtec Government Services LLC, and its principals Dr. Kris Singh, CEO and Executive Chairman; Dr. Rick Springman, President of Global Clean Energy Opportunities; and Admiral Frank Roegge, Chief Strategy Officer, under strict liability for all damages arising from the facility's operation, including thermodynamic harm to the basin that is a direct and calculable consequence of the facility's thermal output [54][192][193][118][119]. Hi Tech Solutions LLC and its principal Chris Hayter, President, COO, and co-founder, as co-signatory to the Utah MOU and designated regional deployment partner [54][55]. TerraPower LLC and its principals Bill Gates, Founder and Chairman; and Chris Levesque, President and CEO, whose Natrium reactor technology developed in partnership with GE Hitachi is being sited in Utah without thermodynamic basin analysis [194], and Flagship Companies and its principal Craig Cannon, Partner, who co-signed the TerraPower MOU and is responsible for identifying nuclear reactor sites in Utah [194]. Valar Atomics and its principals Isaiah Taylor, CEO and Founder; and Max Ukropina, MOU signatory, who delivered the Ward 250 nuclear test reactor to the Utah San Rafael Energy Lab on February 15, 2026 via military airlift without thermodynamic basin analysis [184][185][186][187]. Deep Fission and its principal Liz Muller, Co-founder and CEO, which selected Utah as one of three initial sites for underground nuclear reactor testing without thermodynamic basin analysis [195]. NuCube Energy Inc. and its principals Cristian Rabiti, CEO; and Lorin Young, operational point of contact, who signed an MOU for siting at the Utah San Rafael Energy Lab [196]. Curio Solutions LLC and its principal Edward McGinnis, President and CEO, former senior DOE official, who signed a nuclear fuel recycling MOU with the State of Utah in January 2026 [197], while simultaneously leading a company whose advisory board consists of Alan Brownstein, former Associate Deputy Assistant Secretary for Nuclear Energy at DOE; Dr. Alex Burkart, Department of State, retired; Jeff Duncan, former Member of Congress; Fred Fleitz, Senior Fellow, America First Policy Institute; Thomas F. Gioconda, former Deputy Director of Lawrence Livermore National Laboratory; Bonnie Glick, former Deputy Administrator of USAID; Joe Grimes, TVA, Exelon Nuclear, and PECO, retired; Brian Gutherman, President, Gutherman Technical Services; Dr. Brent Park, former Deputy Administrator for Defense Nuclear Nonproliferation at NNSA; Amy Roma, Esq., Hogan Lovells; Dr. Wolfgang Runde, Department of Energy, retired; John D. Santi Sr., Founder, MFO-USA; D'Anne Emmett Spence, Colonel, USAF, retired; and Dr. Allen Sessoms, Managing Partner, Higher Education Innovation Group [197]. EnergySolutions LLC and its principals K.W. Robuck, CEO; and Pierre Oneid, Executive Vice President for Strategic Initiatives and Partnerships, who signed an MOU for SMR development at the Intermountain Power Project site in Delta, Utah,

while simultaneously operating the Clive Disposal Facility which accepts nuclear waste in Tooele County, with Cameron Cowan, General Manager of the Intermountain Power Agency, as co-signatory [198]. Creekstone Energy and its principal Ray Conley, CEO, developing the nuclear-powered AI data center Gigasite in Delta, Utah, with funding led by Trident Ridge and participated in by Pelion Ventures, Utah's largest venture capital firm [199]. Rocky Mountain Power, operating subsidiary of PacifiCorp, which is 100% owned by Berkshire Hathaway Energy, a subsidiary of Berkshire Hathaway Inc. controlled by Warren Buffett, designated as the grid integration partner for Operation Gigawatt nuclear deployment [200][201]. The financial ecosystem that materially benefits from nuclear energy expansion includes Ensign Peak Advisors, the investment arm owned and operated by the Church of Jesus Christ of Latter-day Saints managing approximately \$61 billion in assets with confirmed equity positions in Vistra Corp; Northrop Grumman; Microsoft Corporation; Meta Platforms Inc.; Amazon.com Inc.; and Nvidia Corporation [202], whose AI infrastructure strategies are materially dependent on nuclear energy expansion; Joule Capital Partners [203]; Magnetar [203]; and Invictus Sovereign, founded by Wayne Aston [203]. The AI demand ecosystem driving the stated justification for nuclear deployment includes Sam Altman, CEO of OpenAI, who backs Oklo Inc. [204], which holds nuclear agreements with Meta Platforms [205]; and Wes Swenson, CEO of Novva, which operates a data center campus in West Jordan whose power demands are a stated rationale for Operation Gigawatt [206]. The lobbying and legal infrastructure advancing nuclear deployment without thermodynamic basin analysis includes Casey Hill and Lincoln Schultz of Lincoln Hill, lobbyists who testified before the Utah Legislature during HB249 hearings and who previously worked for EnergySolutions [183]; Amy Roma, Esq. of Hogan Lovells, nuclear energy counsel to Curio Solutions [197]. Jensen Huang / Nvidia publicly advocates for nuclear energy as AI's power source for their products and hold equity stakes in Utah-based portfolio companies whose Nvidia-powered computing infrastructure operates on the same grid Operation Gigawatt proposes to supply with nuclear reactors financed by Utah ratepayers. Nvidia's venture arm invested \$650 million in TerraPower in June 2025 [203]. TerraPower signed a Utah MOU in August 2025 [194]. INL Director John Wagner, who already signed the Utah MOU in April 2025 [134], announced an INL-Nvidia nuclear AI partnership in February 2026 [204b]. Microsoft and Nvidia announced a joint nuclear acceleration initiative at CERAWEEK four days ago, March 25, 2026 [205b]. Every GPU running every AI application in every Utah data center is manufactured by Nvidia. Nvidia's CEO has stated publicly that nuclear energy is the power source those data centers need [205b]. Utah ratepayers are being asked to finance the infrastructure that makes Nvidia's vision commercially viable.

2. **The advocacy ecosystem.** Unleash Utah, launched July 22, 2025 [208][209], which explicitly connected Operation Gigawatt nuclear deployment to energy abundance without thermodynamic basin analysis, whose founding legislative members include Ann Millner; Heidi Balderree, former community engagement director for Americans for Prosperity; Tyler Clancy; Karianne Lisonbee; Lisa Shepherd; and Trevor Lee, and whose private sector and civic founding members include A. Scott Anderson, Chairman of Zions Bank Advisory Board; Matt Waldrip, Managing Partner of Dauntless Capital and former Chief of Staff to Senator Mitt Romney; Joe Ross, Chairman of the Beehive Energy Alliance; Mike Bird, Trustee of Salt Lake Community College; Melissa Clark, Eagle Mountain City Councilwoman; Bill Rappleye, former Draper Chamber of Commerce President; Bryson Hinkins, Owner of Hinkinite Resources; Luke Searle, Wasatch County Council; Bryson Behm, Cache County Clerk; McKay Newell, former

Utah Republican Party Treasurer; Chase Acheson, Partner at the Acheson Firm; and 1741
 young conservative members Tyler Boyles, Zac Wilson, Mackey Smith, Dallin Bundy, 1742
 Grayson Massey, Ryan Smith, and Abe Vasquez, with Andrew Sandstrom as Execu- 1743
 tive Director, whose launch op-ed was published simultaneously in the Deseret News 1744
 [209]. The Libertas Institute, whose named authors Devin McCormick and Caden Ros- 1745
 enbaum published multiple Deseret News opinion pieces promoting Operation Giga- 1746
 watt nuclear deployment [210][211]. The Abundance Institute, whose named authors 1747
 Josh T. Smith and Chris Koopman published a Deseret News opinion piece in October 1748
 2024 arguing that nuclear energy could refill the Great Salt Lake, directly contradict- 1749
 ing the thermodynamic analysis in this paper [212]. The Utah Nuclear Energy Coal- 1750
 ition. The Beehive Energy Alliance, chaired by Joe Ross. The U.S. Nuclear Industry 1751
 Council, which hosted the Advanced Reactors Summit XII at the Hyatt Regency Salt 1752
 Lake City on February 19, 2025, during the HB249 legislative window, with Emy 1753
 Lesofski, Mason Baker, Marian Rice, and Laura Nelson appearing on the panel pro- 1754
 moting nuclear deployment while HB249 votes were still being counted [213]; Paul 1755
 Morris, MIDA Executive Director; Mike Ostermiller, Partner, Kyler Kohler Ostermil- 1756
 ler & Sorensen LLP; Mark Shepherd, Mayor of Clearfield City and MIDA; Gary Har- 1757
 ter, Executive Director, Utah Department of Veterans and Military Affairs and MIDA; 1758
 Gage Froerer, Weber County Commissioner and MIDA; Phil Lyman [X.com], Politico; 1759
 Luis, a Villarreal, Politico [221]; Mason Baker, CEO of Utah Associated Municipal 1760
 Power Systems; Dr. Marian Rice, professor at the University of Utah and associate 1761
 director of the Energy Futures Research Initiative; Aaron Starks, CEO and president 1762
 of 47G; Ryan Starks, Executive Director of EDCUtah; R6 Six County Association of 1763
 Governments; Emery County Board of Commissioners, chaired by Dennis Worwood, 1764
 Keven Jensen; Edward Castro Bennett, Green River City Manager; Nucleus Institute 1765
 and Kirk Cullimore; Jessica Elwell, COO of OxEon Energy; Jeremy Harrell, ClearPath 1766
 [213]; Chip Pardee, Terrestrial Energy [198]; Dan Stout, TVA [200]; Harlan Bowers, X- 1767
 Energy, Amazon nuclear power; USNIC; Brad Cahoon, environmental lawyer [214]. 1768

3. **The State of Utah.** Who committed public resources to the deployment of nuclear 1770
 reactors in a terminal basin without commissioning or requiring a thermodynamic 1771
 analysis of the basin's survival [56][54]. The State of Utah. Governor Spencer J. Cox, 1772
 who proposed Operation Gigawatt [56], signed partnership agreements with Holtec 1773
 and Hi Tech Solutions [54], TerraPower [194], Valar Atomics [217], NuCube Energy 1774
 [196], EnergySolutions [198], Curio Solutions [197], and the Idaho National Labora- 1775
 tory [222], committed over \$20 million in public resources to nuclear deployment 1776
 [56][54][137], appeared on Bloomberg TV promoting TerraPower deployment [218], 1777
 and stated we are in an arms race to justify nuclear acceleration [217][218], without 1778
 commissioning or requiring a thermodynamic analysis of the basin's survival. Lieu- 1779
 tenant Governor Deidre Henderson, who led a state-sponsored nuclear energy fact- 1780
 finding delegation to the United Kingdom in furtherance of Operation Gigawatt 1781
 [215][216]. Emy Faulkner Lesofski, Director of the Utah Office of Energy Develop- 1782
 ment, who personally signed eight nuclear deployment MOUs between April 2025 1783
 and January 2026 [54][194][196][198][222] and stated the INL agreement would make 1784
 Operation Gigawatt a reality [222]. Joel Ferry, Executive Director of the Utah Depart- 1785
 ment of Natural Resources, who stated at the Brigham City announcement that his 1786
 goal is to have nuclear power flowing within twelve years from Box Elder County 1787
 [219] and stated that reactors would face rigorous NEPA review while no thermody- 1788
 namic basin analysis was commissioned [55][219]. Jefferson Moss, Executive Director 1789
 of the Governor's Office of Economic Opportunity, who announced the Brigham City 1790
 project and administered GOED grants flowing to Box Elder County, Brigham City 1791

- Corporation, the Military Installation Development Authority, the Utah Inland Port Authority, the Utah Aerospace and Defense Association, Eagle Mountain City, and Brigham Young University, all of which are institutional participants in nuclear deployment, while simultaneously appearing as a named Operation Gigawatt participant [151][223]. Jaron Wallace, Utah Office of Energy Development, NuCube MOU operational point of contact and member of the Utah Advanced Nuclear and Energy Institute Advisory Board [132]. Tim Kowalchik, Emerging Technology Strategist, Utah Office of Energy Development [112][220], member of the Utah Advanced Nuclear and Energy Institute Advisory Board [132]. Dusty Monks, Director of Nuclear Programs, Utah Office of Energy Development [112], who presented nuclear deployment plans to the Utah Legislature [113][220]. Robert Carroll, Director of Communications, Office of the Governor, who authored the Operation Gigawatt press release [117]. With the goal of launching nuclear by July 4, 2026 without full authorization and proper channels.
4. **The Nuclear Energy Consortium** established by HB249 and tasked with recommending reactor sites across Utah without thermodynamic basin analysis, whose named members are Emy Lesofski; Scott D. Sandall; Colin Jack; Tim Davis, Executive Director of the Utah Department of Environmental Quality and former Director of the Utah Division of Drinking Water [225]; Joel Ferry; Jerry Fenn, member of the Utah Public Service Commission and former President of Qwest Communications Utah and Regional Vice President of CenturyLink [224]; Jefferson Moss; and Laura Nelson of the Idaho National Laboratory, a Department of Energy facility [136].
 5. **The Utah Advanced Nuclear and Energy Institute Advisory Board**, whose named members planned the state's technical nuclear deployment framework without thermodynamic basin analysis: Emy Lesofski [132]; Jaron Wallace [132]; Tim Kowalchik [132]; Douglas Hansen [132]; Laura Nelson, Idaho National Laboratory [132]; Piyush Sabharwall, Idaho National Laboratory [132]; Richard Boardman, Idaho National Laboratory [132]; Marian Rice, Professor and Associate Director of the Energy Futures Research Initiative at the University of Utah [132][213]; Supathorn Phongikaroon, holder of the EnergySolutions Foundation Presidential Endowed Chair in Nuclear Engineering and Director of the Utah Nuclear Engineering Program at the University of Utah [132][226]; Matt Memmott, co-founder and CEO of AlphaTech Research Corp. and Associate Professor of Chemical Engineering at Brigham Young University [132][227][228]; Andrew Fry, Associate Professor of Chemical Engineering at Brigham Young University [132][243]; Devin Rappleye [132]; Thomas Fronk [132]; Zac Humes [132]; Christopher Fox [132]; Brian Bean [132]; Ryan Hunter [132]; Michael Squires [132]; Neil Abercrombie [132]; Lori Braase, Idaho National Laboratory [132]; and Brian Garrett [132].
 6. **The Utah Energy Council**: established by HB249 and tasked with overseeing energy development zones and reactor siting across Utah without thermodynamic basin analysis, whose named members are Emy Lesofski, Director of the Utah Office of Energy Development; Ann Millner, Utah State Senator, District 5, R-Ogden, and co-sponsor of HB249, member of the Senate Transportation, Public Utilities, Energy, and Technology Committee; Carl Albrecht, Utah State Representative, District 70, R-Richfield, and chief sponsor of HB249, member of the House Public Utilities, Energy, and Technology Committee; Nate Walkingshaw, co-founder and CEO of Torus, a Utah-based energy storage company; and Curtis Wells, Chairman of the Governor's Community Impact Board and former Grand County Commissioner [132][136].

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7. **The Utah Energy Infrastructure Authority:** whose named members administered energy infrastructure tax credit decisions affecting nuclear-adjacent projects without thermodynamic basin analysis: Emy Lesofski, Director of the Utah Office of Energy Development; Lance Soffe, Director of Targeted Industries, Governor's Office of Economic Opportunity; Cameron Cuch, energy industry executive and Lecturer at Utah State University Uintah Basin; Jordan Stephenson; Clinton Painter; Wade Williams; Michelle McConkie, Executive Director of the Utah School and Institutional Trust Lands Administration; and Logan Wilde, former Utah State Representative and former Utah Commissioner of Agriculture and Food [132]. 1844
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8. **The Utah Energy Research Board:** whose named members administered the state's energy research agenda without thermodynamic basin analysis: Todd Combs, Deputy Laboratory Director for Science and Technology and Chief Research Officer, Idaho National Laboratory; Larry Howell, Professor of Mechanical Engineering and Associate Academic Vice President for Research and Graduate Studies, Brigham Young University; John O'Neil, formerly Executive Vice President and Chief Operating Officer, Utah State University; Charles Musgrave, Dean of the John and Marcia Price College of Engineering and Professor of Chemical Engineering and Materials Science, University of Utah; Jefferson Moss, Executive Director, Governor's Office of Economic Opportunity; Laren Huntsman, Managing Director, PacifiCorp; Perna Jain, business development professional, ACES Delta; Dennis Worewood, Emery County Commissioner; Steve Ellis; Mason Baker, CEO of Utah Associated Municipal Power Systems; and Emy Lesofski, Director, Utah Office of Energy Development [132][136]. 1854
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9. **The Utah Legislature.** The following members of the Utah House of Representatives voted in favor of HB249, the Nuclear Power Amendments, which established the Nuclear Energy Consortium, created energy development zones, and committed the state to nuclear deployment without requiring thermodynamic impact analysis of terminal basin effects [136][137]: Nelson T. Abbott; Cheryl K. Acton; Carl R. Albrecht, sponsor; Tiara Auxier; Melissa G. Ballard; Stewart E. Barlow; G. Bennion; Bridger Bolinder; Walt Brooks; Jefferson Burton; Katy Chevrier; Scott H. Chew; Kay J. Christofferson; Tyler Clancy; Paul Cutler; J. Dailey-Provost; A. Defay; R. Dominguez; Jim Dunnigan; Steve Eliason; Joseph Elison; Darlene Fiefia; J. Fitisemanu; Stephanie Gricius; Matthew Gwynn; Katy Hall; Jon Hawkins; S. Hayes; S. Hollins; Ken Ivory; Colin Jack; Jason Koford; Mike Kohler; Jason Kyle; Trevor Lee; Karianne Lisonbee; Anthony Loubet; Matt MacPherson; A. Cory Maloy; A. Matthews; V. Mauga; Tyler Miller; Logan Monson; Carol Spackman Moss; Jefferson Moss; Hoa Nguyen; Calvin Okerlund; Doug Owens; Nathan Peck; Michael Petersen; Karen Peterson; Thomas Peterson; Val L. Peterson; Candice Pierucci; Cory Roberts; A. Romero; Jeffrey Sawyer; Mike Schultz, House Speaker; D. Shallenberger; Troy Shelley; Lisa Shepherd; R.P. Shipp; Casey Snider; A. Stoddard; M.A. Strong; J. Thompson; Norman Thurston; Neil Walter; Raymond P. Ward; Christine Watkins; Stephen Whyte; and Ryan Wilcox. The following members of the Utah State Senate voted in favor of HB249 [136][137]: J. Stuart Adams, Senate President; Heidi Balderree; Brady Brammer; Lincoln Fillmore; Keith Grover; Wayne A. Harper; David P. Hinkins; Don L. Ipson; John D. Johnson; Michael K. McKell; Ann Millner, Senate sponsor; Calvin R. Musselman; Derrin R. Owens; Jennifer Plumb; Scott D. Sandall; Jerry W. Stevenson; Keven J. Stratton; Daniel W. Thatcher; Evan J. Vickers; Todd D. Weiler; Chris H. Wilson; and Ronald M. Winterton. 1868
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- 10. The municipal officials** who committed their jurisdictions to nuclear deployment without thermodynamic basin analysis: D.J. Bott, Mayor of Brigham City, who committed Brigham City as the host of the first full-scale nuclear energy ecosystem on alluvial valley fill three miles from the Wasatch Fault Brigham City segment [223][128]; Vicki Lyman, Commissioner, Millard County; Trevor Johnson, Commissioner and Chair, Millard County; Bill Wright, Commissioner, Millard County; Adam Richins, County Planner and Building Official, Millard County; Tyler Maffitt, Communications Manager, Eagle Mountain City; Scott Hughes, former Power Director, Hurricane City; Rick Hansen, Power Director, Washington City; and Evan Berrett, Economic Development Director, Eagle Mountain City.

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- 11. The regional governors** who signed the tri-state MOU of April 29, 2025 committing Utah, Idaho, and Wyoming to a coordinated nuclear deployment framework without environmental analysis of terminal basin impacts: Spencer J. Cox, Governor of Utah; Brad Little, Governor of Idaho; and Mark Gordon, Governor of Wyoming [229].

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- 12. The academic institutions** whose researchers promoted, planned, and enabled nuclear deployment without commissioning thermodynamic basin analysis: the University of Utah, through Michael Simpson, Professor of Materials Science and Engineering, who received a \$1.5 million DOE ARPA-E grant in 2022 to develop spent nuclear fuel recycling processes [230]; Marian Rice, Professor and Associate Director of the Energy Futures Research Initiative [213]; Supathorn Phongikaroon, holder of the EnergySolutions Foundation Presidential Endowed Chair in Nuclear Engineering and Director of the Utah Nuclear Engineering Program [226]; and Gary Sandquist, Professor Emeritus of Mechanical and Nuclear Engineering [231]; and Brigham Young University, through Matt Memmott, Associate Professor of Chemical Engineering and Co-founder and CEO of AlphaTech Research Corp, who received \$470,250 in GOED grants in 2024 while sitting on the Utah Advanced Nuclear and Energy Institute Advisory Board [132][151][227][228]; and Utah State University, through the Janet Quinney Lawson Institute for Land, Water and Air, whose Executive Director Brian Steed and Managing Director Anna McEntire launched the Gigawatt Fellowship (position 2026-9817) in partnership with the Utah Office of Energy Development, establishing a two-year joint fellowship dedicated to advancing Operation Gigawatt without requiring thermodynamic impact analysis of terminal basin effects [232].

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- 13. The Banks** The following financial institutions have materially advanced, financed, publicly committed to, or otherwise benefited from the expansion of nuclear energy infrastructure that includes the deployment of reactors in the Great Salt Lake basin, whether through direct investment in Utah nuclear thermodynamic waste deployment partners, structured financing of nuclear operators, participation in the COP28 declaration to triple global nuclear energy capacity by 2050, attendance at the New Nuclear Capital conference convened by the U.S. Nuclear Industry Council on December 2, 2025, or equity and debt positions in companies with active nuclear deployment agreements with the State of Utah, and are identified here for purposes of conflict of interest disclosure, financial ecosystem mapping, and the public record: Abu Dhabi Commercial Bank [233]; ABN AMRO [236]; Apollo Global Management [239]; Ares Management [233]; Asian Development Bank [237]; Bank of America [233]; Barclays [233]; BNP Paribas [233][236]; Brookfield Asset Management [233]; C5 Capital [234]; Citigroup [233]; Commonwealth Fusion Systems, financed by Goldman Sachs [240]; Crédit Agricole CIB [233][236]; Cross River Infrastructure Partners [234]; Deutsche Bank [234]; European Bank for Reconstruction and Development [237];

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European Investment Bank [237]; Export-Import Bank of the United States [248]; FTI Capital Advisors [234]; Goldman Sachs [233][240]; Guggenheim Securities LLC [233]; HD Hyundai [241]; Hoosier Energy [244]; HSBC [236]; Invictus Sovereign [249]; Joule Capital Partners [250]; JPMorgan Chase [242]; La Caisse [236]; Magnetar [247]; Morgan Stanley [233]; NVentures (Nvidia) [241]; Pelican Energy Partners [234]; Pelion Ventures [238]; Reliance Industries [246]; Rothschild and Co. [233]; Royal Bank of Canada [236]; Segra Capital Management [233]; SK Group [243]; Société Générale [233]; Tremblant Capital [234]; Trident Ridge [238]; U.S. Department of Agriculture Rural Utilities Service [244]; U.S. Department of Energy Loan Programs Office [150]; U.S. International Development Finance Corporation [248]; UBS [241]; Wolverine Power Cooperative [244]; Fidelity Investments [251]; World Bank Group [235][237]; and Zions Bank [252].

14. **The Nuclear Regulatory Commission**, which is charged by statute with ensuring adequate protection of public health and safety [123], has failed to discharge that mandate with respect to nuclear deployment in the Great Salt Lake watershed on three independent grounds. First, the Commission accepted the SMR-300 design application for docketed review without requiring any site-specific analysis of waste heat discharge in a terminal basin, seismic ground motion on alluvial valley fill at the Brigham City site, or cumulative water consumption impact over the operational and decay timeline of a reactor fleet deployed in the Great Salt Lake watershed [124]. Second, the Commission has exercised no licensing jurisdiction whatsoever over the Valar Atomics Ward 250 reactor — physically airlifted to Utah on February 15, 2026 via three U.S. Air Force C-17 Globemaster III aircraft under Operation Windlord from March Air Reserve Base, California to Hill Air Force Base, Utah, and subsequently delivered to the Utah San Rafael Energy Lab in Emery County for testing toward a July 4, 2026 criticality target — because that reactor operates under the Department of Energy's Reactor Pilot Program, established by Executive Order 14301, a pathway explicitly structured to bypass NRC licensing entirely, without a construction permit, operating license, site-specific environmental review, seismic or hydrological assessment, or public notice and comment period [186][187][189][255][256]; and because the Department of Energy secretly rewrote the safety orders governing that program in January 2026, eliminating the ALARA radiation standard without public notice or comment period, directly reducing the floor of radiological protection applicable to the reactor now operating in proximity to the Great Salt Lake watershed [253]. Third, the Commission's capacity to exercise independent regulatory authority over any future Utah deployment has been structurally compromised by Executive Order 14300 of May 23, 2025, which placed NRC rulemaking under White House Office of Management and Budget review, directed DOGE-coordinated reductions in force including reduction of the Advisory Committee on Reactor Safeguards to the statutory minimum, directed reconsideration of the linear no-threshold radiation model in contradiction of National Academy of Sciences findings, and explicitly directed streamlining of the public hearings process through which this petition proceeds [254]. The Commission is therefore not a neutral or fully functional arbiter of the public health questions raised herein.

15. **The United States Department of Energy**, has materially advanced nuclear deployment in the Great Salt Lake basin without conducting or requiring the environmental analysis that such deployment demands. The Department provided \$400 million in federal funding for the SMR-300 program through its Generation III+ SMR Pathway to Deployment Program [131][132] and an additional \$1.52 billion in loan guarantees

to Holtec through its Loan Programs Office [125]; its Office of Nuclear Energy published promotional materials supporting SMR-300 deployment [133]; its Idaho National Laboratory Director John C. Wagner personally signed a memorandum of understanding with the State of Utah on April 28, 2025 to collaborate on nuclear research and deployment [134]; Laura Nelson served simultaneously as a DOE national laboratory employee and a member of two Utah state nuclear deployment planning bodies; Jess Gehin, Associate Laboratory Director for Nuclear Science and Technology; Piyush Sabharwall; Richard Boardman; and Lori Braase were each named as INL participants in Utah nuclear deployment planning; and Theodore J. Garrish, confirmed as Assistant Secretary for Nuclear Energy in September 2025, brought over four decades of continuous nuclear industry promotion to the office he holds — including prior service as Assistant Secretary for Nuclear Energy under President Reagan, private sector counsel to a small modular reactor company, and Vice President of the Nuclear Energy Institute — representing an institutional commitment to SMR deployment that preceded and shaped the Department's engagement with Operation Gigawatt [258]. None of these activities were accompanied by an environmental analysis of deployment in an endorheic basin, a thermodynamic assessment of waste heat impacts on the Great Salt Lake, or a hydrological modeling of cumulative water consumption under multi-reactor fleet scenarios. That the Department simultaneously stated in writing that it is not part of Operation Gigawatt [135] while funding, staffing, and providing infrastructure support for its core components does not diminish its material role; it compounds the conflict of interest this petition places in the record.

16. **The United States Department of War**, which coordinated the military airlift of the Valar Atomics Ward 250 nuclear reactor to Hill Air Force Base on February 15, 2026 under Operation Windlord pursuant to Executive Order 14301 [186][187][189][255], thereby facilitating the physical deployment of a nuclear reactor into Utah without an NRC construction permit, operating license, site-specific environmental review, or public notice and comment period, has acted as an active instrument of nuclear deployment in proximity to the Great Salt Lake watershed. Secretary of War Pete Hegseth publicly announced the operation, stating that the Department of War was advancing President Trump's executive order on nuclear energy; and Under Secretary of War for Acquisition and Sustainment Michael Duffey, who accompanied the reactor aboard the C-17 flight, stated on the record that the operation demonstrated the ability to move nuclear power sources across state lines at speed and that the goal was to give innovators the opportunity to bring their technologies to bear without the burdens of bureaucracy [186][259]. The Department of War's participation in Operation Windlord was not accompanied by any independent environmental review of reactor deployment in the Utah San Rafael Energy Lab site, any assessment of radiological risk to the communities of Emery County, or any analysis of cumulative energy infrastructure impacts in the Colorado River watershed in which USREL is situated. The Department is accordingly identified as a responsible party whose actions have materially advanced nuclear deployment in Utah while bypassing every federal environmental review mechanism Congress created for that purpose.

17. **The United States Congress and Senate**, which authorized, funded, and legislatively accelerated nuclear deployment in the Great Salt Lake basin through the ADVANCE Act [141], the Generation III+ SMR Pathway to Deployment Program appropriations [131][132], and executive order enabling legislation [138][139][255], has done so without requiring site-specific thermodynamic analysis of reactor deployment in an endorheic basin. The members identified below have each played a material and

documented role in that acceleration. Michael S. Lee, R-Utah, Chairman of the Senate Energy and Natural Resources Committee, introduced the International Nuclear Energy Act and used his committee chairmanship to advance the regulatory and funding infrastructure enabling Operation Gigawatt [143]. John R. Curtis, R-Utah, introduced the Advanced Nuclear Reactor Prize Act, which was enacted as part of the ADVANCE Act; explicitly referenced Operation Gigawatt in Senate hearings; and was physically present at Hill Air Force Base on February 15, 2026, having flown aboard one of the three C-17 aircraft carrying the Ward 250 reactor to Utah, where he spoke at the press conference following the reactor's arrival [142][260]. Blake Moore, R-Utah, represents Utah's 1st Congressional District, which includes Brigham City and the proposed SMR-300 site. Celeste Maloy, R-Utah, represents Utah's 2nd Congressional District. Burgess Owens, R-Utah, represents Utah's 4th Congressional District. Moore, Maloy, and Owens each voted for every piece of legislation identified in this paragraph that accelerated nuclear deployment in Utah, without any of that legislation requiring site-specific thermodynamic analysis of waste heat in the Great Salt Lake basin, seismic assessment of the Wasatch Fault zone, or cumulative hydrological modeling of reactor fleet water consumption in a terminal watershed [138][139][141][255].

18. **Donald J. Trump**, 47th President of the United States, has undertaken a sustained, coordinated campaign of executive action to deploy nuclear reactors throughout the United States, including in the State of Utah, without requiring thermodynamic basin analysis, site-specific seismic assessment, or cumulative hydrological impact review. The full record of that campaign, as it bears on the Great Salt Lake basin, is as follows. On January 20, 2025, President Trump signed Executive Order 14154, Unleashing American Energy, rescinding the Council on Environmental Quality's NEPA implementing regulations, directing all federal agencies to eliminate regulatory burdens on energy development, and removing the social cost of carbon from federal permitting adjudications [261]. In January 2025, nuclear energy startup executives, including Valar Atomics founder Isaiah Taylor, attended a nuclear investor summit at Mar-a-Lago; those same executives were subsequently given advance access to draft executive order text and permitted to suggest edits, according to documents reviewed by ProPublica [263]. On February 5, 2025, Secretary of Energy Chris Wright issued his first Secretarial Order, titled "Unleashing the Golden Era of American Energy Dominance," directing the Department of Energy to prioritize commercial nuclear power deployment [264]. On May 23, 2025, President Trump simultaneously signed four nuclear executive orders: Executive Order 14299, Deploying Advanced Nuclear Reactor Technologies for National Security, authorizing DOE and DOD to approve and deploy advanced reactors at federal sites without NRC licensing and directing deployment of a nuclear reactor at a domestic military installation by September 30, 2028 [265]; Executive Order 14300, Ordering the Reform of the Nuclear Regulatory Commission, placing NRC rulemaking under White House OMB review, directing DOGE-coordinated reductions in force, and explicitly directing streamlining of the public hearings process through which this petition proceeds [254]; Executive Order 14301, Reforming Nuclear Reactor Testing at the Department of Energy, establishing the DOE Reactor Pilot Program outside the NRC licensing framework, directing elimination of NEPA environmental reviews for advanced reactor authorizations, and setting a July 4, 2026 criticality deadline that drives the deployment timeline at USREL in Emery County, Utah [255]; and Executive Order 14302, Reinvigorating the Nuclear Industrial Base, directing the DOE Loan Programs Office to prioritize nuclear deployment financing and directing construction starts on ten new large reactors by 2030 [262]. During the summer of 2025, DOGE operatives with no nuclear policy or legal

experience were deployed to the NRC, the agency's nuclear office lost approximately one-third of its staff, and the NRC's top attorney was replaced by an oil and gas lawyer from the DOGE team [263]. On January 28, 2026, Secretary Wright signed the DOE categorical exclusion for advanced nuclear reactors, published in the Federal Register on February 2, 2026 and made effective immediately, eliminating NEPA environmental review for the authorization, siting, construction, operation, and decommissioning of advanced nuclear reactors including the Valar Ward 250 reactor operating in Utah under this categorical exclusion [266]; twelve state attorneys general, led by California Attorney General Rob Bonta, filed formal opposition to this categorical exclusion before the March 4, 2026 comment deadline, arguing it is illegal, arbitrary, and capricious under NEPA and the Administrative Procedure Act [267]. Also in January 2026, the Department of Energy secretly rewrote nuclear safety orders eliminating the ALARA radiation standard without public notice or comment, as reported by NPR on January 28, 2026 [253]. On February 15, 2026, President Trump's nuclear agenda culminated in Operation Windlord, the military airlift of the Ward 250 reactor to Hill Air Force Base, Utah, at which Energy Secretary Wright publicly stated that the Department of Energy is in active talks with Utah and other states to host nuclear waste reprocessing or permanent disposal sites [186][187][189]. None of these actions was accompanied by a thermodynamic analysis of waste heat deployment in the Great Salt Lake basin, a seismic assessment of reactor siting on alluvial valley fill adjacent to the Wasatch Fault, or hydrological modeling of reactor fleet water consumption in a terminal watershed.

19. **Every regulatory body**, federal agency, state agency, legislative body, advisory board, advocacy coalition, lobbying firm, academic institution, financial institution, and named individual identified in this section required the public to prove what the proponents never analyzed. The burden of demonstrating that a nuclear reactor will not destroy a terminal basin belongs to the entity proposing to build it. That burden has not been met by any operator, any agency, any investor, or any official before a single reactor was authorized, funded, sited, or flown into Utah. This paper is the analysis that should have been performed before the first reactor arrived at Hill Air Force Base on February 15, 2026, before the project was advertised to the public as economic development, and before the categorical exclusion was signed on January 28, 2026 eliminating the environmental review that would have required it.

The absence of a regulation does not create the absence of a consequence [153][154][155][156][157]. The physics operates whether or not a regulation acknowledges it. One gigawatt of waste heat evaporates 11,318 acre-feet per year whether or not the NRC requires the applicant to calculate it. The Great Salt Lake does not recognize categorical exclusions. It recognizes acre-feet.

12. Report Summary

What is the projected health of the Great Salt Lake including elevation, toxic dust exposure, brine shrimp viability, and lake-effect precipitation at operational license end and at 100, 300, and 1,000 years post-shutdown, accounting for 8.97 gigawatts of continuous waste heat into a terminal basin with no thermal exit pathway, the 43-percent probability of a Wasatch Fault magnitude 6.75 seismic event within 50 years, and simultaneous cooling water loss and radiological release into the

primary water supply of 80 percent of Utah’s population and who is liable for the irreversible harm across the full decay timeline?

The deployment of the Holtec SMR-300 in the Great Salt Lake basin presents a threat profile that satisfies the criteria for an irreversible high-consequence systemic failure under established risk assessment methodology. The primary failure vector is thermodynamic: 13.65 GW of continuous waste heat discharged into an endorheic basin with no thermal exit pathway accelerates evaporation at a rate of 155,657 acre-feet per year, initiating a self-reinforcing cascade in which declining lake volume concentrates heat per unit area, which increases the evaporation rate, which further reduces volume, crossing irreversibility thresholds that no subsequent intervention can reverse [45][46][47][53][107][129][130]. Secondary failure vectors compound the primary: the 43-percent probability of a magnitude 6.75 or greater seismic event on the Wasatch Fault Brigham City segment within the first operational license period [72][74][75]; the projected exhaustion of 14 of 50 instrumentation and control materials before license end [86][87][88][89][90]; and simultaneous cooling water loss and radiological release into the primary water supply of 2.5 million people in the event of seismic breach [39][71][72]. The decay heat timeline of 24,110 years under ANS/ANS-5.1-2014 [53] exceeds the institutional control framework by three orders of magnitude. Ecological consequences are permanent at each projected timepoint: brine shrimp population collapse within the first decade of operation [25][26][28][29], cessation of lake-effect precipitation upon lake loss [108][109][112], and irreversible toxic dust exposure across 1,700 square miles of lakebed for the duration of the decay timeline [36][37][38]. The proximate cause of the energy demand driving this deployment is a thermodynamic specification omission in the 1964 IBM byte standardization, which excluded the Landauer minimum energy relationship $E = k_B T \ln(2)$ despite its publication at IBM in 1961 [12][17][52]. The correction of that omission through thermodynamic byte redesign, for which the materials science has existed since 2016 [14][15], would eliminate the artificial demand that this deployment proposes to satisfy at the cost of an irreplaceable terminal wetland. No analysis of these consequences has been performed by any operator, agency, legislative body, or named party prior to the publication of this paper [114][115][116][117]. [The Great Salt Lake or any connected system is not a suitable site for thermodynamic development or behaviors.](#)

Year	Toxic Dust	Brine Shrimp	Lake Effect Precipitation	Waste Heat
40	1,400 mi ² exposed; PM10 26× EPA; arsenic, mercury, lead, cadmium	Collapsed decade 1; 40-50% of global cyst supply gone	Reduced 20-30%; Snowbird 210-235 in	13.65 GW; 154,491 AF/yr; 6.18M AF cumulative
100	1,700 mi ² exposed; entire lakebed is dust source	Extinct 90 years; no recovery pathway	Reduced 50%; snowpack halved	11.4 MW fleet; 129 AF/yr; damage permanent
300	1,700 mi ² for 260 years; surface crust broken; dust increasing	Extinct 290 years; exists only in records	Lake-effect ceased; watershed structurally drier	9.1 MW fleet; 103 AF/yr; 6.56M AF cumulative
1000	1,700 mi ² for a millennium; heavy metals do not decay	Extinct 990 years; no recovery exists	No lake-effect 960 years; climate permanently altered	7.2 MW fleet; 81 AF/yr; Pu-239 at 95.9%

24,110	Geological playa; dust is permanent	Extinct longer than civilization has existed	No lake-effect years; lake is historical artifact	24,000 AF/yr; half of Pu-239 remains
Year	Earthquake Probability	Cooling Water Loss	Radiological Release	
40	36.2%; 0.3 events	6.18M AF; 74% of lake consumed	36.2% seismic breach at peak fission product inventory	
100	78.7%; 1.2 events	928K AF (2-reactor); compounding through precipitation feedback	78.7%; Cs-137 at 10% peak; still water-soluble	
300	98.0%; 2.9 events	943K AF (2-reactor); no restoration pathway	98.0%; Pu-239 and Am-241 dominant; mobilizable by seismic disruption	
1000	99.999%; 8.9 events on 1,000-yr-old infrastructure	959K AF (2-reactor); 14 of 50 I&C materials exhausted before first license ended	Near certain breach; Pu-239 nearly full; no institutional control precedent	
24,110	100% (10^{-118}); 207 events	3.14M AF (13-reactor); exceeds current lake volume	207 earthquakes; containment designed for 40 years enduring 24,110; contamination is statistical certainty	

The thermodynamic incompatibility analysis presented in this paper applies with equal force to any deployment of the Holtec SMR-300, including the Pioneer Units 1 and 2 proposed for the Palisades Energy site in Covert, Michigan, which received a \$1.52 billion DOE loan guarantee [150] and a \$400 million Generation III+ SMR Pathway to Deployment award [131][132] and whose dual-unit 600 MWe configuration operating at 92.5 percent capacity factor would generate 13.65 GW of cumulative thermal output [45][46][47] subject to the same decay heat timeline of 24,110 years calculated under ANS/ANS-5.1-2014 [53] regardless of siting location, establishing that the thermodynamic liability documented in this paper attaches to the SMR-300 design itself and not exclusively to its proposed deployment in the Great Salt Lake basin.

Proposal

Instead of installing a nuclear system in The Great Salt Lake Basin, order of operations is proposed. The technology driving the demand for nuclear is rooted in the design of the IBM Byte, which despite having Landauer linking information-energy in 1961 ignored the $E = kBT \ln(2)$ in its 1964 design allowing the market, not physics to dictate the design of the byte resulting in the energy crisis data center nuclear demand we have today.

The redesign of the byte is not theoretical and has been within our ability and power since 1950s. In addition, the materials and design to reach Landauer's limit which further pushes the byte into thermodynamic equilibrium reducing information-energy demand to Landauer's limit has existed since 2016. More nuclear and more power is not needed. A BIOS update which costs a few million and RAM update is all that is required to reduce the demand on our energy grid. Completely eliminating the avenue of

exploitation of taxpayer resources and funding.

■ More power is not the solution. Correcting the standard is. This paper proposes that Congress direct NIST to revise the computational byte standard to require thermodynamic compliance with $E = kBT \ln(2)$, eliminating the artificial demand that Operation Gigawatt proposes to serve with reactors in a basin that cannot survive them [115][116][117].

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