

SMALL MODULAR REACTORS:

Current Status, Open Issues in the U.S.A.

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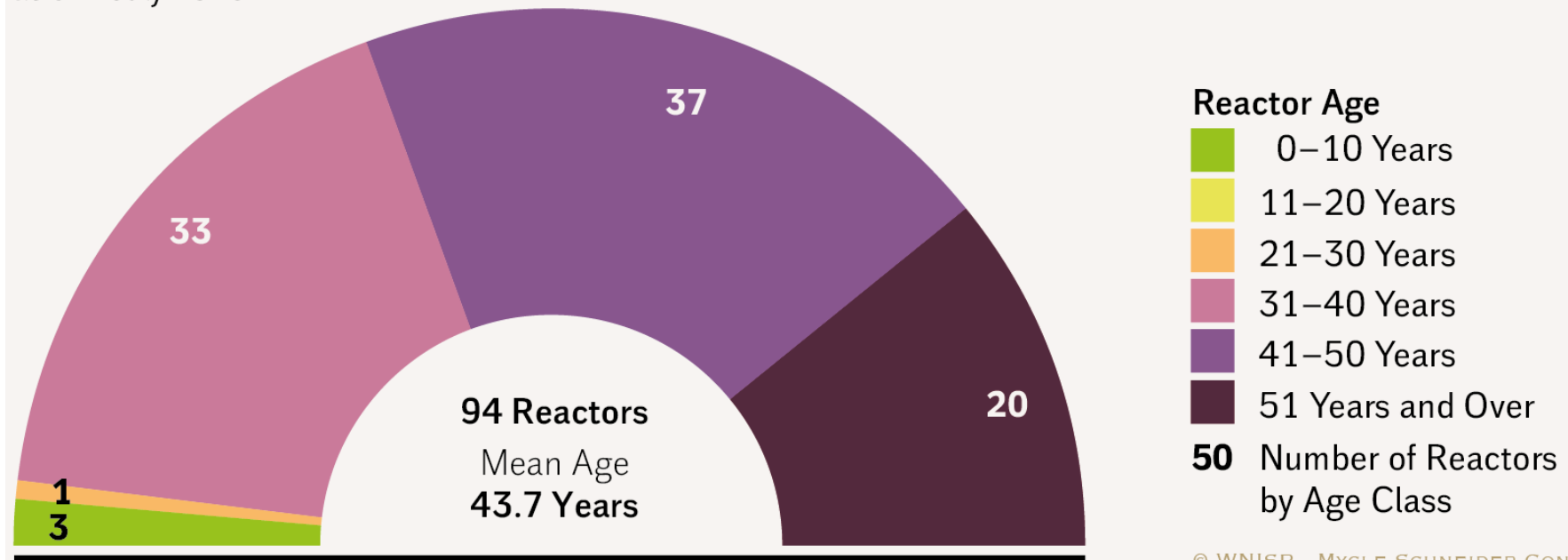
Overview: Nuclear Energy in the U.S.

U.S. reactors among oldest in the world's

- Average age 43+ years
- 2024: 17.8% of U.S. electricity vs. 24.6% from renewables
 - Down from 22.5% in 1995

Age of U.S. Nuclear Fleet

as of 1 July 2025



Nuclear Construction History

1952-1996: 247 reactors proposed

- 1970: President Nixon projected 1,000 reactors by 2000
- 1977: last reactor placed on order until 2008

131 reactors completed

- 47% cancellation rate
- 42 reactors retired (through 2024)

Ever-growing Costs and Delays

- Average construction times grew to 14+ years
- Costs averaged 307% of original estimates
 - Some exceeded 1000%

Nuclear “Renaissance”: 2005-2024

2005 Energy Policy Act

- Loan Guarantees: \$18.5 billion
- Production Tax Credits: \$6 billion
- Next-Gen Nuclear Plant: \$1.25 billion
- Licensing Delay Insurance: \$2 billion

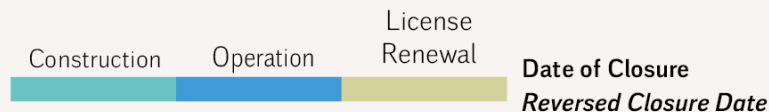
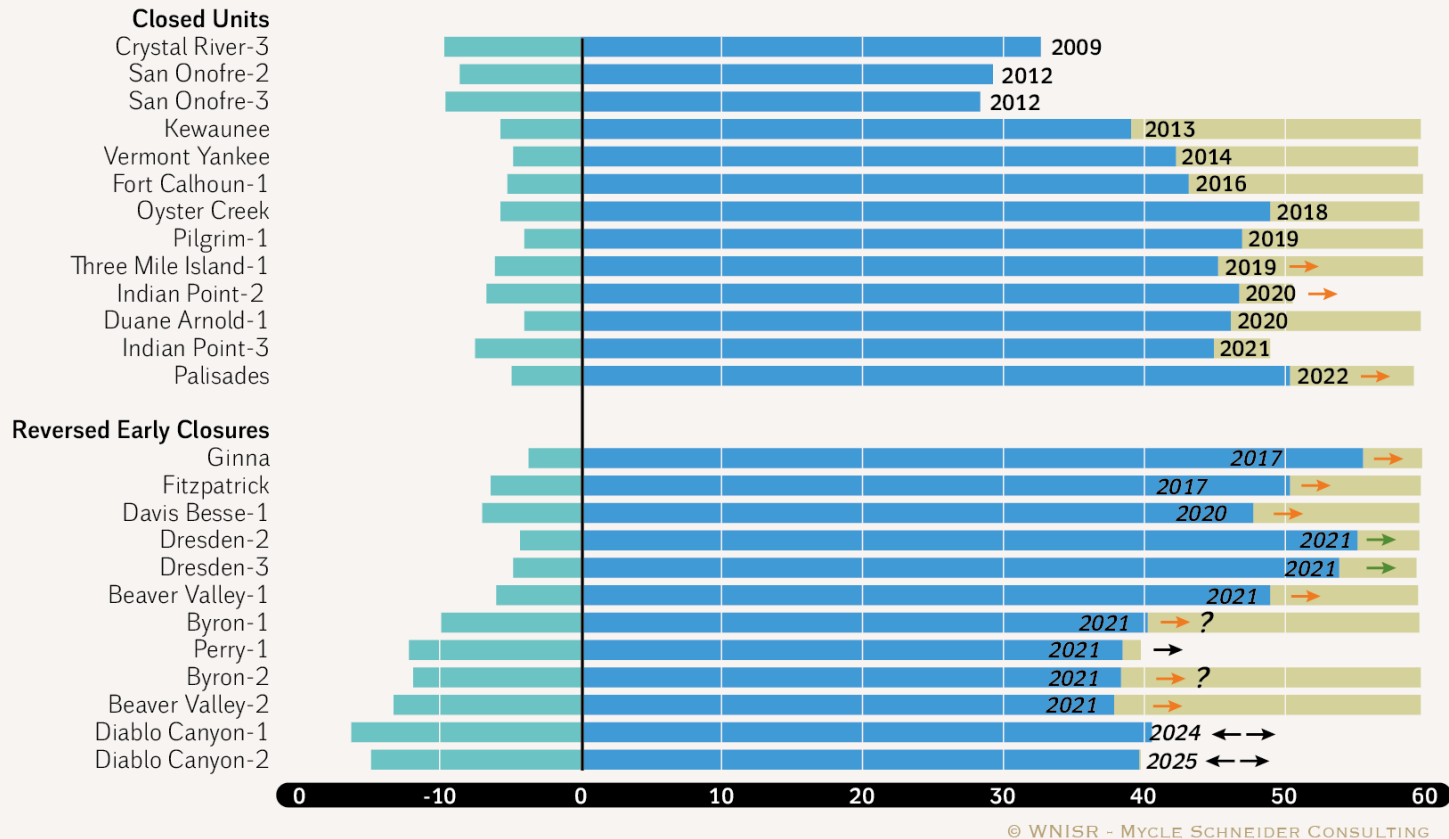
30 Reactors Proposed (2006-2008)

- 14 licenses issued
- 4 construction starts: Vogtle 3&4 (GA) and Summer 2&3 (SC)
 - 2017: Cost overruns bankrupt Westinghouse
- 2 reactors completed (2024)
 - Vogtle 3 & 4: 7 years late + **\$37 billion final cost**
 - **23.6% rate increases** for Georgia Power customers
- **93% cancellation rate**

Subsidies Halt Retirements

Timelines of 25 U.S. Reactors Subject to Early-Retirement 2009–2025

as of 1 July 2025



← Previous License Renewal Withdrawn
→ Initial License Renewal under Review
→ Subsequent License Renewal under Review
→ Expected Subsequent License Renewal

Federal Legislation (2018-2024)

2018: Nuclear Energy Innovation Capabilities Act (S.97)

- R&D infrastructure and subsidies

2019: Nuclear Energy Innovation & Modernization Act (S.512)

- NRC required to create “technology-inclusive, performance-based” licensing, reduce license fees

2021: Infrastructure Investment and Jobs Act (IIJA)

- ~\$10 billion for unprofitable reactors, “advanced reactor demonstrations,” & hydrogen production

2022: Inflation Reduction Act

- Subsidies and financing for new and old reactors, HA-LEU fuel, hydrogen (\$100+ billion)

2023: Nuclear Fuel Security Act

- Redirects \$2.7 billion of IIJA nuclear funds to HA-LEU and fuel production

2024: ADVANCE Act (S.870)

- Revises NRC mission and promotes nuclear exports, accelerated licensing, foreign ownership, etc.

Direct Federal Investments

Infrastructure Investment & Jobs Act: US\$10.5 B

- **Civil Nuclear Credit Program** US\$6 billion
 - US\$1.1 B for Diablo Canyon-1 & -2
 - US\$2.72 B reallocated for HALEU and Fuel Production
- **Advance Reactor Demonstrations** US\$3.11 billion
 - US\$2.5 billion allocated to X-Energy & Terrapower
- **Regional Hydrogen Hub Demonstrations** US\$2 billion

Inflation Reduction Act: up to US\$387 B

- **Existing Reactors**
 - Production Tax Credit @ US\$15/MWh up to US\$72.3 billion
 - Loan Guarantees up to US\$250 billion
- **New Reactors**
 - Production Tax Credit @ US\$15/MWh
 - Investment Tax Credit @ 30-50% of capital cost > US\$4 billion
 - Loan Guarantees up to US\$40 billion
- **HA-LEU Procurement + R&D** US\$700 million
- **Hydrogen Production Tax Credit** up to US\$20 billion (est.)

Status of Reactor Restarts

Limited Options: 3 reactors (~2.2 GW)

- No regulatory precedent for restoring licenses
- Retired reactors must be maintained to preserve the restart option

	Palisades-1	Three Mile Island-1	Duane Arnold-1
Reactor Type	PWR	PWR	BWR
Capacity	811 MW	829 MW	615 MW
Dates	Retired: 2022 Restart: 2026 (from 2025)	Retired: 2019 Restart: 2028	Retired: 2020 Restart: 2029
Status	NRC approvals issued Fuel loaded	Applications under review	Applications submitted
Cost	\$1.52 billion (2024)	\$1.6 billion (2025)	\$1.6 billion (2025)
Finance Details	Loan Guarantee: US\$1.52 B PPA Subsidy: US\$1.3 B Tax Credit: ≥US\$100 M/yr.	Loan Guarantee: US\$1.0 B Tax Credit: ≥ US\$200 M/yr.	unknown
Customer	Rural Electric Coops (Michigan and Indiana)	Microsoft: ~\$US98/MWh	Alphabet: PPA price unknown

Status of New Reactor Designs

No SMR or “Advanced” reactors fully approved

- First demonstration projects are nearing construction starts
- Operating license applications to be submitted in several years

Corp. & Design	NuScale SMR 600/460	Terrapower Natrium	X-Energy Xe-100	GE-Hitachi BWRX-300	Kairos Hermes
Reactor Type	SMR	non-LWR	SMR/n-LWR	SMR	SMR/n-LWR
	Light-Water	Liquid Sodium	High-Temp Gas	Light-Water	Molten Salt
Power Capacity	(a) 50 MW (b) 77 MW	345 MW	4 x 80 MW	300 MW	2 x 75 MW
Design Status	(a) partly approved (2020, design abandoned) (b) Standard Design Approval (2025)	Construction permit review completed (Dec. 2025)	Construction permit under review • 27% complete (Dec. 2025)	Construction permit under review 3% complete (Dec. 2025) <i>Canada: construction permits issued (2025)</i>	Non-power prototypes starting construction (2024)
Constr Start	No US proposals (Romania)	TBA (2026/2027)	2028 (est.)	unknown	unknown

Status of New Reactor Licensing

NRC Pre-application Engagement

- 23 reactor designs + 2 construction permits + 2 early site permits

Early Site Permit Applications

- 1 under review
- 1 ESP renewal under review
- 1 active ESP connected to construction permit application

Design Certification Applications

- 0 under review
- 1 SMR design certification (*partially approved* – NuScale SMR 600)
- 1 SMR standard design approval (NuScale SMR 460)

Construction Permit Applications

- 3 under review
- 3 permits issued (non-power prototypes)

Combined Operating License Applications

- 4 pending (4-unit NPP project)

Nuclear Construction Costs Rising

Cost projections for small modular reactors, by year



Source: IEEFA 2024

Use Case: Nuclear for AI & Crypto

Power Demand/Generation

- AI Data Centers: 100 - 650 MW (1,000+ MW projected)
 - Growth Projection: 2030 = 50 GW 2035 = 81 GW
- Nuclear Reactors: 300 - 1,100 MW

Construction Times (incl. planning & permitting)

- AI Data Centers: 3-4 years
- Nuclear Reactors: 12-17 years

Water Consumption

- AI Data Centers:
 - Average: 550,000 gallons/day evap: 440,000 gpd
 - Large (300 MW): 3.7 million gpd evap: 2.7 million gpd
- Nuclear Reactor (900-1,200 MW):
 - Once-Through: 1 to 1.5 billion gpd evap: 4 to 10 million gpd
 - Cooling Tower: 80 to 108 million gpd evap: 60 to 80 million

Nuclear Power and Data Centers

Several Deals – Few Commitments, Little Investment, Major Contingencies

	Microsoft	Amazon	Amazon	Alphabet	Nvidia
Nuclear Corp.	Constellation	X-Energy	Talen Energy	1. Kairos 2. Elementl	Terrapower
Type	Existing	New (SMRs)	Existing	New (SMRs)	New (SFRs)
Investment	\$0	<US\$500 million	US\$0	US\$0	<US\$650 million
Reactors (Power)	June 2023: “Virtual Hourly” PPA Sept. 2024: TMI Restart (820 MW)	Oct. 2024: 4 SMRs (320 MW)	June 2025: PPA with Susquehanna NPP for up to 1,920 MW for data centers	1. Oct. 2024: 500 MW (7 SMRs) 2. May 2025: 3 “projects” (~1,800 MW)	June 2025: Equity investment in Natrium project 345 MW reactor + 150 MW storage
Dates	(a): unknown (b): 2028(?)	unknown	Ramp: 2024-2032 Expire: 2042 (extend option)	unknown	2027(?)

Trump Policies: Executive Orders

14302: Reinvigorating the Nuclear Industrial Base

14301: Reforming Nuclear Reactor Testing at the Department of Energy

14300: Ordering the Reform of the NRC

14299: Deploying Advanced Nuclear Reactor Technologies for National Security

Other Presidential Actions

DOE Authority at NRC

- DOGE Staffer at DOE assigned to NRC
 - Told NRC Chair: ***“DOE, DOD would approve stuff, and then NRC would be expected to just kind of rubber-stamp it.”***

NRC Commission Changes

- June 14: Fired Commissioner Christopher Hanson (2-1)
- June 16: Reappointed David Wright as Chair (3-1)
- July 29: Commissioner Annie Caputo resigned (2-1)
- July 31: Appointment of former NRR Director Ho Nieh (3-1)

Investment Deals

Japan Investment Deal

- US\$100 billion investment in reactor projects
 - US\$80 billion for Westinghouse AP1000 deployments
 - Role for GE-Hitachi SMRs and Japan contractors/suppliers

Westinghouse Profit-Sharing, IPO, & Equity

- US receives 20% of profits after first US\$17.5 billion
- Westinghouse goes public at \$30 B – US receives 8.3% equity share

Export Deals

- Saudi Arabia Nuclear Cooperation Agreement
- AP1000s: Poland, Netherlands, Slovenia, Bulgaria
- SMRs: Romania (NuScale), United Kingdom

Ukraine: Zaporizhzhia NPP Co-ownership Proposal

Executive Orders

What is an EO?

- Article II Constitutional power:
 - “take care that the laws be faithfully executed.”
- Presidential directive to federal agencies:
 - How to interpret laws/statutes
 - How to prioritize and undertake their duties
- EOs *cannot*:
 - Supersede or contradict laws
 - Exercise powers not granted to the Executive branch

14299: Deploying ANR Technologies for National Security

Aligns nuclear power and AI as national security priorities

- DOD: begin using nuclear reactors to power bases and operations by 2028
- DOE: designate AI data centers and power supplies as **“critical defense facilities”**
- DOE create a HALEU fuel bank for reactors that power DOE and AI facilities
- DOE directed to **utilize “all available legal authorities”** to develop nuclear reactors and fuel infrastructure
- Nuclear Exports: State Dept. to pursue exports and 20 new cooperation agreements

14302: Reinvigorating the Nuclear Industrial Base

- **Finance “Restarts, Completion, Upgrades, or Construction”**
 - Target of 5 GW of upgrade capacity
 - Target of 10 new large reactors under construction by 2030
- Develop a plan to expand uranium conversion and enrichment capacity
- Program for transporting HALEU and reactors with HALEU
- Directs DOE to report on options for fuel chain infrastructure:
 - Consolidated Interim Storage
 - Reprocessing
 - Milling, Conversion, Enrichment, Fuel Fabrication
- Recommendations for disposal of reprocessing wastes

14300: Ordering the Reform of the NRC

Policy: 400 GW of nuclear power by 2050

Directs NRC to Subjugate Safety to Promotion

- “NRC’s mission shall include facilitating nuclear power while ensuring reactor safety”
- “In consultation with NRC’s DOGE Team ... reorganize the NRC to promote the expeditious processing of license applications and the adoption of innovative technology”
- “... undertake reductions in force in conjunction with this reorganization, though certain functions may increase in size ... including those devoted to new reactor licensing.”
- “The personnel and functions of the ACRS shall be reduced to the minimum necessary... focus on issues that are truly novel or noteworthy.”

14300: Ordering the Reform of the NRC

Regulatory Changes

- **9 months:** “review and wholesale revision of its regulations and guidance documents”
- **18 months:** “issue final rules and guidance to conclude this revision”
- **Licensing Deadlines:**
 - **New Reactors:** 18 months
 - **Relicensing:** 12 months
- **Radiation:** “NRC shall reconsider reliance on the linear no-threshold (LNT) model for radiation exposure and the ALARA standard”
 - *“Those models are flawed ...”*
- “Establish an expedited pathway to approve reactor designs that the DOD or the DOE have tested”

14300: Ordering the Reform of the NRC

Regulatory Changes -- Inspections and Enforcement:

- “Revise the Reactor Oversight Process and reactor security rules and requirements to reduce unnecessary burdens ...”
- “... ensure that reactor safety assessments focus on credible, realistic risks.”
- “Streamline the public hearings process.”

14301: Reforming Nuclear Reactor Testing at DOE

Sets the Stage for DOE Takeover of New Reactor Regulation

- “The Secretary shall create a **pilot program for reactor construction and operation outside the National Laboratories**, pursuant to the AEA’s authorization of reactors under the Department’s sufficient control... “
- “... approve at least three reactors pursuant to this pilot program with the goal of achieving criticality in each of the three reactors by July 4, 2026.”
- “... use all available authorities to **eliminate or expedite the Department’s environmental reviews** for authorizations, permits, approvals, leases, and any other activity requested by an applicant or potential applicant.

Post Exec. Order Nuclear Projects

Fermi America, Inc.: Donald J. Trump NPP

- Founder: former Texas Gov. and Energy Secretary Rick Perry
- Location: Pantex nuclear weapons plant
- Scope: 11 GW power and AI data center development
- Generation: 4 Westinghouse AP1000 reactors + gas plants + SMRs
 - Status: COL application for AP1000's partially submitted

Project Janus:

- Dept. of Defense program – microreactors to power military bases
- November 2025: six bases identified as prime candidates

Deep Fission:

- December 2025: groundbreaking in Kansas, no NRC permit
- 10 MW reactors in mile-deep boreholes and buried in place w/ fuel

Energy Reactor Pilot Program

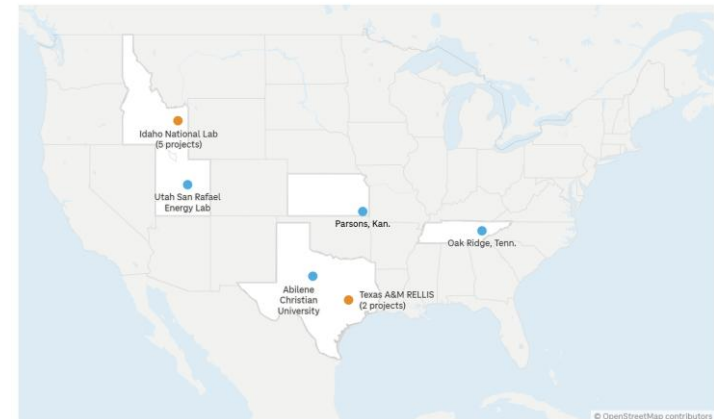
Established under Exec. Order 14301

- DOE selected 11 “advanced” reactor designs
 - Aalo, Antares, Atomic Alchemy, Deep Fission, Last Energy, Oklo (two projects), Natura, Radiant, Terrestrial Energy, Valar Atomics
- Goal: 3 reactor criticalities by 4 July 2026

NPR: DOE has “... secretly rewritten nuclear safety rules”

- 750+ pages of safety, security, environmental rules eliminated
- 2 Feb. Notice: environmental reviews to be categorically excluded

Sites across the country will host new reactor designs



Credit: Compiled by Geoff Brumfiel/NPR, Map by Brent Jones/NPR

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