Nuclear Energy: State of Advanced Reactors

Rhode Island House: State Government and Elections Committee

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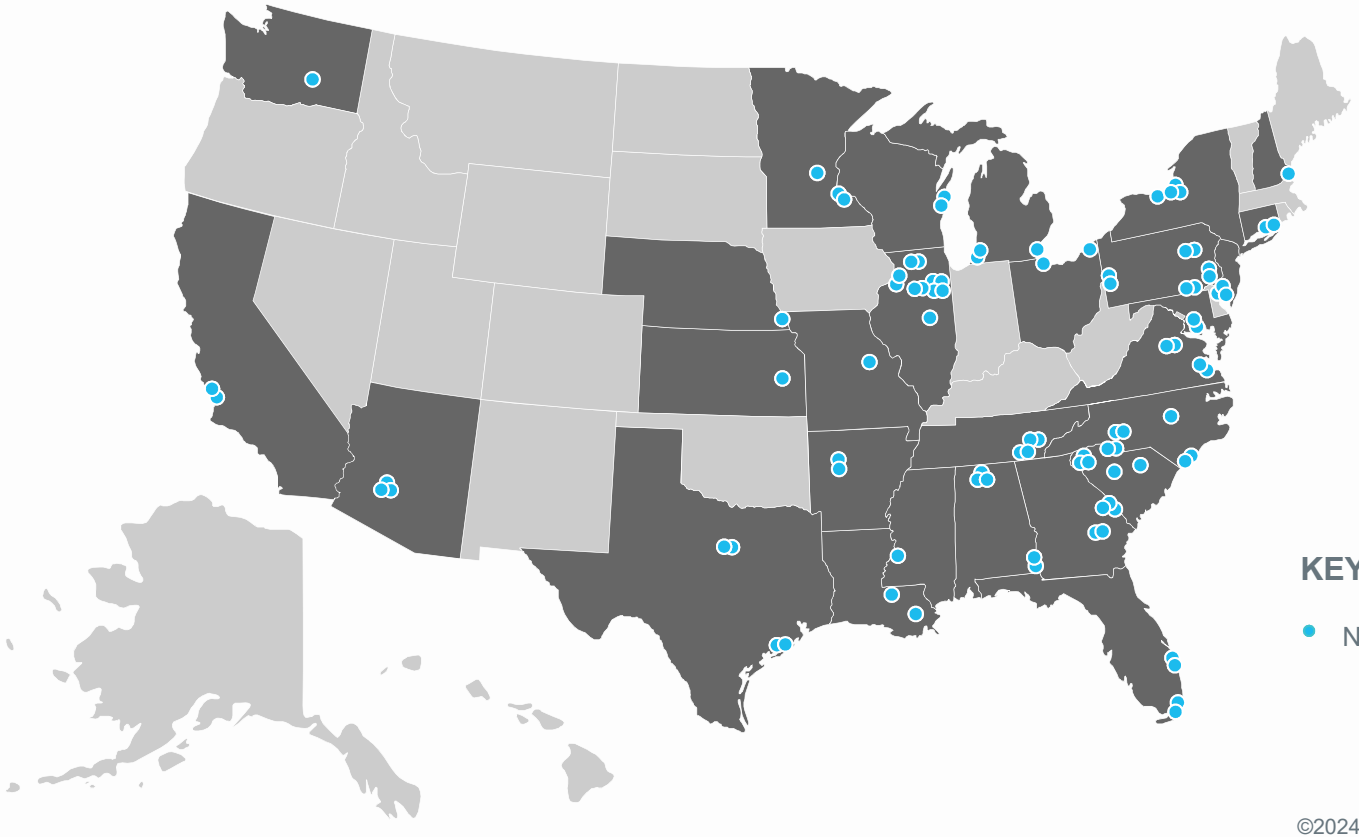
NUCLEAR ENERGY INSTITUTE

Nuclear Provided Majority of Emissions-Free Electricity



Nuclear generated 19% of electricity in the U.S.

From 93 reactors at 53 plant sites across the country

KEY

- Nuclear power reactor

Updated: May 2023

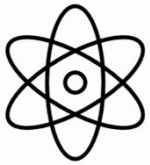
System Benefits of Advanced Reactors

Long term price stability	• Low fuel and operating costs
Reliable dispatchable generation	• 24/7, 365 days per year, years between refueling (Capacity factors >92%)
Efficient use of transmission	• Land utilization <0.1 acre/TWh (Wind =1,125 acre/TWh; Solar 144 acre/TWh)
Environmentally friendly	• Zero-carbon emissions, one of lowest total carbon footprints • Many SMRs are being designed with ability for dry air cooling
Integration with renewables and storage	• Paired with heat storage and able to quickly change power
Black-start and operate independent from the grid	• Resilience for mission critical activities • Protect against natural phenomena, cyber threats and EMP

Source: SMR Start, *SMRs in Integrated Resource Planning*

Lowest System Cost Achieved by Enabling Large Scale New Nuclear Deployment

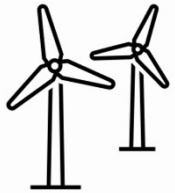
Lowest Cost System



Nuclear is 43% of generation (>300 GW of new nuclear)

Wind and solar are 50%

Energy System with Nuclear Constrained



Wind and Solar are 77% of generation

Nuclear is 13% (>60 GW of new nuclear)

Increased cost to customers of $449 Billion

Both scenarios are successful in reducing electricity grid GHG emissions by over 95% by 2050 and reducing the economy-wide GHG emissions by over 60%

Source: Vibrant Clean Energy: https://www.vibrantcleanenergy.com/media/reports/

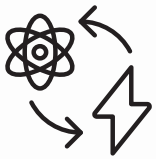
Recent Survey of NEI's U.S. Utilities

Nuclear power's potential role in meeting their company's decarbonization goals:

SLR

>90% of fleet expects to operate to at least **80 years**

GW



100 GW of new nuclear opportunity by **2050s**

SMRs

Translates to roughly **300 SMR-scale plants**

NEI utility member companies produce nearly half of all US electricity.

Growth Rates Increasing Almost Everywhere

From 2022 to 2023, the 5-year national forecast for peak demand shot up by about 50% – from 0.63% annual growth to 0.93%.

Annual growth rates are measured using the Compound Annual Growth Rate (CAGR). The CAGR represents the rate at which the initial load forecast or current load needs to grow annually to match the forecasted load in the final year assuming an annually compounded growth rate.

CAGRs can be useful to compare forecasted load growth of different utilities regardless of the size of the utility.

The only region where the CAGR decreased in 2023 is MISO. However, as discussed in the MISO profile, expedited new load projects are flooding MISO's planning process and should drive an increase in future load forecasts.

NOTE | The "Southwest" region includes some utilities that might be characterized as central western.

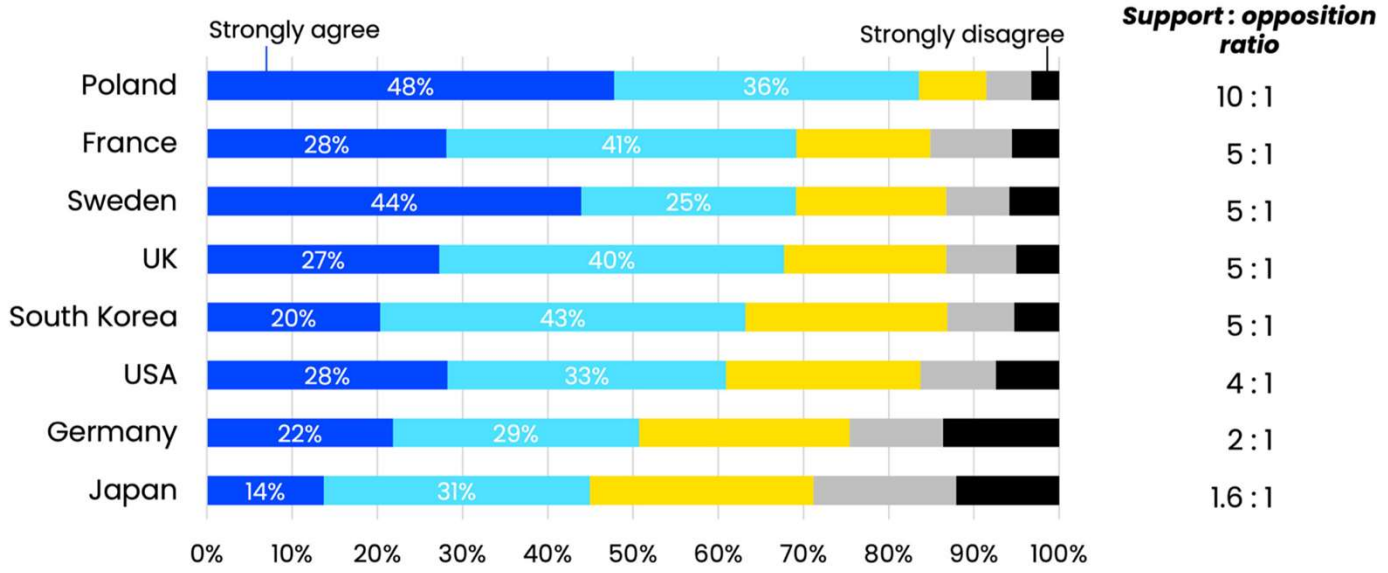
GridStrategies

Source: https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf

Strong Public Support for Nuclear Energy

Figure 1: Support significantly outnumbers opposition across the globe

"I support the use of the latest nuclear energy technologies to generate electricity, alongside other energy sources." (5-point scale from strongly disagree to strongly agree)



Question: To what extent do you agree or disagree with the following statement: "I support the use of the latest nuclear energy technologies to generate electricity, alongside other energy sources." Response options: Strongly agree / Somewhat agree / Neutral / Somewhat disagree / Strongly disagree
Sample: Nationally representative n=1,007 Poland, 1,589 UK, 1,515 South Korea, 1,046 France, 1,013 Sweden, 4,250 USA, 1,586 Germany, 1,534 Japan

Source: Potential Energy, 2023, https://potentialenergycoalition.org/wp-content/uploads/NewNuclear_Report_May2023.pdf

Voices for Nuclear

"The United States views nuclear energy as a pivotal technology in the global effort to lower emissions, expand economic opportunity, and ultimately combat climate change. We have been supporting the development of SMRs for decades."

Jennifer Granholm
Secretary
U.S. Department of Energy
November 4, 2021

"For the United States to maintain a geopolitical advantage and strong national defense, the ability to provide affordable and reliable energy to consumers, and meet climate goals of the 21st century, it is essential to advance the nuclear industry."

Rep. Jeff Duncan
(R-S.C.)
November 11, 2022

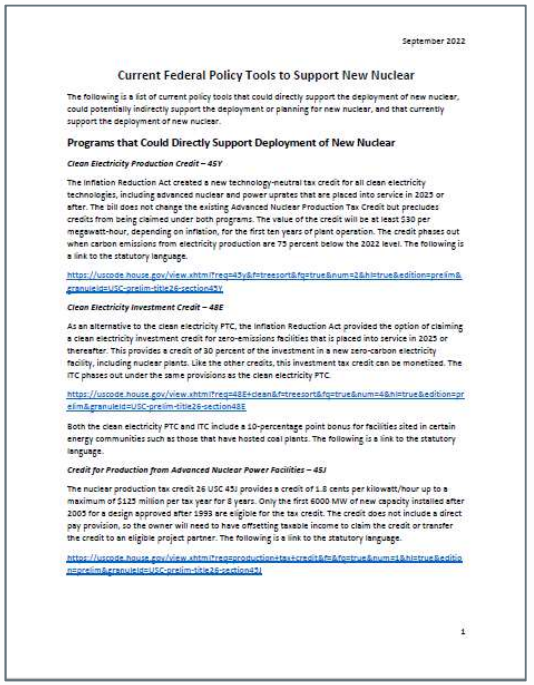
"If we're going to continue to move and talk about decarbonization and not going to move forward with nuclear we're [going to have] serious problems."

Sen. Joe Manchin
(D-W.V.)
June 4, 2020

Scan to see what everyone is saying about America's largest clean energy source.

Strong Federal Support for Advanced Reactors

- DOE funding 12 different designs, >$5B over 7 years
- Infrastructure Bill
  - $2.5B funding for two demonstration projects
- Inflation Reduction Act
  - PTC: At least $30/MWh for 10 years
  - ITC: 30% of investment
  - Both can be monetized, include 10% bonus for siting in certain energy communities
  - Loan Guarantees – up to $40B in expanded authority
  - HALEU Fuel - $700M
- CHIPS Act
  - Financial assistance to States, Tribes, local governments and Universities



September 2022

Current Federal Policy Tools to Support New Nuclear

The following is a list of current policy tools that could directly support the deployment of new nuclear, could potentially indirectly support the deployment or planning for new nuclear, and that currently support the deployment of new nuclear.

Programs that Could Directly Support Deployment of New Nuclear

Clean Electricity Production Credit – 45Y

The Inflation Reduction Act created a new technology-neutral tax credit for all clean electricity technologies, including advanced nuclear and power uprates that are placed into service in 2025 or after. The bill does not change the existing Advanced Nuclear Production Tax Credit but precludes credits from being claimed under both programs. The value of the credit will be at least $30 per megawatt-hour, depending on inflation, for the first ten years of plant operation. The credit phases out when carbon emissions from electricity production are 75 percent below the 2022 level. The following is a link to the statutory language.

https://uscode.house.gov/view.xhtml?req=45y&f=treesort&fq=true&num=2&hl=true&edition=prelim&granuleId=USC-prelim-title26-section45Y

Clean Electricity Investment Credit – 48E

As an alternative to the clean electricity PTC, the Inflation Reduction Act provided the option of claiming a clean electricity investment credit for zero-emissions facilities that is placed into service in 2025 or thereafter. This provides a credit of 30 percent of the investment in a new zero-carbon electricity facility, including nuclear plants. Like the other credits, this investment tax credit can be monetized. The ITC phases out under the same provisions as the clean electricity PTC.

https://uscode.house.gov/view.xhtml?req=48E+clean&f=treesort&fq=true&num=4&hl=true&edition=prelim&granuleId=USC-prelim-title26-section48E

Both the clean electricity PTC and ITC include a 10-percentage point bonus for facilities sited in certain energy communities such as those that have hosted coal plants. The following is a link to the statutory language.

Credit for Production from Advanced Nuclear Power Facilities – 45J

The nuclear production tax credit 26 USC 45J provides a credit of 1.8 cents per kilowatt/hour up to a maximum of $125 million per tax year for 8 years. Only the first 6000 MW of new capacity installed after 2005 for a design approved after 1993 are eligible for the tax credit. The credit does not include a direct pay provision, so the owner will need to have offsetting taxable income to claim the credit or transfer the credit to an eligible project partner. The following is a link to the statutory language.

https://uscode.house.gov/view.xhtml?req=productions+tax+credit&f=treesort&fq=true&num=1&hl=true&edition=prelim&granuleId=USC-prelim-title26-section45J

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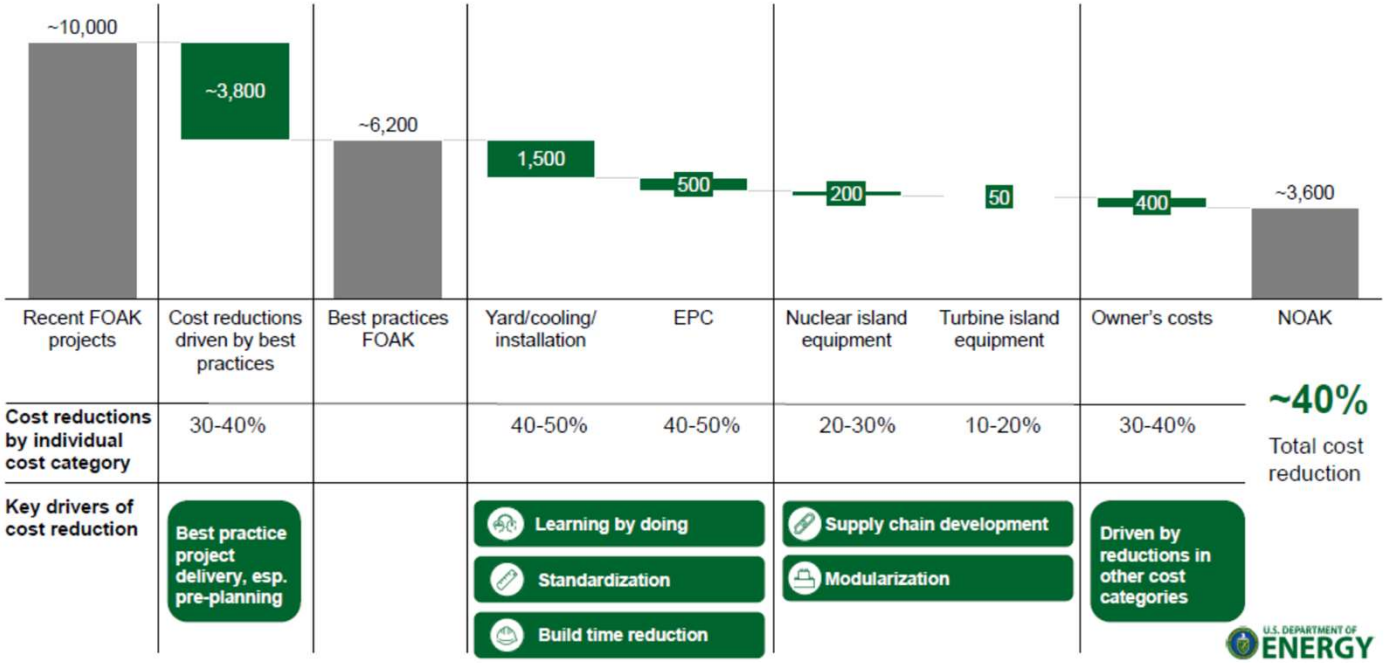
Current Federal Policies: https://www.nei.org/CorporateSite/media/filefolder/advantages/Current-Policy-Tools-to-Support-New-Nuclear.pdf

Getting to Cost Competitive

Why will new projects be different than recent over-budget builds?

Potential advanced nuclear FOAK to NOAK overnight capital costs, $/kW



Advance Reactor Roadmap

01 First Mover Success	1. Government policies are equitable for nuclear and fully funded 2. Policies support industry's implementation of project best practices 3. Building education and comfort in the investment community
02 Fast Followers	4. Decisions that support industry's achieving de-risking milestones 5. Actions that support industry's pursuit of standardization of fleets
03 Regulatory Efficiency	6. Reform and modernize the regulators 7. Congress and Parliament to enable regulatory reform
04 Siting Availability	8. Rapid decision making to enable designs that are capable of being deployed in a wide range of site conditions 9. Industry will need to develop flexible designs that are both standardized and adaptable
05 Public Engagement	10. Governments enable early engagement of public in processes 11. Enable communities to more effectively engage the industry on advanced reactors 12. Collaborative engagement of Indigenous peoples
06 Supply Chain Ramp-up	13. Congress and DOE establish programs to assure access to fuel 14. Government support for prototyping novel components early in design
07 Workforce Development	15. Government programs support industry's action to establishes programs to recruit, train and retain workers

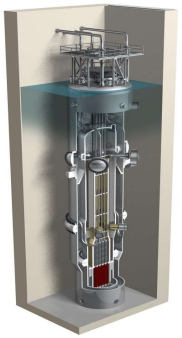
Advanced Reactor Developer Members

Expanding Versatility through Advanced Technology

Micro Reactors (< 20MW)

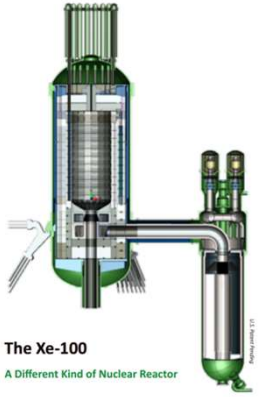
Oklo (shown)
Approximately a dozen in development

LWR SMRs <300MW



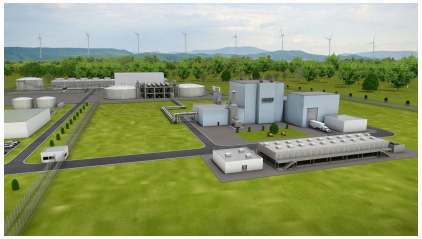
NuScale (shown)
GEH X-300
Holtec SMR-160

High Temp Gas Reactors



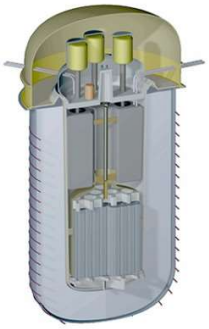
X-energy (shown)
Several in development

Liquid Metal Reactors



TerraPower Natrium (shown)
Several in development

Molten Salt Reactors



Terrestrial (shown)
Several in development

Non-Water Cooled
Most <300MW, some as large as 1,000 MW

NIA Technology Primer: https://nuclearinnovationalliance.org/sites/default/files/2022-07/ANRT-APrimer-July2022.pdf

Expanded Versatility Meets a Diverse Set of Market Needs

Spectrum of Sizes and Options

Micro (Few MW)

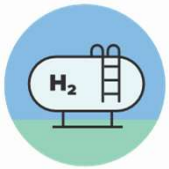
Mini (10s of MW)

Small (100s of MW)

Large (1,000+ MW)

Variety of Outputs

Electricity



H_2 Hydrogen

Process Heat

Multitude of Uses

Homes

Vehicles

Businesses

Aviation

Rail

Shipping

Concrete

Steel

Factories

Water

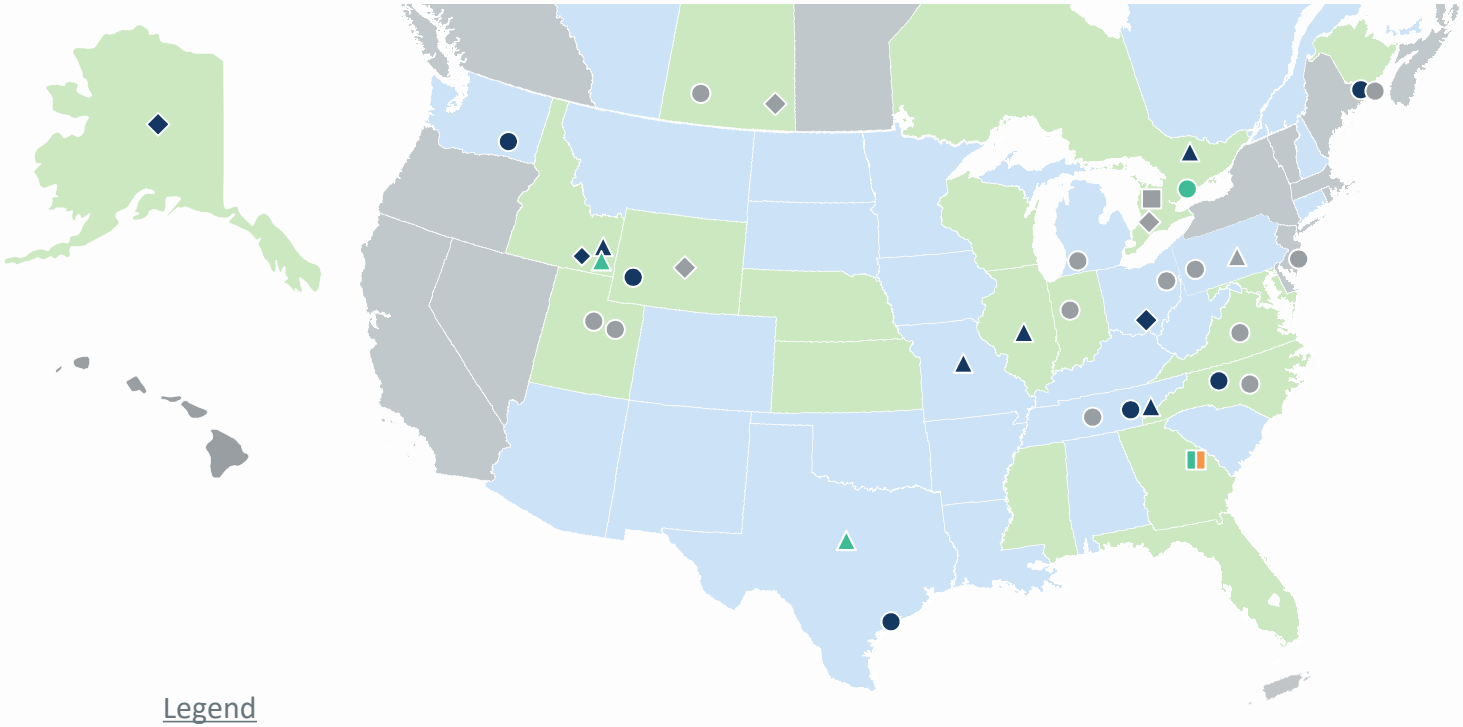
Space

Watch the video: https://www.youtube.com/watch?v=7zN_YLg-roo

Advanced Nuclear Deployment Plans

State support and projects that may be in operation by early 2030s

Updated 12/19/2023
Source: NEI Website



Legend

State Actions – Substantive Incentives
State Actions – Supportive and Exploring
Considered project
Planned project
Under construction
Operating
Large (1,000 MWe)
Small (<300 MWe)
Micro-reactor (<50 MWe)
University / Research / Test

QUESTIONS?