Nuclear Energy: State of Advanced Reactors

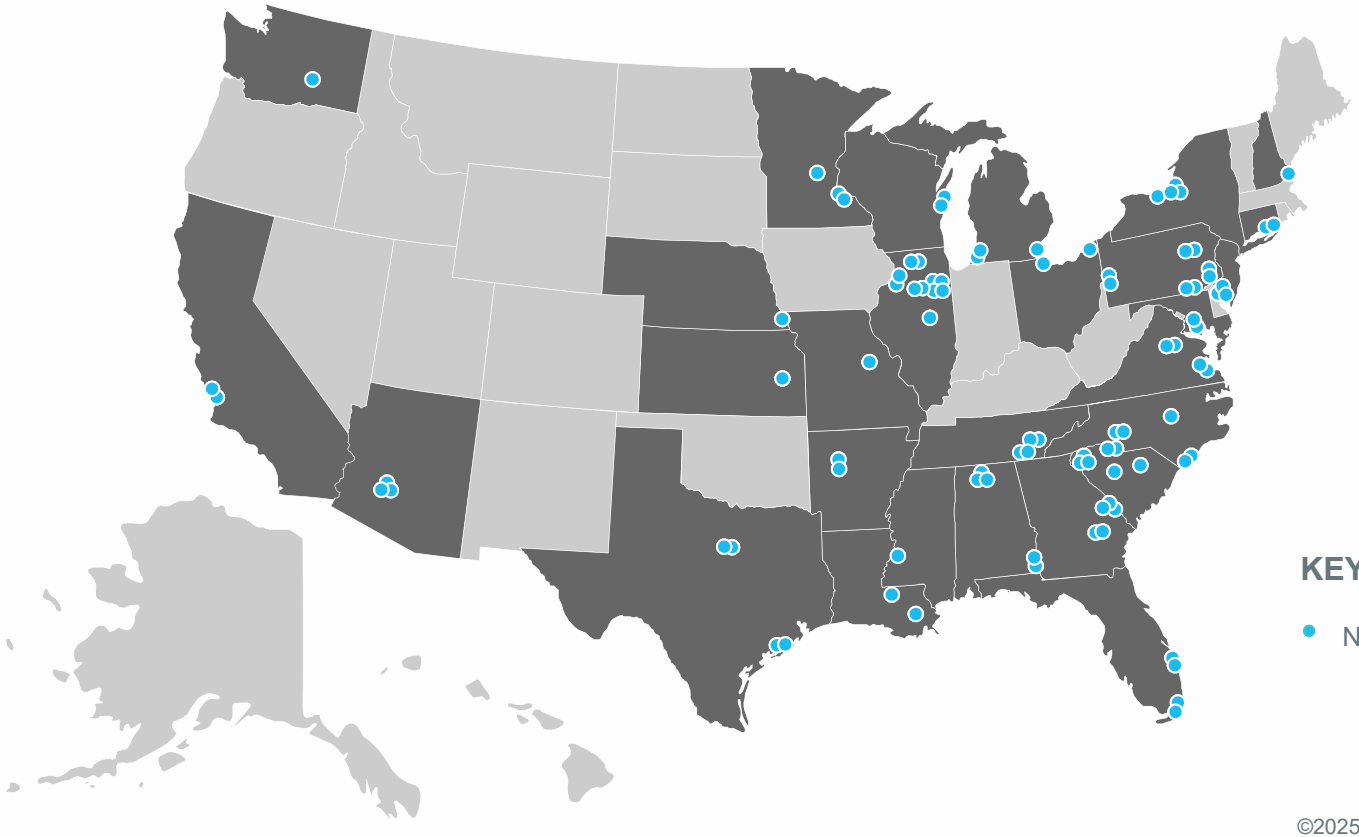
Rhode Island House: State Government and Elections Committee

April 8, 2025

Marc Nichol
Executive Director, New Nuclear

NUCLEAR ENERGY INSTITUTE

Nuclear Provided Majority of Emissions-Free Electricity



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

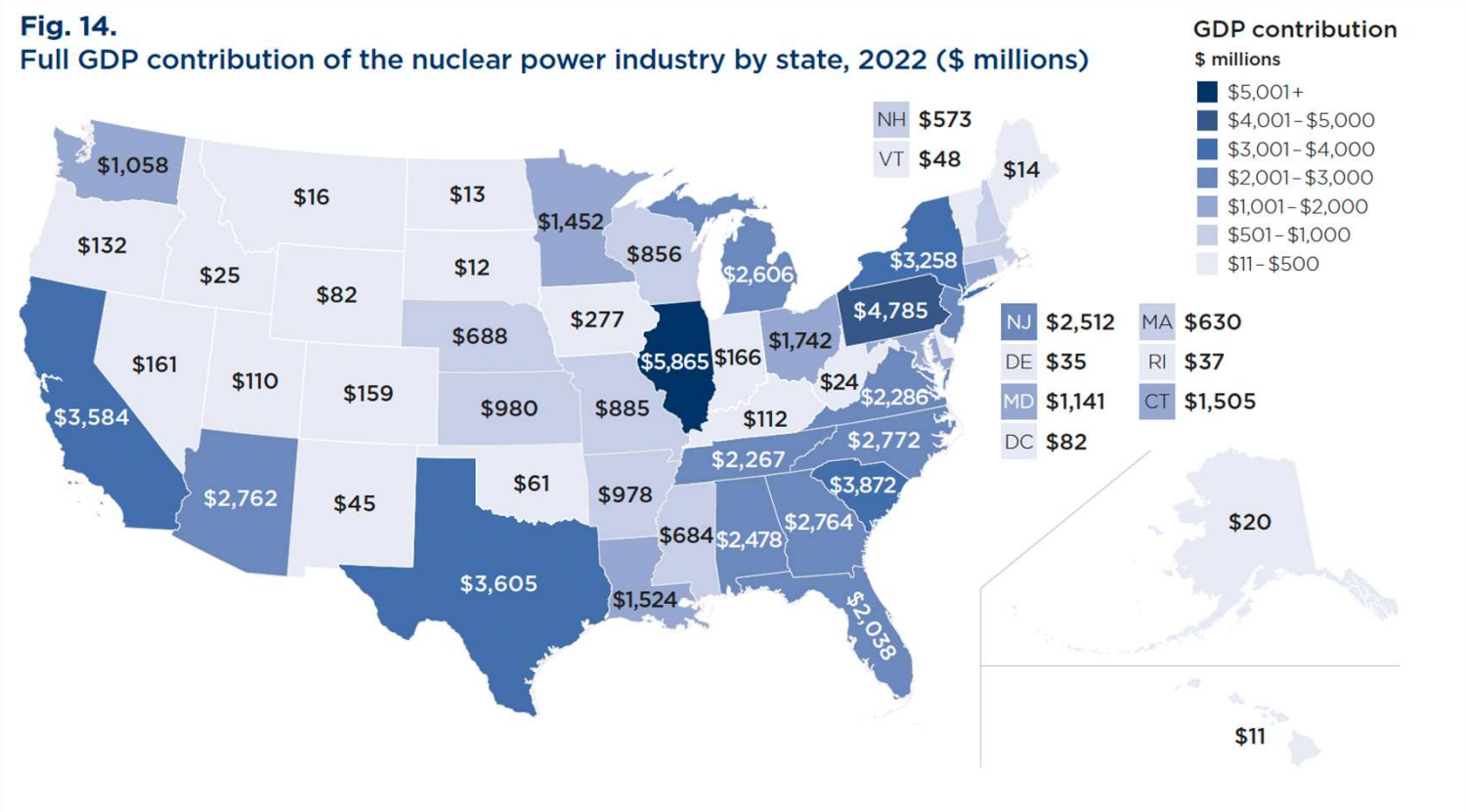
From 93 reactors at 53 plant sites across the country

KEY

- Nuclear power reactor

Updated: May 2023

Economic Impacts of Nuclear in the U.S.



Source: https://www.oxfordeconomics.com/resource/the-economic-contribution-of-the-us-nuclear-power-industry/

Advanced Nuclear Designer Members

Aalo

ALPHA NUR

ANTARES

arc CLEAN TECHNOLOGY

BWXT BWX Technologies, Inc.

DEEP FISSION

GENERAL ATOMICS

HITACHI

HOLTEC INTERNATIONAL

Kairos Power

LAST ENERGY

NANO Nuclear Energy Inc.

Natura Resources

newcleo Futurable Energy

NuCube Energy

NuGen

NUSCALE Power for all humankind

OKLO

RADIANT

REPLOY POWER

Steady Energy

TerraPower

TERRESTRIAL ENERGY

Westinghouse

X energy

ZENO POWER SYSTEMS

ZettaJoule

Types of Advanced Reactors

Range of sizes and features to meet diverse market needs

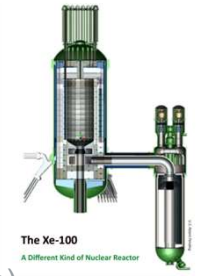
Water Cooled

Westinghouse AP1000® (shown)
GE ABWR
GE ESBWR

GEH BWRX-300 (shown)
NuScale
Holtec SMR-300
Westinghouse AP300

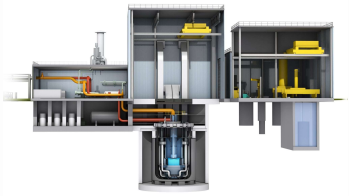
Non-Water Cooled

High Temp Gas Reactors



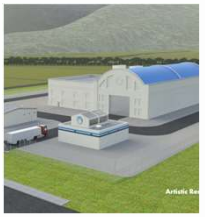
X-energy (shown)

Liquid Metal Reactors



TerraPower Natrium™ (shown)

Molten Salt Reactors



Kairos Hermes (shown)
Natura Resources

Both

Oklo (shown)
Last Energy
Radiant
Westinghouse eVinci™

Large ~1000 MWe — Small Modular Reactors < 300 MWe — Micro < 50 MWe

Learn more about innovative technologies with the Nuclear Innovation Alliance.

Expanded Versatility Meets a Diverse Set of Market Needs

Spectrum of Sizes and Options

Micro (Few MW)

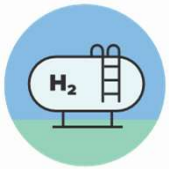
Mini (10s of MW)

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

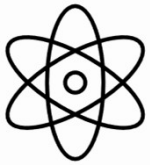
System Benefits of Advanced Reactors

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

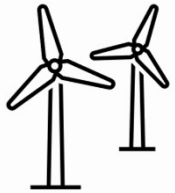
Lowest Cost System



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/

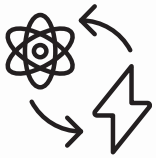
Recent Survey of NEI's U.S. Utilities

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**

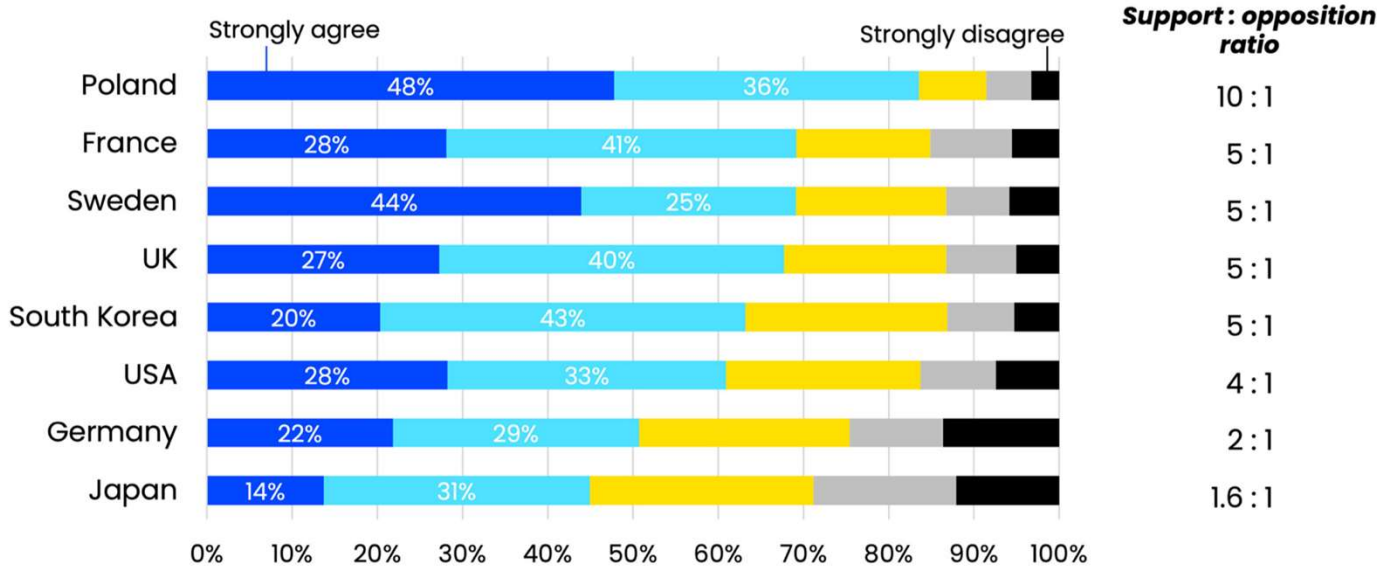
NEI utility member companies produce nearly half of all US electricity.

- More than half have more interest than in 2022 (prior survey year)
- Interest in 23 Early Site Permits, 18-19 Construction Permits, and 8 Combined Operating Licenses (by 2034)

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

Enablers and Opportunities

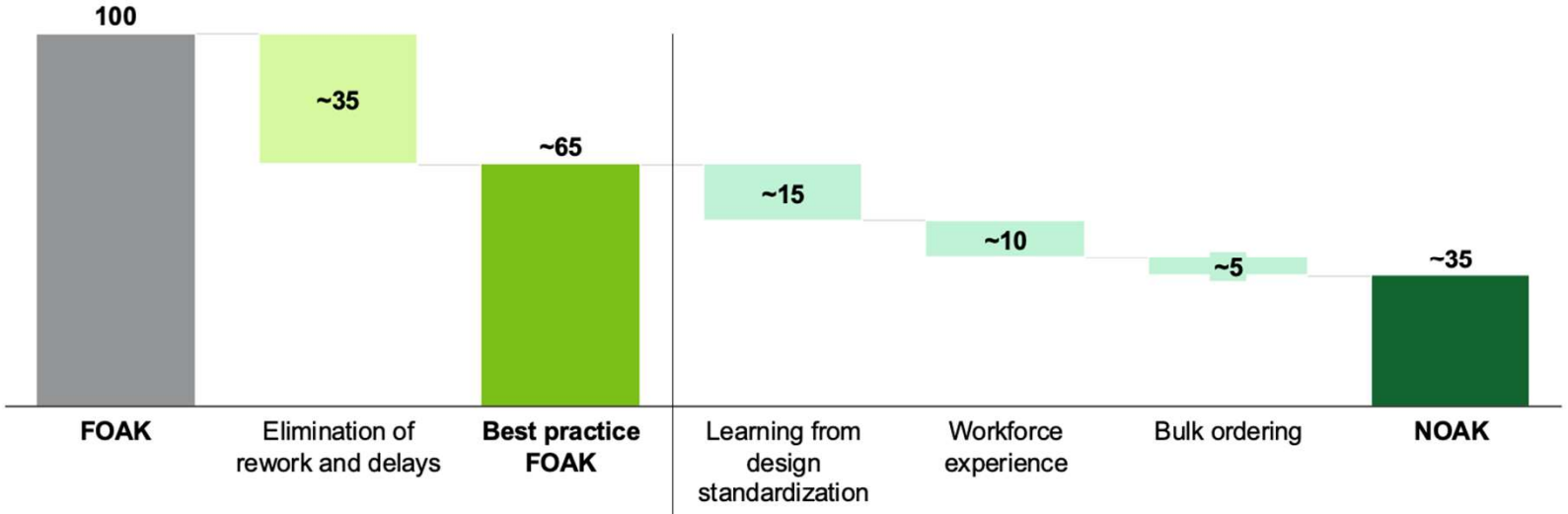
01 First Mover Success	1. Government policies are equitable for nuclear and fully funded 2. Policies support industry's implementation of project best practices 3. Building education and comfort in the investment community
02 Fast Followers	4. Decisions that support industry's achieving de-risking milestones 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

https://publicdownload.epri.com/PublicAttachmentDownload.svc/AttachmentId=83812

DOE Liftoff Report

Figure 26: Investment in pre-construction planning and design standardization are essential for reducing costs

Relative impact of FOAK to NOAK cost reduction levers on overnight capital costs, $/kW



Investing in pre-construction planning reduces costly rework and delays: ensuring design completion and constructor proficiency can reduce construction time and cost

Design standardization maximizes learning: multiple orders of a standardized design increase the ability to realize learning effects between projects

Early Mover Success

Industry De-Risking

- Construction Best Practices
- Risk Registers
- Fast Follower Approaches
- Fleet Deployment Models

Federal Policies

- Tax Incentives
- Loan Guarantees
- Demonstration Cost Shares
- Early Mover Support

State Policies

- Energy Policy
- Reliability
- Economic Policy
- Sustainability
- Permitting
- Infrastructure

Key Federal Policies

Bipartisan Infrastructure Law
November 15, 2021

Advanced Reactor Demonstration Program (ARDP) Funding
$2.5B for two commercial demos

Nuclear Hydrogen Hub
$8B total

Civil Nuclear Credit Program
$6B to support financially challenged plants

Inflation Reduction Act
August 16, 2022

Production Tax Credit (PTC) for Operating Plants
Up to $15 per MWh

Technology-Inclusive PTC for Clean Electricity
$30 per MWh

Technology-Inclusive Investment Tax Credit (ITC) for Clean Electricity
30% + 10% in energy communities + 10% using U.S. components

Clean Hydrogen Credit
$3 per kilogram

118th Congress

Nuclear Fuel Security Act
LEU/HALEU domestic production authorizing legislation in FY 2024 NDAA (December 22, 2023)

FY 2024 Appropriations Legislation
$2.72 Billion for domestic fuel production (March 9, 2024)

Additional $800 Million for Small Modular Reactors (March 9, 2024)

40 Year Reauthorization of the Price-Anderson Indemnification Act (March 23, 2024)

ADVANCE Act
Increase regulatory efficiency & reduce regulatory costs (July 9, 2024)

Federal Funding Opportunities for New Nuclear

Tax Credits

- PTC: At least $30/MWh for 10 years
- ITC: 30% of investment
- Bonuses for energy communities and domestic supply

Demonstrations (Awarded)

- DOE funding 12 different designs, >$5B over 7 years
- ARDP Demos, Risk Reduction, Early development

Loan Guarantees

- >$250B in authority
- $63B in Nuclear Applications (6/2024)

Deployments (New)

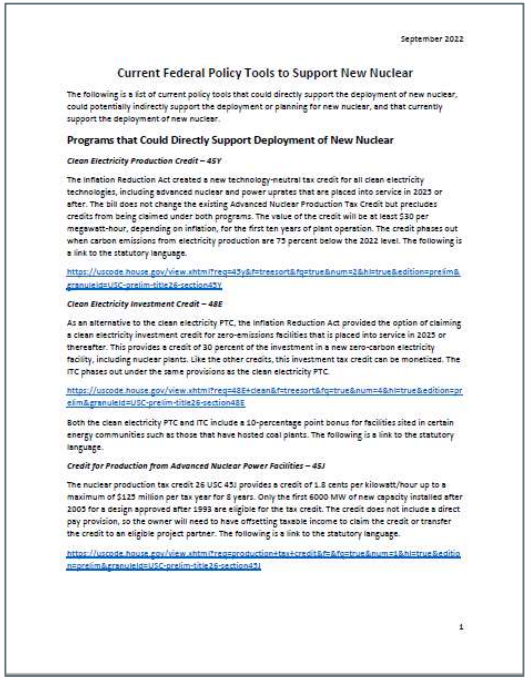
- $800 Million for utility use of light-water SMRs

Fuel and Supply Chain

- HALEU Fuel - $700M
- $2.7 Billion for fuel (conditional on Russian import ban)

Other Support

- GAIN Vouchers
- NRIC Partnerships



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=production+tax+credit&f=treesort&fq=true&num=4&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

States Taking Action for Nuclear

Exploring Nuclear Technology with Studies, Working Groups, Commissions and Task Forces	Connecticut, Florida, Indiana, Kentucky, Louisiana, Maryland, Michigan, Montana, Nebraska, New Hampshire, Ohio, Pennsylvania, Tennessee, and Texas
Recognizing Nuclear as a Clean Energy Resource	Idaho, Michigan, Minnesota, North Carolina, Ohio Tennessee, Utah, Virginia and Washington
Removing Barriers and Signaling Support	Repealing Nuclear Moratoriums: Connecticut, Illinois, Kentucky, Montana, West Virginia, and Wisconsin Signaling Regulatory Support: Indiana, Mississippi, North Carolina, and South Dakota
Incentivizing Nuclear Technology and Supply Chain	Kentucky, Michigan, Tennessee, Virginia, Washington, and Wyoming

NEI's "State Legislation and Regulation Supporting Nuclear Energy 2025 State Policy Options: https://www.nei.org/resources/reports-briefs/policy-options-for-states-to-support-new-nuclear

State Restrictions on New Nuclear

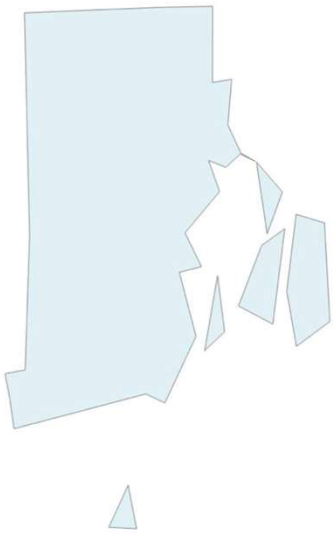
Removing Barriers to Enable Clean, Reliable and Affordable Energy

- Restrictions on new nuclear:
  - Established in late 1970s
  - Conditioned on a repository
  - Before Nuclear Waste Policy Act and experience with used fuel safety
- States pursuing restriction repeals recognize that
  - Used fuel is not the concern once perceived
  - New nuclear needed to meet goals for clean, reliable and affordable energy
- Nearly every state with a restriction is looking into new nuclear*
  - 6 - State Moratoriums Repealed: Connecticut, Illinois, Kentucky, Montana, West Virginia, and Wisconsin
  - 9 – States with recent bills to Repeal: Connecticut (remove Millstone only), California, Hawaii, Illinois (remove 300 MWe cap), Maine, Minnesota, Oregon, Rhode Island
  - 4 - States with bills to study nuclear: Hawaii, Massachusetts, Oregon, Vermont

*New Jersey is the only other state with a restriction, and while it has several bills for nuclear clean energy, nothing is currently being considered

Nuclear Energy Benefits in Rhode Island

NUCLEAR PLANTS



$37 Million

Full GDP contribution of nuclear in RI in 2022

$0 Million

RI State and Local Taxes in 2022

323

Total Employment in RI in 2022 (Direct, Indirect and Induces)

300

High-paying, permanent jobs created at a new small modular reactor plant

394

Operating and retired coal plant sites that could be converted to nuclear plants

SMR (300 MWe) During Operations

>20%

Electricity generation (~2x current clean energy)

$250 Million

Full GDP contribution, annually

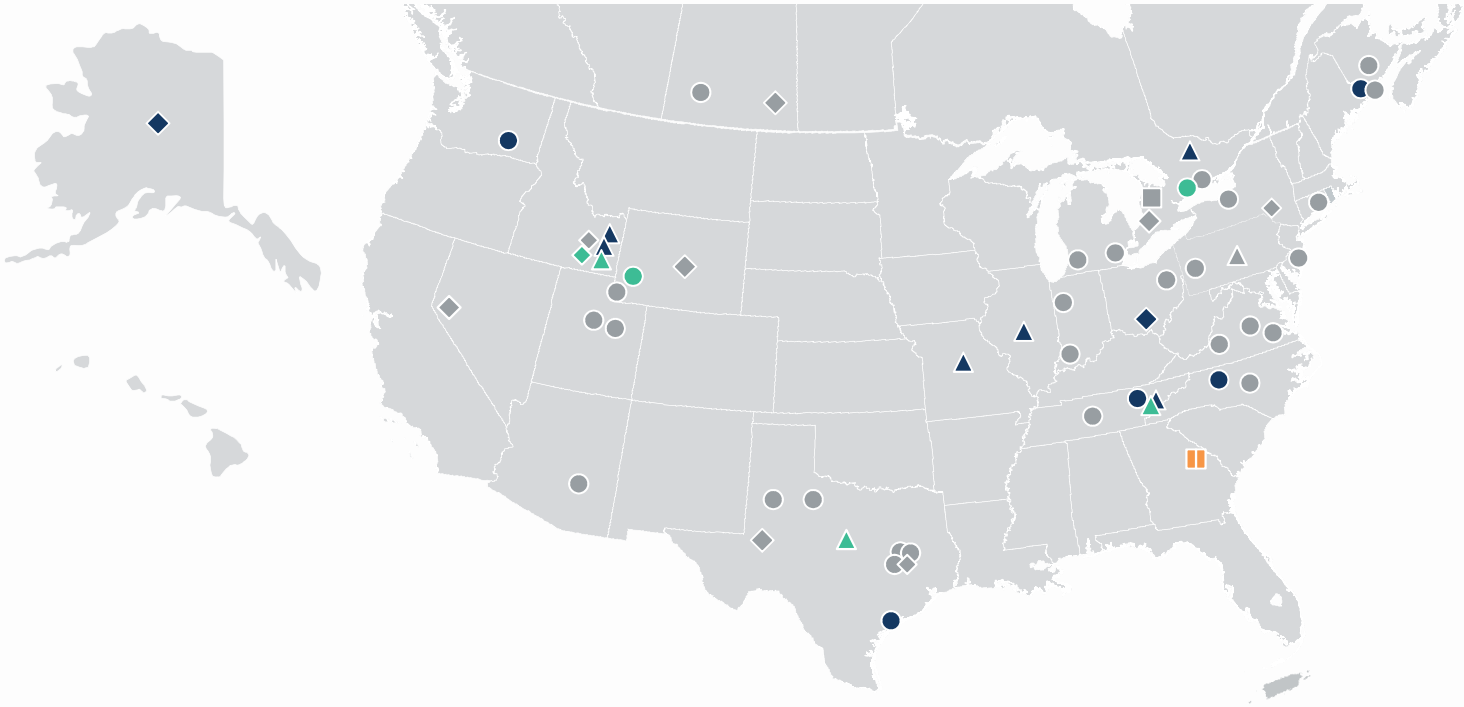
>500

Total Employment (Direct, Indirect and Induces)

Sources: https://www.nei.org/resources/fact-sheets/u-s-nuclear-plants
https://www.oxfordeconomics.com/resource/the-economic-contribution-of-the-us-nuclear-power-industry/
https://www.nei.org/CorporateSite/media/filefolder/advanced/SMR-Start-Economic-Analysis-2021-(APPROVED-2021-03-22).pdf

Advanced Nuclear Deployment Plans

Projects that may be in operation by early 2030s



Legend

Considered project | Planned project | Under construction | Operating

Large (1,000 MWe) | Small (<300 MWe) | Micro-reactor (<50 MWe) | University / Research / Test

Updated 04/03/2025

Does not include plans for more than 10 additional projects that have not announced site locations.

QUESTIONS?