Advanced Nuclear Energy 101

Louisiana Public Service Commission

February 8, 2024

NUCLEAR ENERGY INSTITUTE

Nuclear Power Contributions

470.1 million
Carbon emission reductions per year in metric tons

188,000
Short tons of NOx prevented

227,000
Short tons of SO_2 prevented

>90%
The average capacity factor since 1999

$10 billion
Contributions in federal taxes each year

$2.2 billion
Contributions in state taxes each year

475,000
Jobs supported

6%
Average electricity bill savings for consumers

$60 billion
in contributions to the country's GDP

U.S. Clean Generation (2022)

45.5%
NUCLEAR

25.6%
WIND

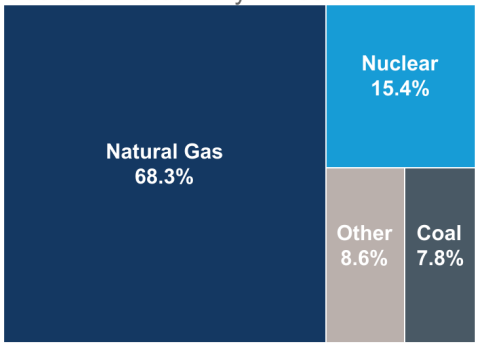
15.1%
HYDRO

12.0%
SOLAR

1.0%
GEOTHERMAL

Nuclear Energy in Louisiana

Sources of electricity in Louisiana



91.6%
Nuclear's share of Louisiana's carbon-free electricity, complementing wind and solar

1,670
High-paying, reliable jobs provided by Louisiana's nuclear plants

State Carbon Goals

Net zero GHG emissions by 2050

Utility Carbon Goals

American Electric Power

Entergy

Nuclear News

The 2022 Louisiana Climate Action Plan includes nuclear in the recommendations to meet a net-zero goal by 2050.

The U.S. Congress passed the Bipartisan Infrastructure Law in 2021 and Inflation Reduction Act in 2022, supporting nuclear and other clean energy development.

REACTOR DETAILS

Reactor Name	County	Majority Owner	Capacity (MW)	Capacity Factor (%)	License End Year
River Bend 1	West Feliciana	Entergy	968	93.3%	2045
Waterford 3	St Charles	Entergy	1,165	86.9%	2044

NUCLEAR PLANTS

89.8%
Capacity factor of nuclear plants in Louisiana from 2020 to 2022

8.2 million
Metric tons of carbon emissions avoided in Louisiana

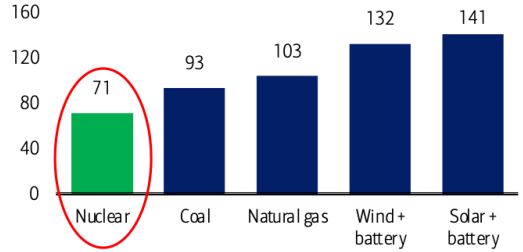
1.1 million
Number of homes powered by nuclear energy in Louisiana

Source: https://www.nei.org/resources/fact-sheets/u-s-nuclear-plants

Nuclear Energy is Affordable

"Nuclear appears to be the cheapest scalable, clean energy source by far."

Exhibit 20: Nuclear is cost-effective…
Cost of generation, different sources ($/MWh)



Source: BofA Research Investment Committee, Lazard, Entler, et al. (2018). Note: nuclear, coal, and natural gas price estimates from Entler, et al. Wind and solar cost estimates are from Lazard's 2023 Levelized Cost of Energy+ report. Wind + battery and solar + battery use estimates from California's Independent System Operator (CAISO) and assume a 4-hour lithium-ion battery storage system to account for firming costs. All cost estimates show unsubsidized costs.

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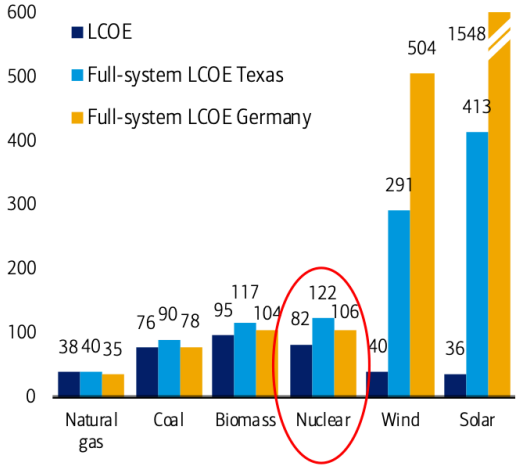
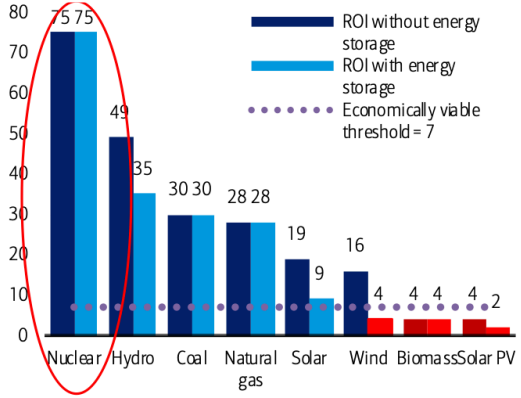
Exhibit 21: …especially on an "all-in basis"…
LCOE & LFSCOE calculations by energy source



Source: BofA Research Investment Committee, Idel 2022

BofA GLOBAL RESEARCH

Exhibit 22: …and has the highest energy ROI
Energy returned on energy invested, by source



Source: BofA Research Investment Committee, D. Weißbach, G. Ruprecht, A. Huke, K. Czerski, S. Gottlie, A. Hussein; Red signals EROI below economically viable threshold

BofA GLOBAL RESEARCH

Bank of America Analyst Report: https://advisoranalyst.com/wp-content/uploads/2023/05/bofa-the-ric-report-the-nuclear-necessity-20230509.pdf

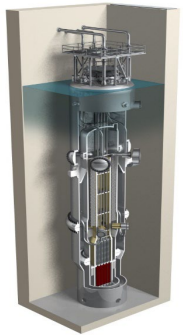
Types of Advanced Reactors

Range of sizes and features to meet diverse market needs

Micro-Reactors < 20 MWe

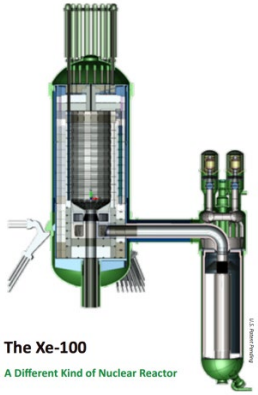
Oklo (shown)
Approximately a dozen in development

Light-Water SMRs < 300 MWe



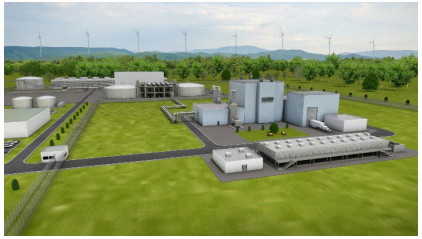
NuScale (shown)
GEH BWRX-300
Holtec SMR-160
Westinghouse AP300

High Temp Gas Reactors



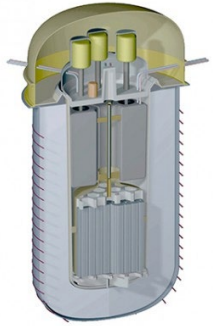
X-energy (shown)
Several in development

Liquid Metal Reactors



TerraPower Natrium™ (shown)
Several in development

Molten Salt Reactors



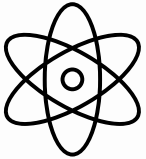
Terrestrial (shown)
Several in development

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

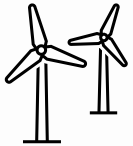
Learn more about innovative technologies with the Nuclear Innovation Alliance.

Lowest System Cost Achieved by Enabling Large Scale New Nuclear Deployment

Lowest Cost System

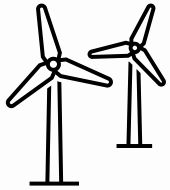


Nuclear is 43% of generation (>300 GWe of new nuclear)

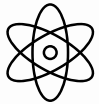


Wind and solar are 50%

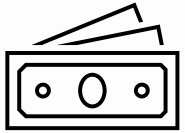
Energy System with Nuclear Constrained



Wind and Solar are 77% of generation



Nuclear is 13% (>60 GWe 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/

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*

Economic Benefits of SMRs

- Employment
  - 900 manufacturing and construction jobs over 4 years (average)
  - 300 permanent positions during 60+ years of operation
  - Multiplier effect: additional 1.66 jobs in local economy, 2.36 rest of the state
  - Nuclear jobs pay 20% more, on average, than jobs at other energy sources
  - Nuclear jobs pay 36% more than average salaries in local area
- Economic Activity
  - $500M+ in direct and indirect economic output annually
    - $270 million in electricity sales
    - Spending at local ($10M), State ($48M) and national ($236M) level
  - Taxes: $10M in state and local, and $40M in federal (annually)

Source: SMR Start, *Economics of Small Modular Reactors*
Based on a 600 MWe SMR plant

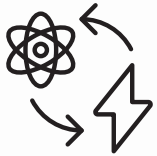
Recent Survey of NEI's U.S. Utilities

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 GWe 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.

Small Modular Reactors/Advanced Reactors Offer Significant Well-Paying, Long-Term Jobs

Generation Type	Permanent Jobs on Site	Industry Wage Median	Carbon-free Energy?	Grid-firm Energy?	Benefits Concentrated in Local Community?
Nuclear	237*	$41.32	**Yes**	**Yes**	**Yes**
Coal	107	$33.64	No	**Yes**	**Yes**
Natural Gas	30	$34.02	No	**Yes**	**Yes**
Wind	80	$25.95	**Yes**	No	No
Solar	36	$24.48	**Yes**	No	No

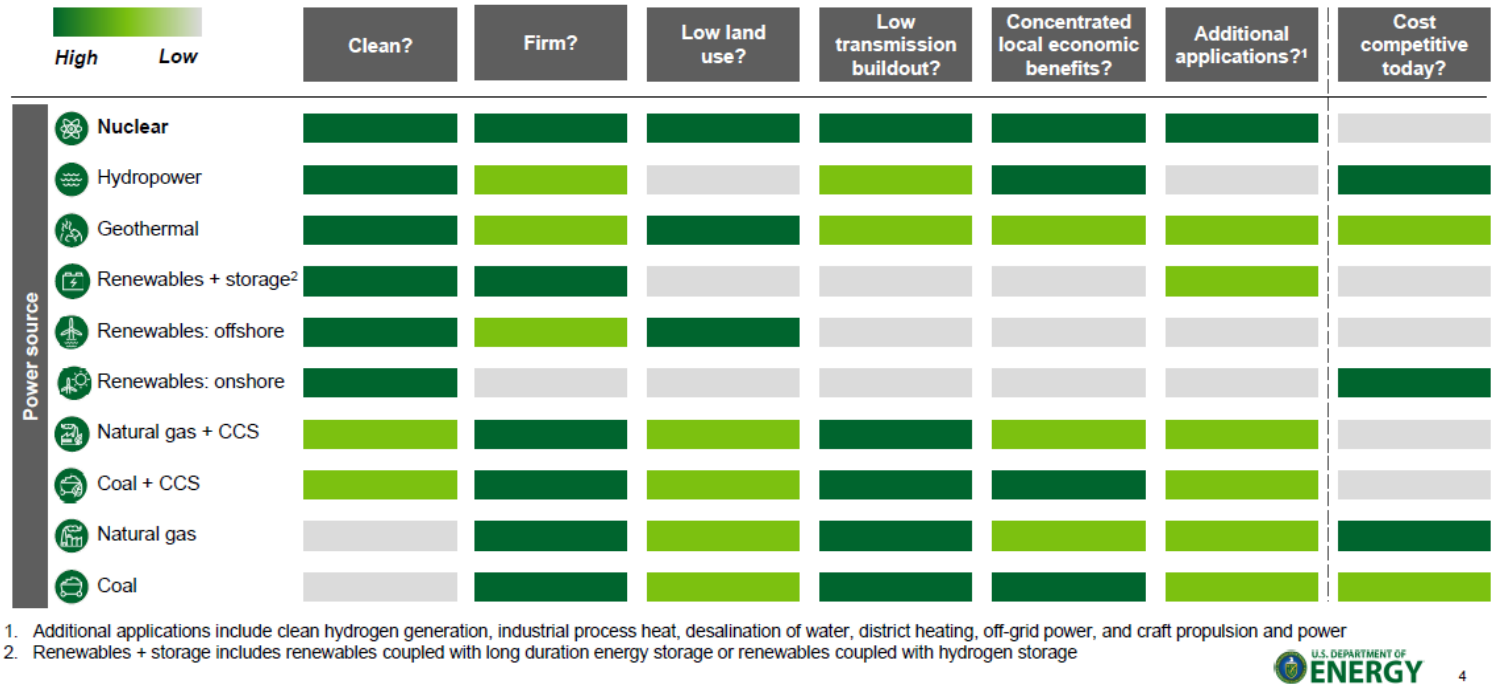
* Based on NuScale VOYGR-12 design

Note: Comparison of alternatives producing annual electricity output equivalent to a typical 1,000 MWe coal plant

Source: ScottMadden, *Gone with the Steam*, October 2021
https://www.scottmadden.com/content/uploads/2021/10/ScottMadden_Gone_With_The_Steam_WhitePaper_final4.pdf

DOE Pathways to Commercial Liftoff

Nuclear has a unique value proposition for the net-zero grid



1. Additional applications include clean hydrogen generation, industrial process heat, desalination of water, district heating, off-grid power, and craft propulsion and power
2. Renewables + storage includes renewables coupled with long duration energy storage or renewables coupled with hydrogen storage

U.S. DEPARTMENT OF ENERGY

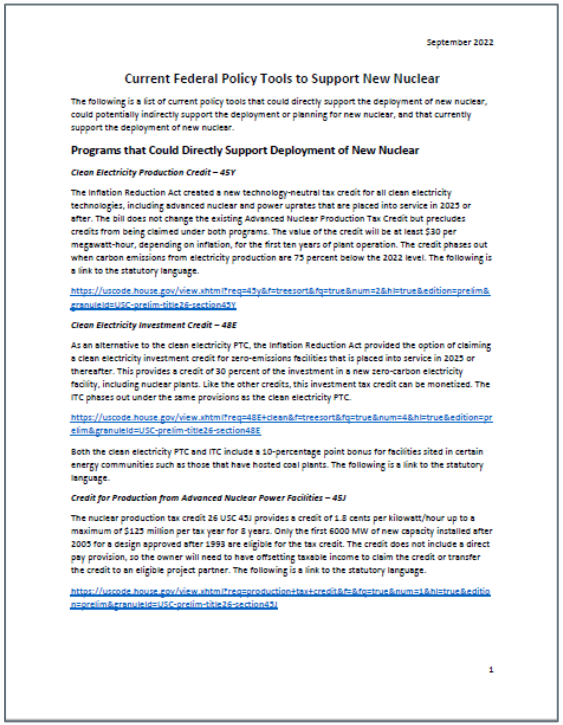
4

Source: https://liftoff.energy.gov/advanced-nuclear/

More on cost: Kutak Rock, November 2023, *What is the Cost of Power*

Strong Federal Support for Advanced Reactors

- DOE funding 12 different designs, >$5B over 7 years
- Bipartisan Infrastructure Law
  - $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=production+tax+credit&f=&fq=true&num=1&hl=true&edition=prelim&granuleId=USC-prelim-title26-section45J

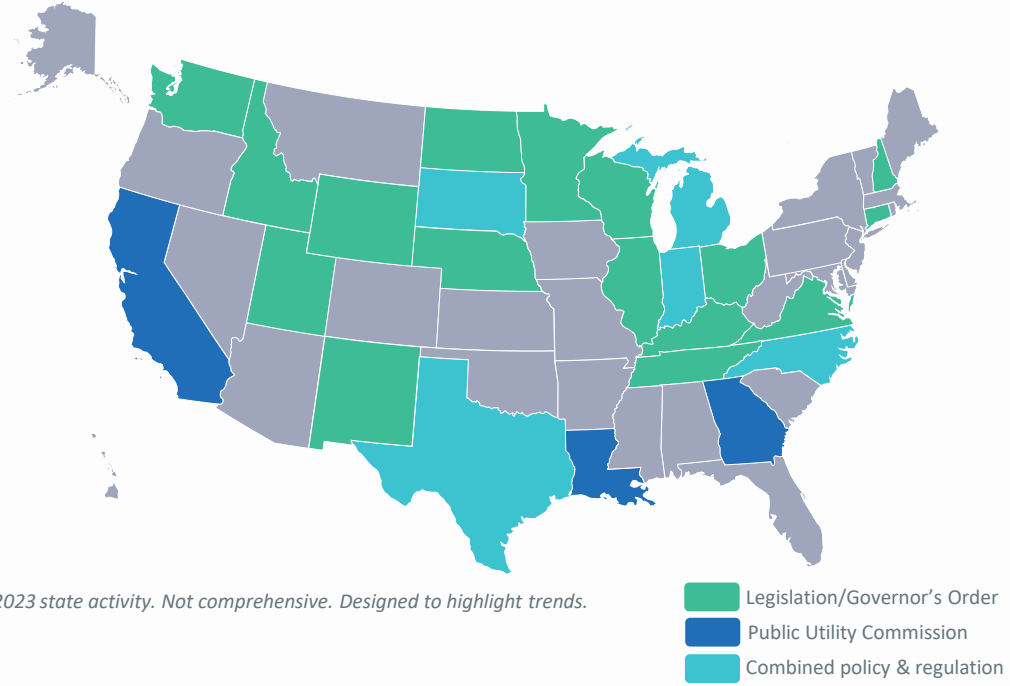
1

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

State Policies & Regulations

Activities include defining nuclear as clean energy, establishing working groups or commissioning studies, providing regulatory support signals, removing bans on the construction of new nuclear facilities, among others

- At least 24 states enacted policies or approved orders in 2023 supporting existing reactors or the deployment of new reactor technologies.
- 11 states have prohibitions on new nuclear facility construction, but restrictions are quickly changing (IL most recently).
- Many states are requiring studies of the economic and carbon free benefits of next generation nuclear technology.
- More states are considering measures that better define nuclear as clean energy.

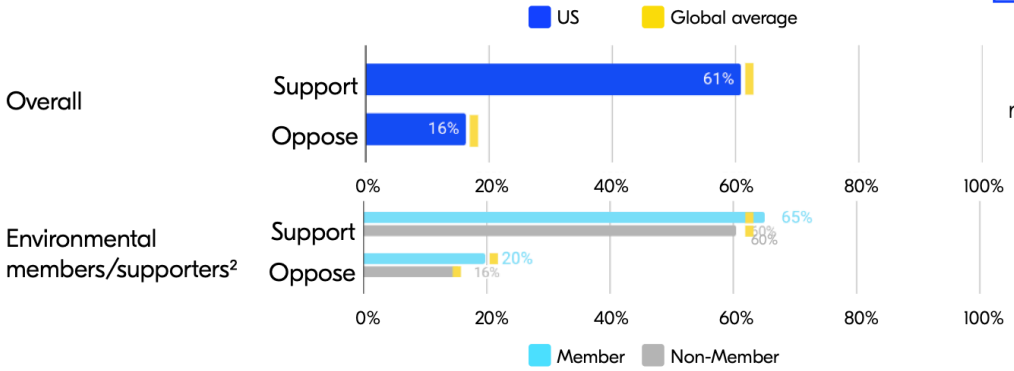


https://www.nei.org/resources/reports-briefs/state-legislation-and-regulations

Strong Public Support for Nuclear Energy

US

Support vs. opposition[1]



n=4,250

Support by...

Gender

Men	73%
Women	50%

Age

18-34	58%
35-54	62%
55+	62%

Income

Low income (under 50k USD)	52%
Medium income (50k-100k USD)	60%
High income (100k+ USD)	70%

Political Affiliation

Democrat	61%
Independent	60%
Republican	66%

Top 5 nuclear sentiments[3]
(% agree)

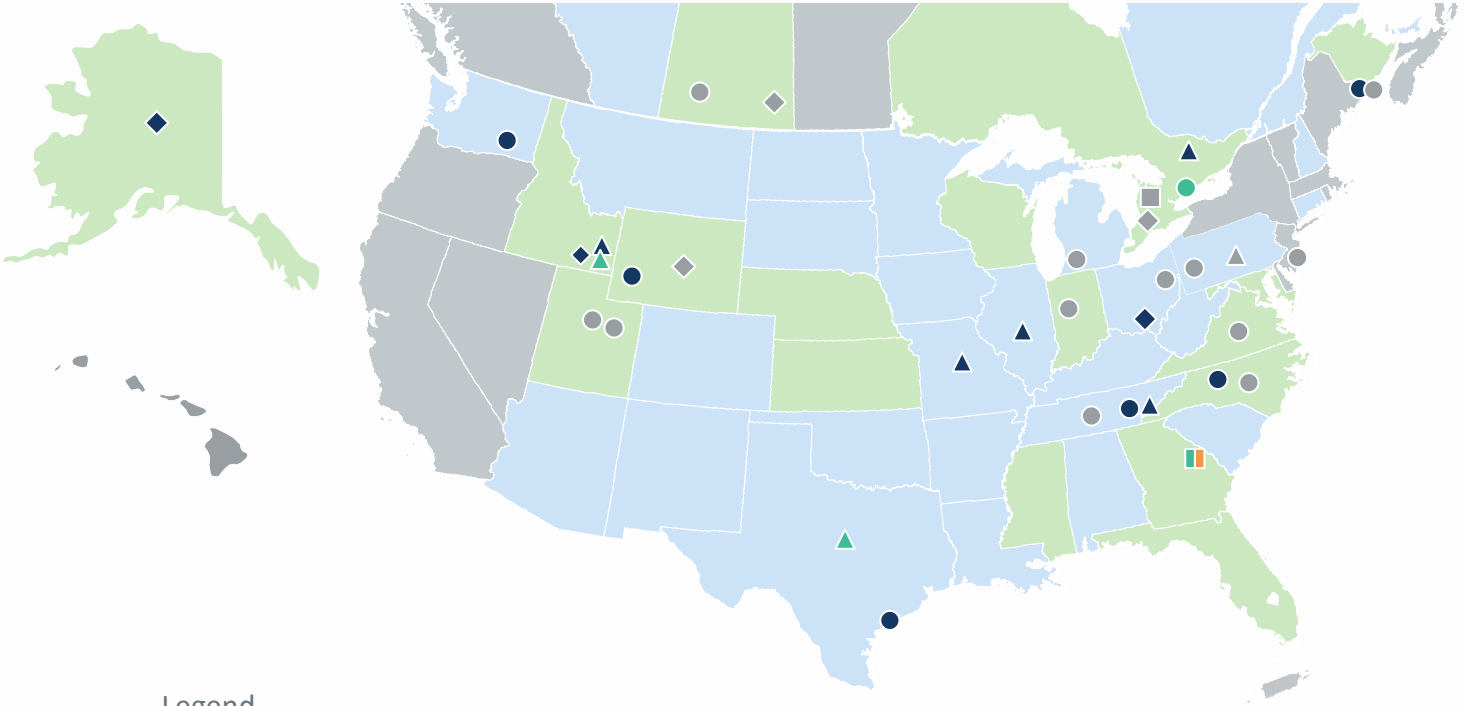
We need a way to produce more and more energy for our economy to keep growing	76%
We need to be building capacity for more energy, not just trying to use less	63%
We need nuclear energy in the mix, along with renewables, if we are to meet our climate goals	60%
Leaving nuclear waste behind is just wrong, however safe it is	59%
We should use advanced nuclear energy to reduce our dependence on other countries	58%

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

Advanced Nuclear Deployment Plans

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

Updated 12/19/2023



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?

By Third Way, GENSLER