Advanced Nuclear Energy

Kansas Corporation Commission Work Study

October 22, 2024

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Senior PM, New Nuclear

NUCLEAR ENERGY INSTITUTE

Nuclear Power Contributions in the U.S.

476.5 million
Carbon emission reductions per year in metric tons

217,000
Short tons of NOx prevented

262,000
Short tons of SO_2 prevented

>90%
The average capacity factor since 1999

$10 billion
Contributions in federal taxes each year

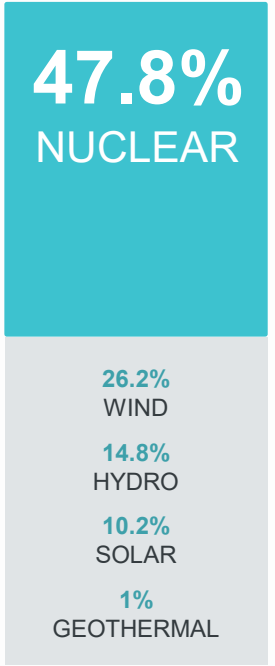
$2.2 billion
Contributions in state taxes each year

475,000
Jobs supported

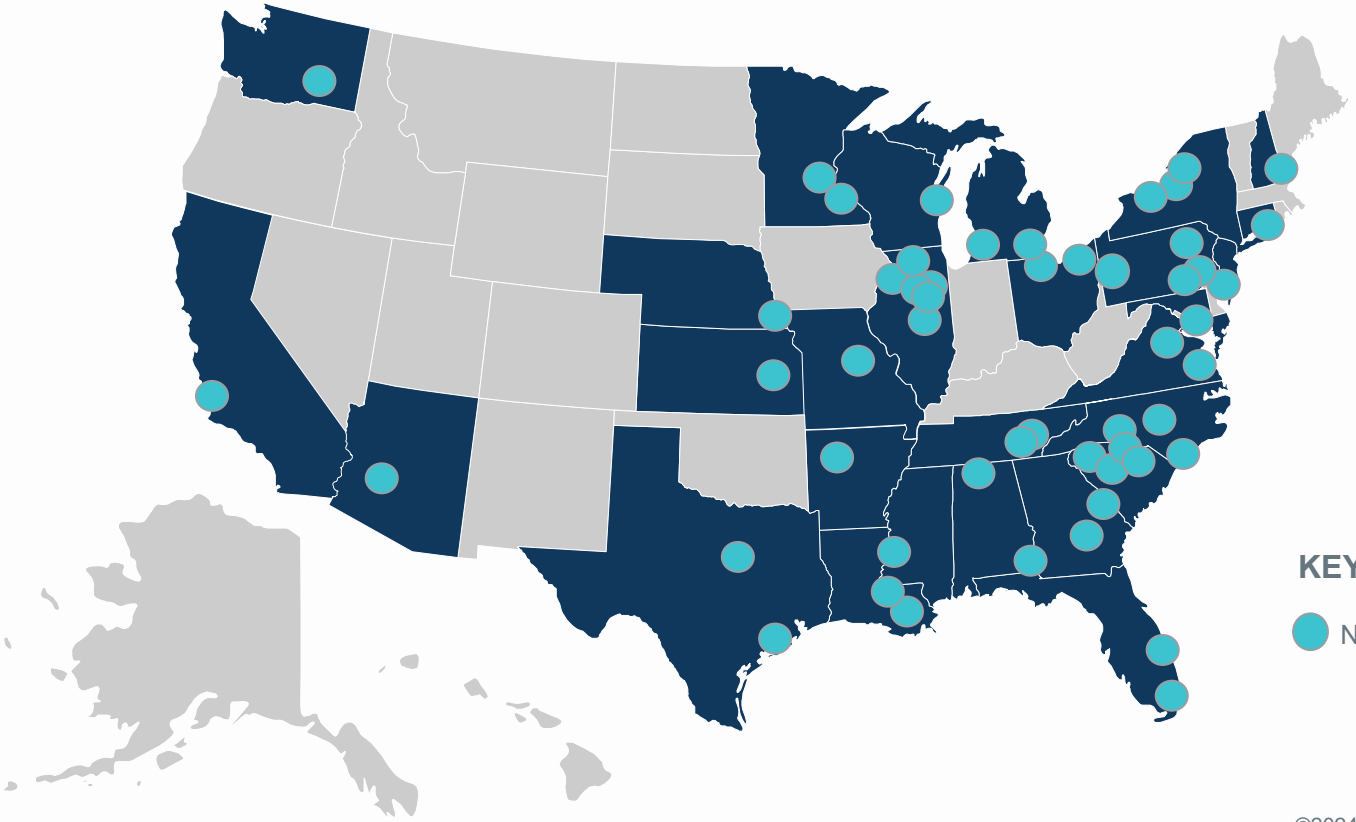
6%
Average electricity bill savings for consumers

$60 billion
in contributions to the country's GDP

U.S. Clean Generation (2023)



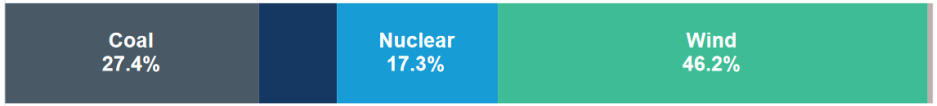
94 reactors at 53 plant sites in the U.S.



Updated: July 2024

Nuclear Energy in Kansas

Sources of electricity in Kansas



1,000
High-paying, reliable jobs provided by Kansas' nuclear plants

27.1%
Nuclear's share of Kansas' carbon-free electricity, complementing wind and solar

State Carbon Goals
None

Utility Carbon Goals
Evergy

Nuclear News

U.S. Congress supports nuclear & other clean energy in the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act.

REACTOR DETAILS

Reactor Name	County	Majority Owner(s)	Capacity (MW)	Capacity Factor (%)	License End Year
Wolf Creek 1	Coffey	Evergy	1,225	86.5%	2045

Updated June 2024 | © 2024 Nuclear Energy Institute

NUCLEAR PLANTS

86.5%
Capacity factor of nuclear plants in Kansas from 2021 to 2023

8.9 million
Metric tons of carbon emissions avoided by nuclear energy in Kansas

925,000
Number of homes powered by nuclear energy in Kansas

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

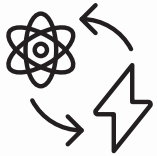
Recent Survey of NEI's U.S. Utilities

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

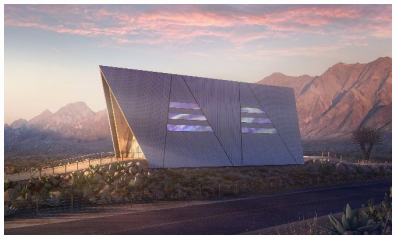
Translates to roughly **300 SMR-scale plants**

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

Types of Advanced Reactors

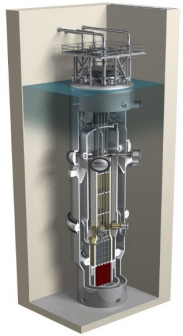
Range of sizes and features to meet diverse market needs

Micro-Reactors < 50 MWe



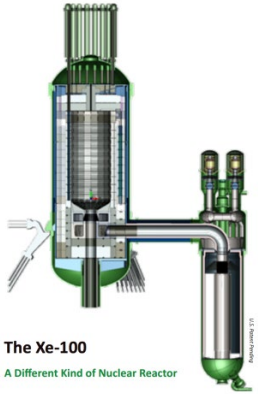
Oklo (shown)
Approximately a dozen in development

Light-Water SMRs < 300 MWe



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

High Temp Gas Reactors

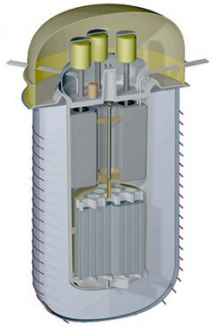


X-energy (shown)
Several in development

Liquid Metal Reactors

TerraPower Natrium™ (shown)
Several in development

Molten Salt Reactors

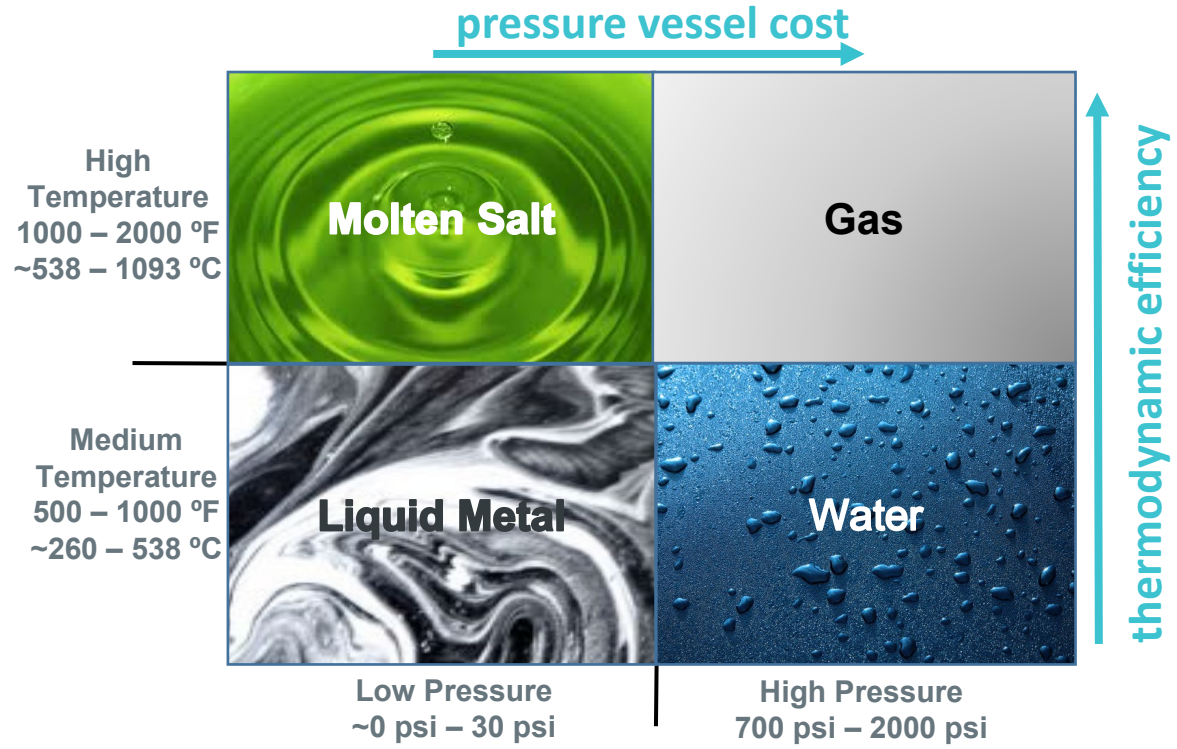


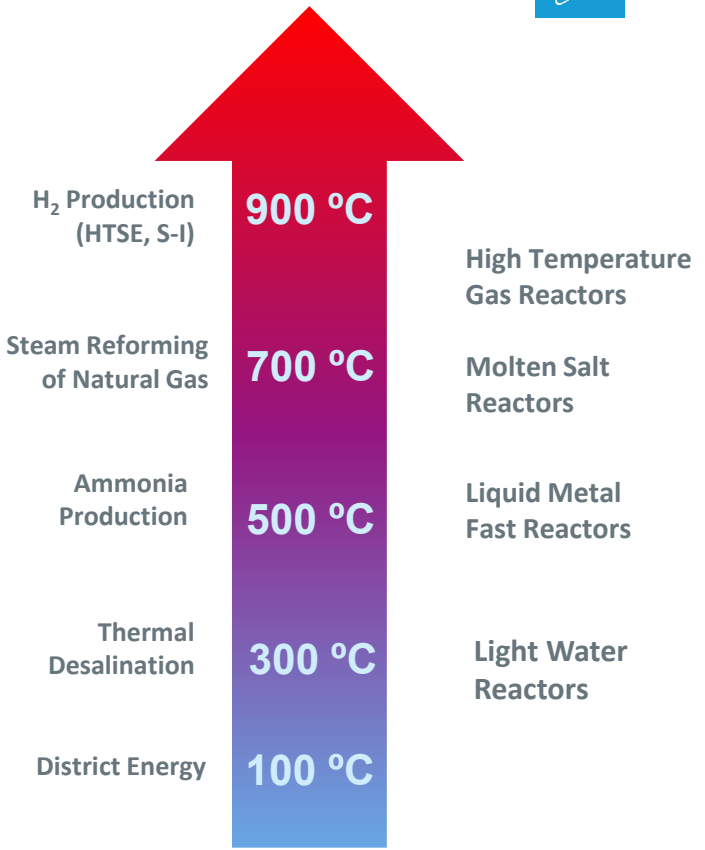
Terrestrial (shown)
Several in development

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

Learn more about innovative technologies with the Nuclear Innovation Alliance.

Technology and Temperature





Advanced Nuclear Versatility

Spectrum of Sizes and Options

Micro

Small

Large

Variety of Outputs

Electricity

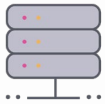
Isotopes

Hydrogen

Process Heat

Multitude of *New* Customers

Energy Transitions



Data Centers

Military Bases

Petrochemical

Cement

Steel

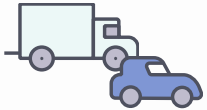
Oil & Gas

District Energy

Space

Pulp & Paper

Block Chain Mining



Transportation

Rail

Aviation

Maritime

Mining

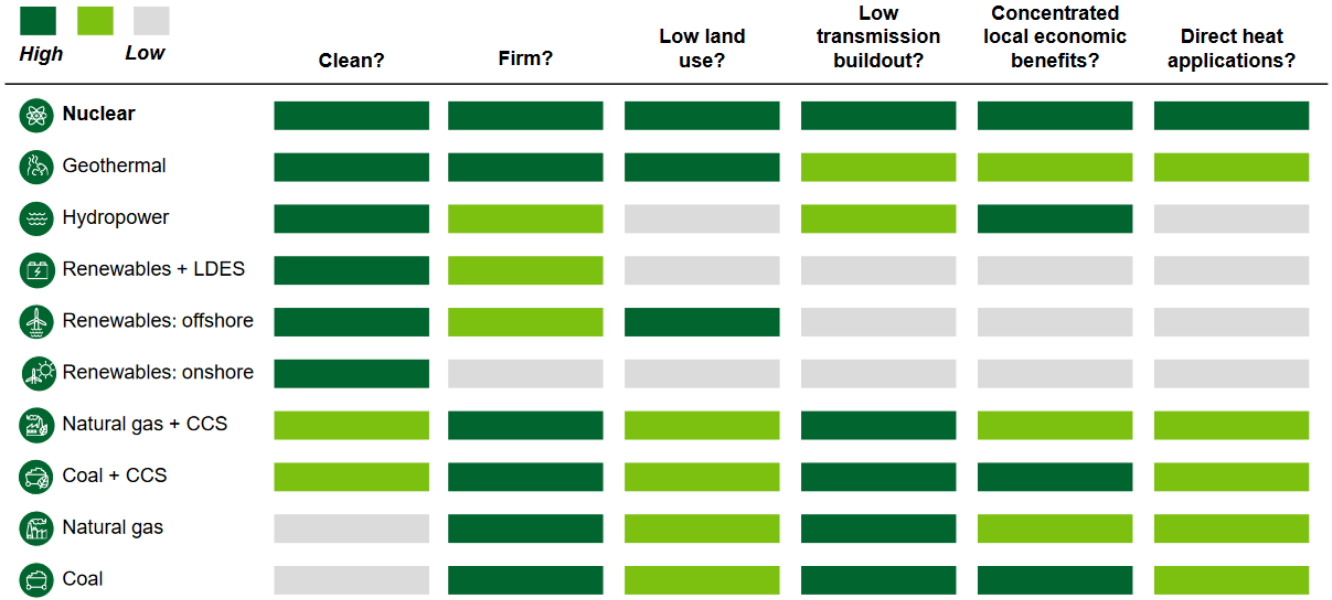
Agriculture

Fashion

Desalination

DOE Pathways to Commercial Liftoff

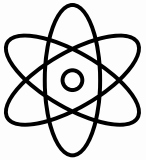
Nuclear offers a unique value proposition for a net zero grid



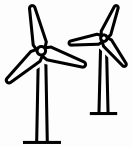
Source: https://liftoff.energy.gov/advanced-nuclear/

Lowest System Cost Achieved by Enabling Large Scale New Nuclear Deployment

Lowest Cost System

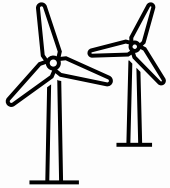


Nuclear is 43% of generation (>300 GW of new nuclear)

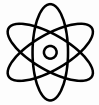


Wind and solar are 50%

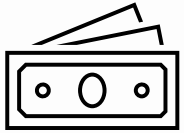
Energy System with Nuclear Constrained



Wind and Solar are 77% of generation



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



Increased cost to customers of $449 Billion

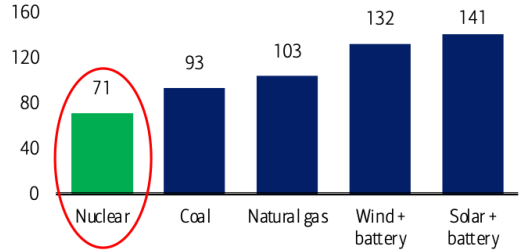
Both scenarios are successful in reducing electricity grid GHG emissions by over 95% by 2050 and reducing the economy-wide GHG emissions by over 60%

Scan to view the complete study.

Nuclear Energy is Affordable

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

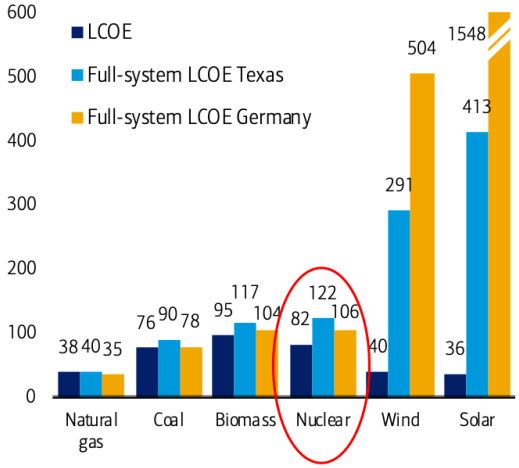
Exhibit 20: Nuclear is cost-effective…
Cost of generation, different sources ($/MWh)



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.

BofA GLOBAL RESEARCH

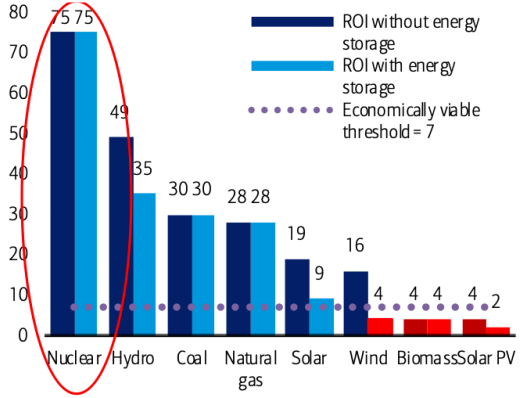
Exhibit 21: …especially on an "all-in basis"…
LCOE & LFSCOE calculations by energy source



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

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

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

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, Tennessee, Utah, and Virginia
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

Current State Policies: https://www.nei.org/resources/reports-briefs/state-legislation-and-regulations
State Policy Options: https://www.nei.org/resources/reports-briefs/policy-options-for-states-to-support-new-nuclear

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)

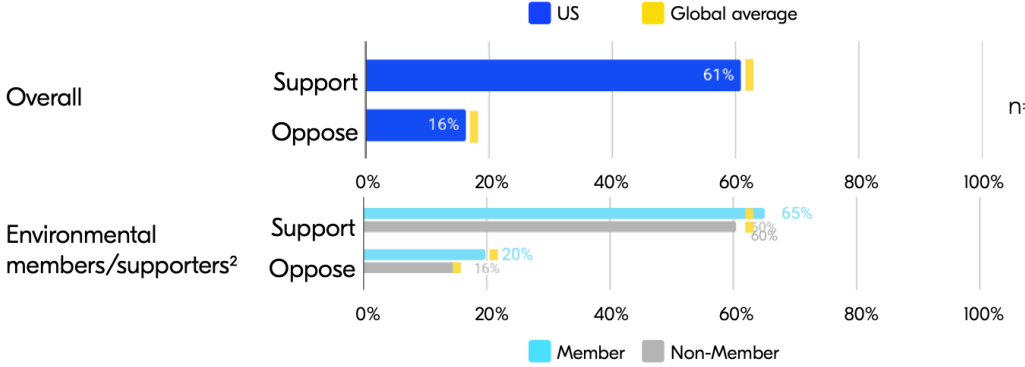
40 Year Reauthorization of the Price-Anderson Indemnification Act (March 23, 2024)

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

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)

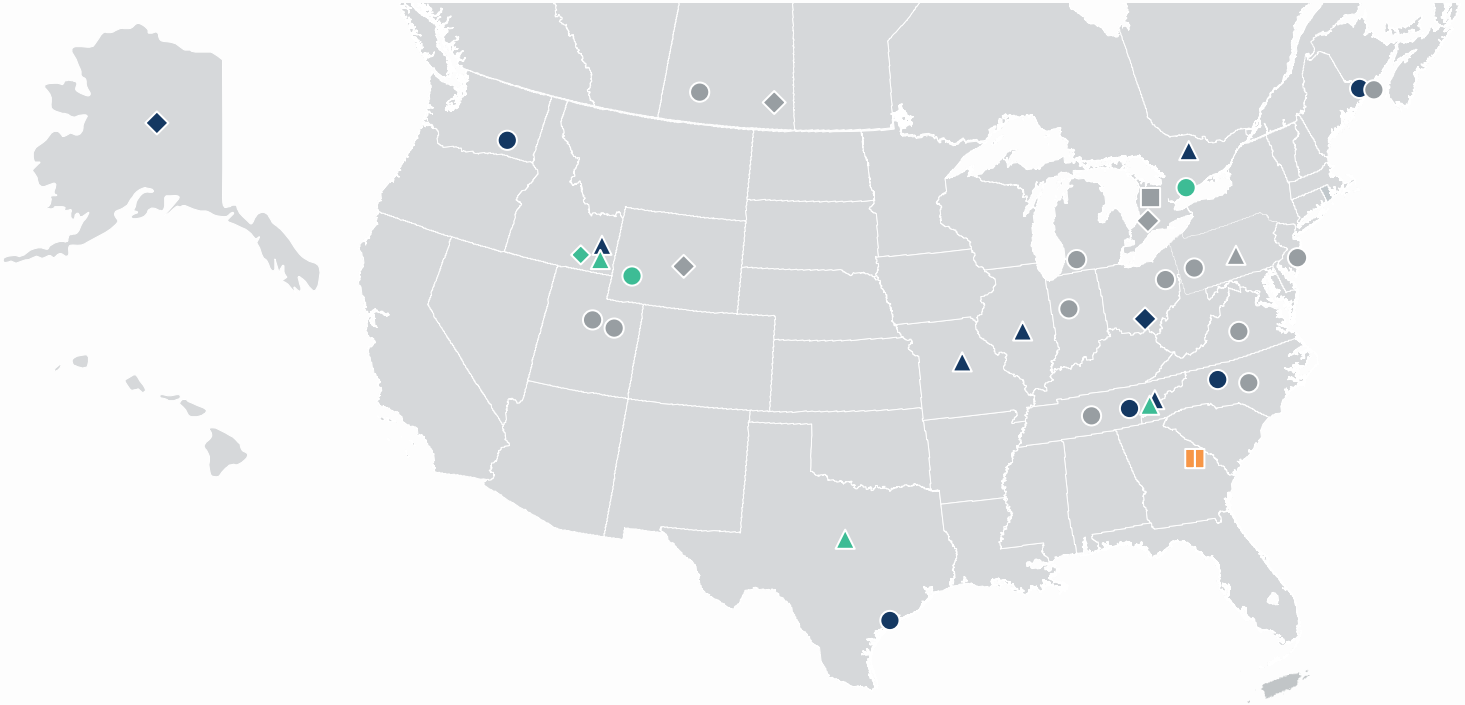
We need a way to produce more and more energy for our economy to keep growing	76%
We need to be building capacity for more energy, not just trying to use less	63%
We need nuclear energy in the mix, along with renewables, if we are to meet our climate goals	60%
Leaving nuclear waste behind is just wrong, 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 09/25/2024



Legend

- 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