State of New Nuclear

Nuclear Quality Assurance Challenges Workshop

December 5, 2024

Marc Nichol
Executive Director, New Nuclear

NUCLEAR ENERGY INSTITUTE

Advanced Nuclear Developer Members

Types of Advanced Reactors

Range of sizes and features to meet diverse market needs

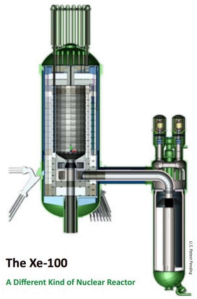
Water Cooled

Westinghouse AP1000® (shown)
ABWR

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

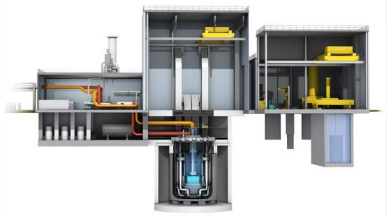
Non-Water Cooled

High Temp Gas Reactors



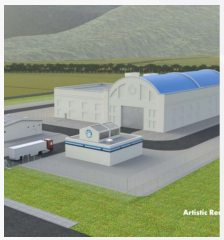
X-energy (shown)

Liquid Metal Reactors



TerraPower Natrium™ (shown)

Molten Salt Reactors



Kairos Hermes (shown)

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

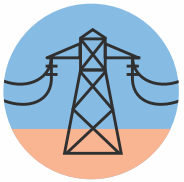
Micro (Few MW)

Mini (10s of MW)

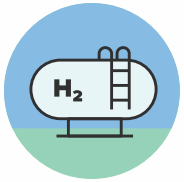
Small (100s of MW)

Large (1,000+ MW)

Variety of Outputs



Electricity



H_2 Hydrogen

Process Heat

Multitude of Uses

Homes

Vehicles

Businesses

Aviation

Rail

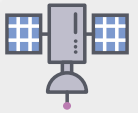
Shipping

Concrete

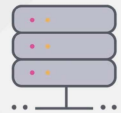
Steel

Factories

Water



Space



Data Centers

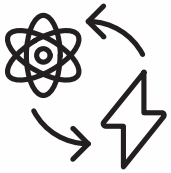
Watch the video: https://www.youtube.com/watch?v=7zN_YLg-roo

Recent Survey of NEI's U.S. Utilities

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**

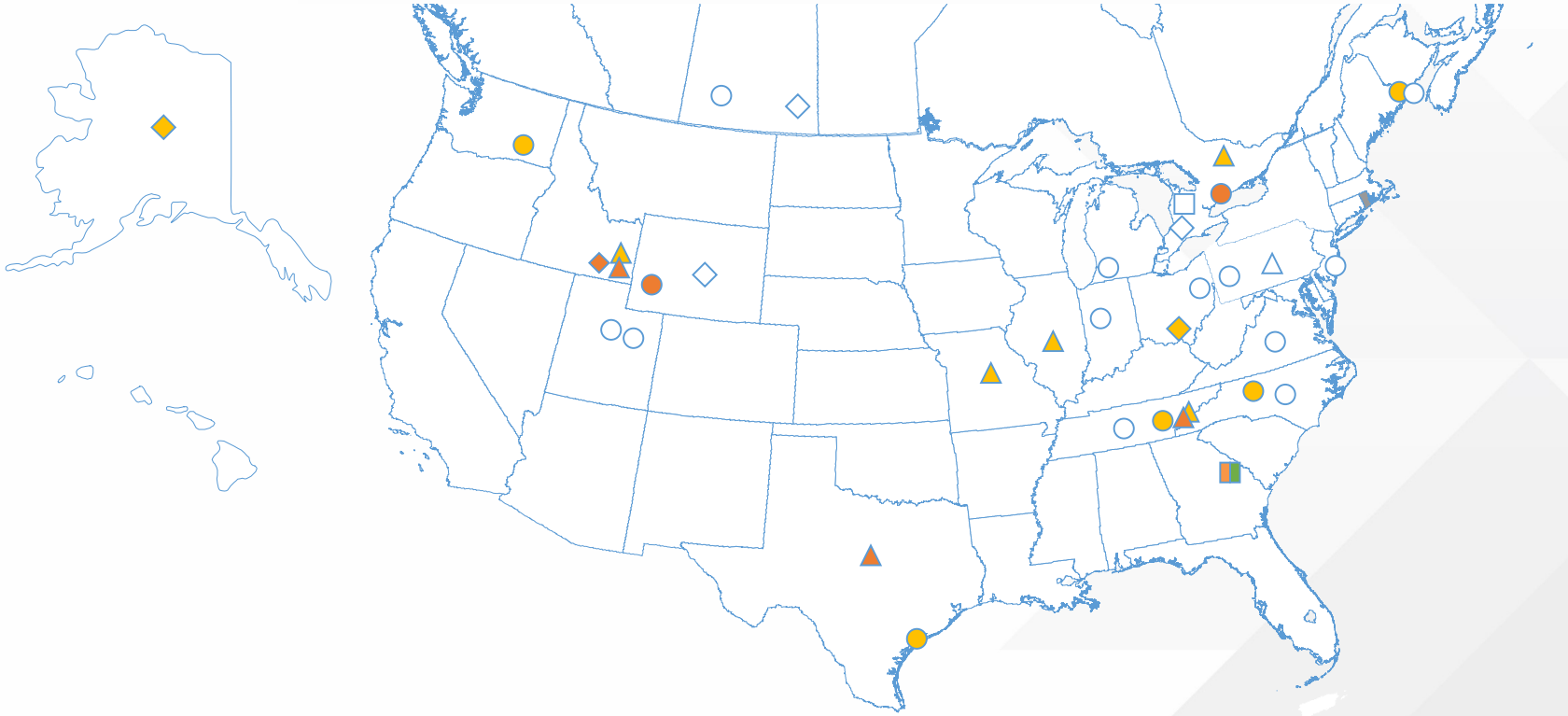
NEI utility member companies produce nearly half of all US electricity.

- 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)

Advanced Nuclear Deployment Plans

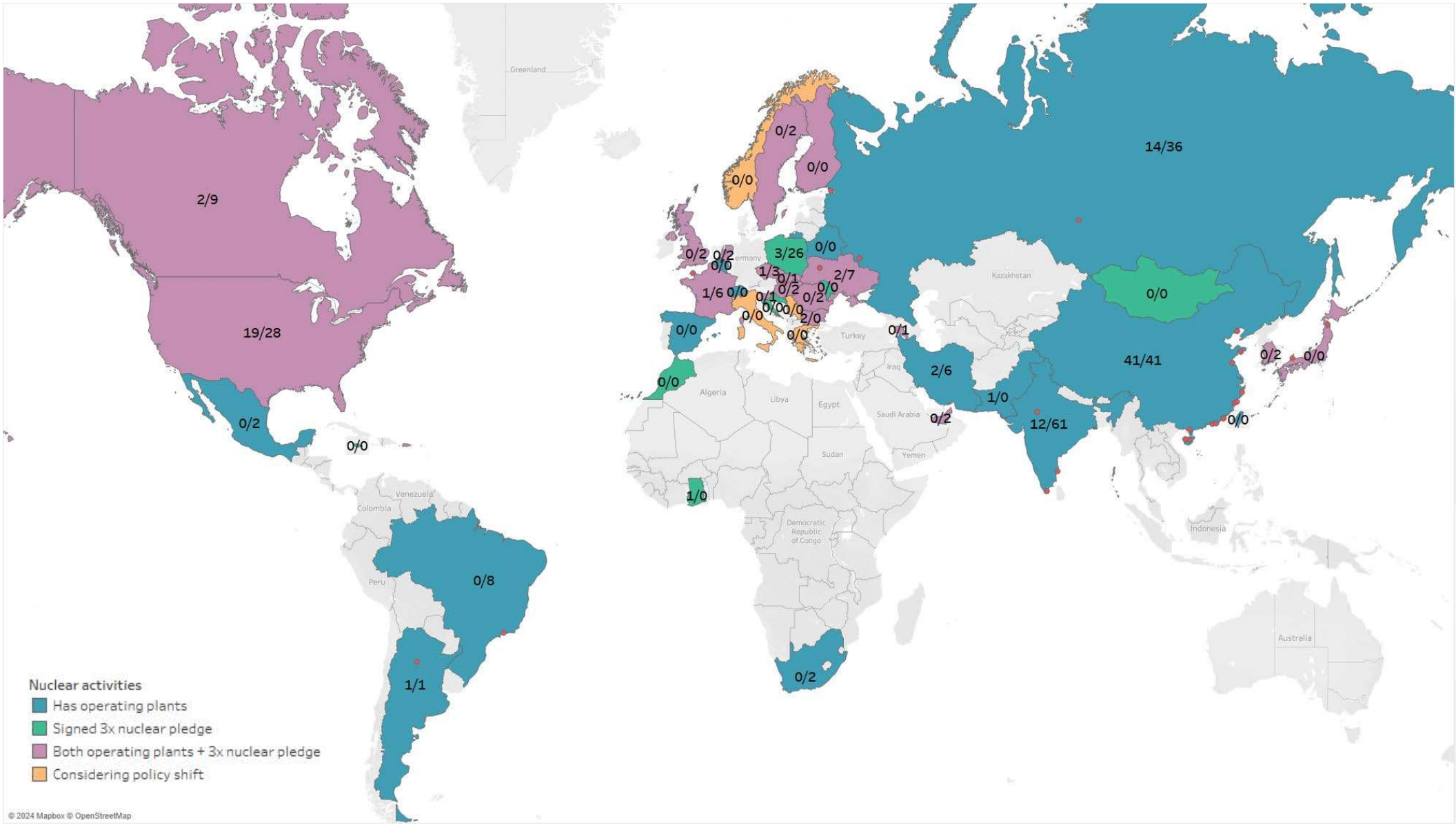
State support and projects that may be in operation by early 2030s

Updated 09/25/2024



Legend

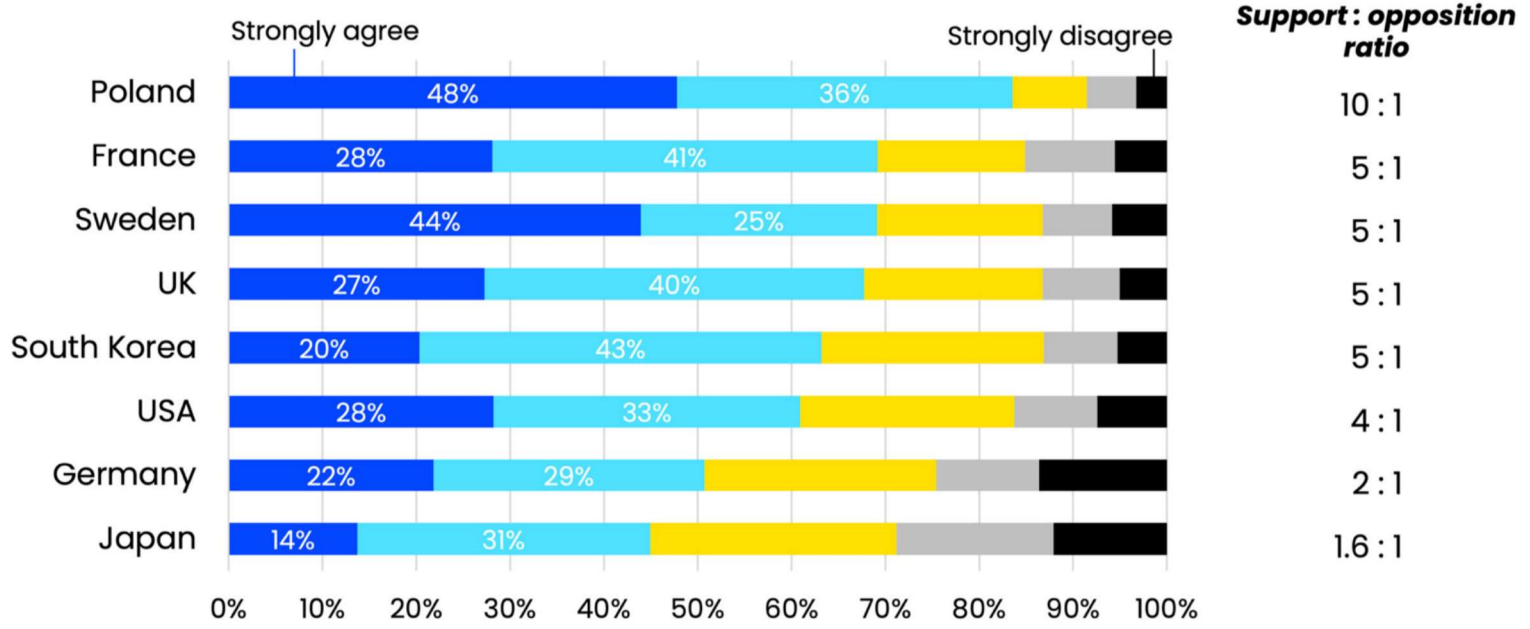
Considered project
Planned project
Under construction
Operating
Large (1,000 MWe)
Small (<300 MWe)
Micro-reactor (<50 MWe)
University / Research / Test


Greenland
2/9
19/28
0/2
0/0
Venezuela
Colombia
Peru
0/8
1/1
0/2
0/2
0/0
0/0
3/26
0/0
1/3
0/1
2/7
1/6
0/0
0/1
0/2
0/2
0/0
0/0
0/0
0/0
2/0
0/0
0/0
0/1
Turkey
Iraq
Algeria
Libya
Egypt
Saudi Arabia
Sudan
Yemen
1/0
Democratic Republic of Congo
0/2
14/36
Kazakhstan
0/0
41/41
0/2
0/0
2/6
1/0
0/2
12/61
0/0
Indonesia
Australia
Nuclear activities
Has operating plants
Signed 3x nuclear pledge
Both operating plants + 3x nuclear pledge
Considering policy shift
© 2024 Mapbox © OpenStreetMap

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

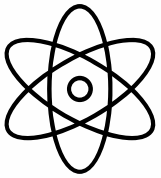
System Benefits of Advanced Reactors

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

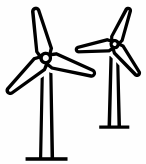
Source: SMR Start, *SMRs in Integrated Resource Planning*

Lowest System Cost Achieved by Enabling Large Scale New Nuclear Deployment

Lowest Cost System

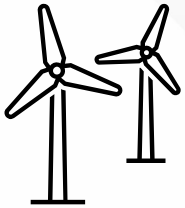


Nuclear is 43% of generation (>300 GW of new nuclear)

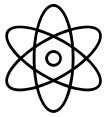


Wind and solar are 50%

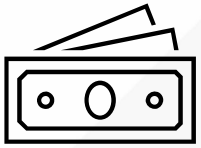
Energy System with Nuclear Constrained



Wind and Solar are 77% of generation



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

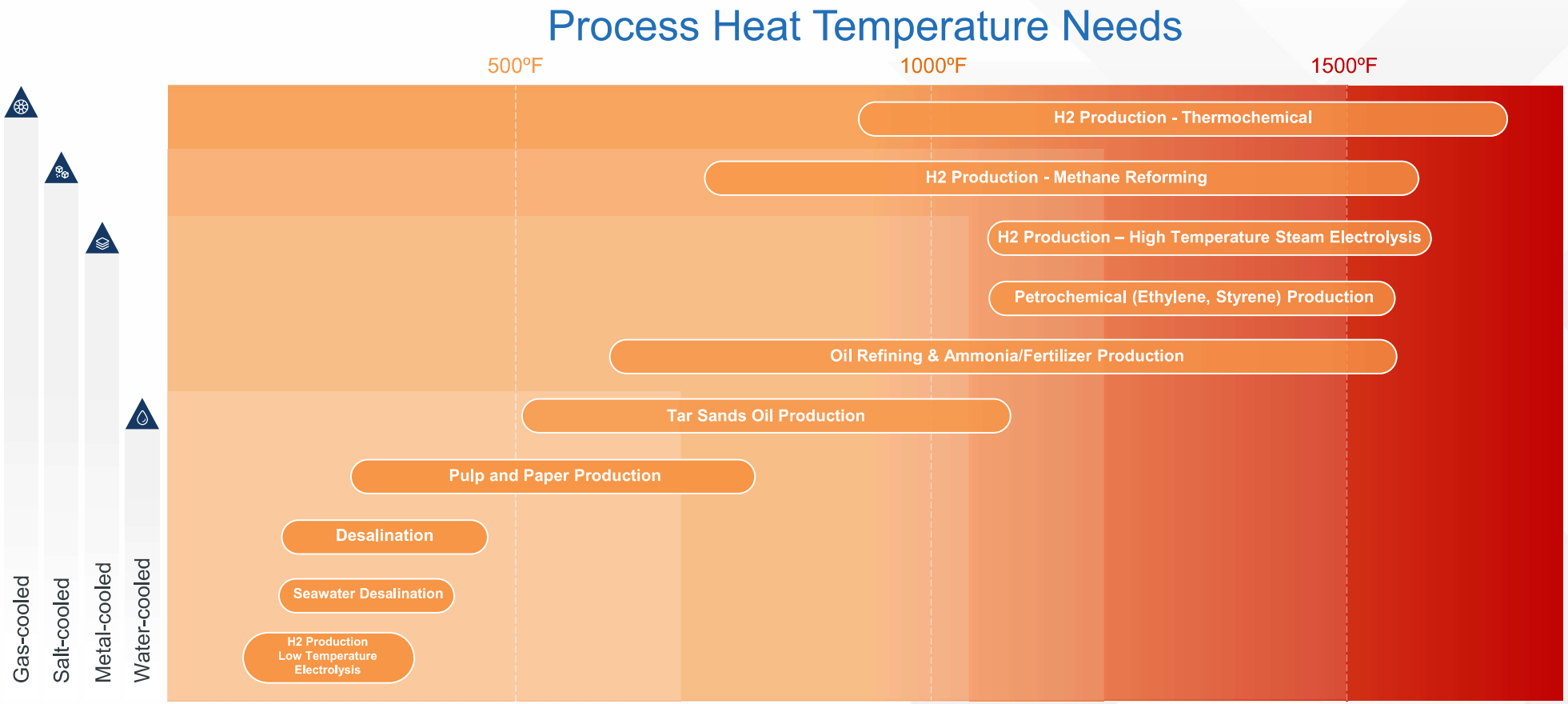


Increased cost to customers of $449 Billion

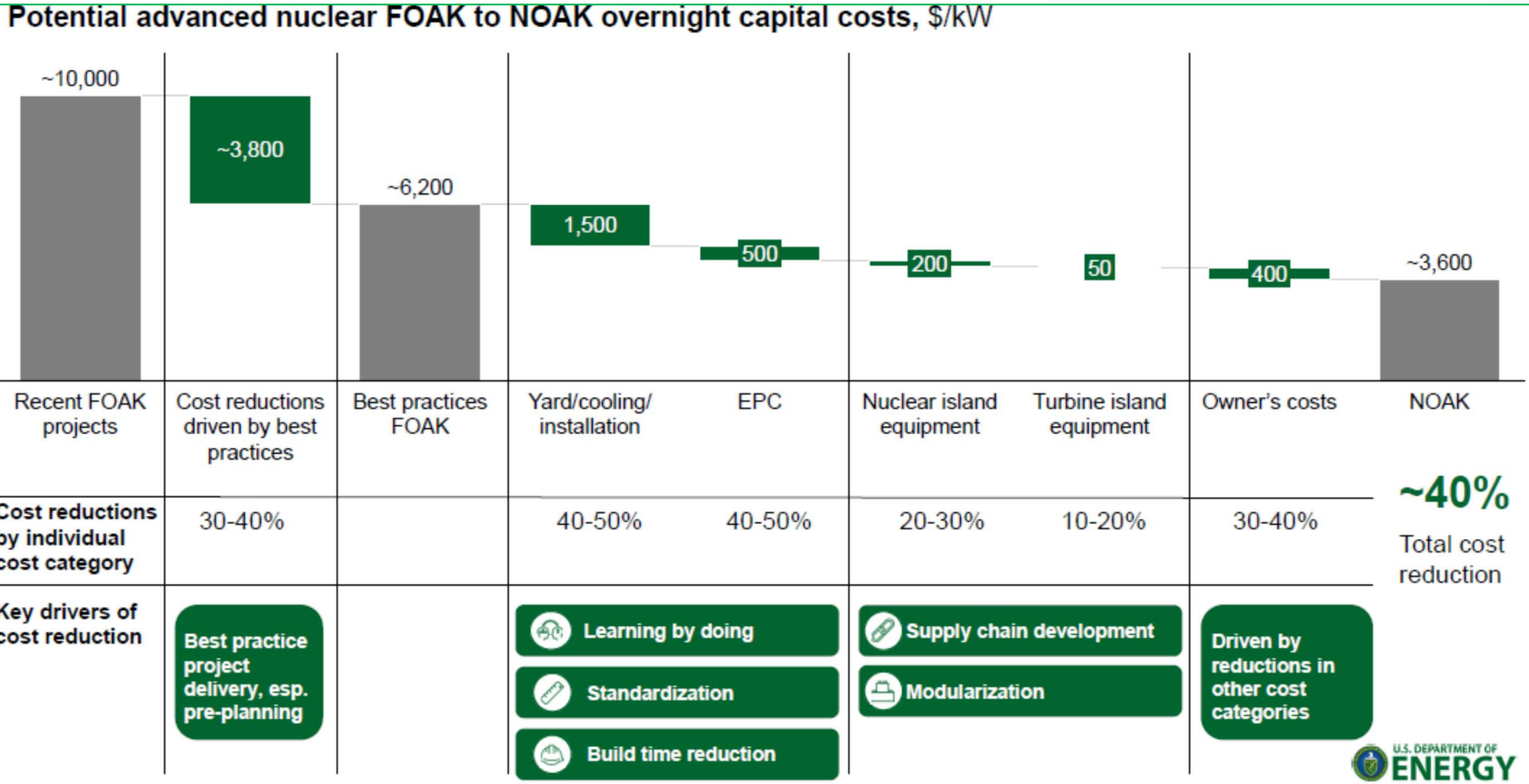
Both scenarios are successful in reducing electricity grid GHG emissions by over 95% by 2050 and reducing the economy-wide GHG emissions by over 60%

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

Nuclear Process Heat Capabilities



DOE Liftoff Report



Advanced 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

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

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)

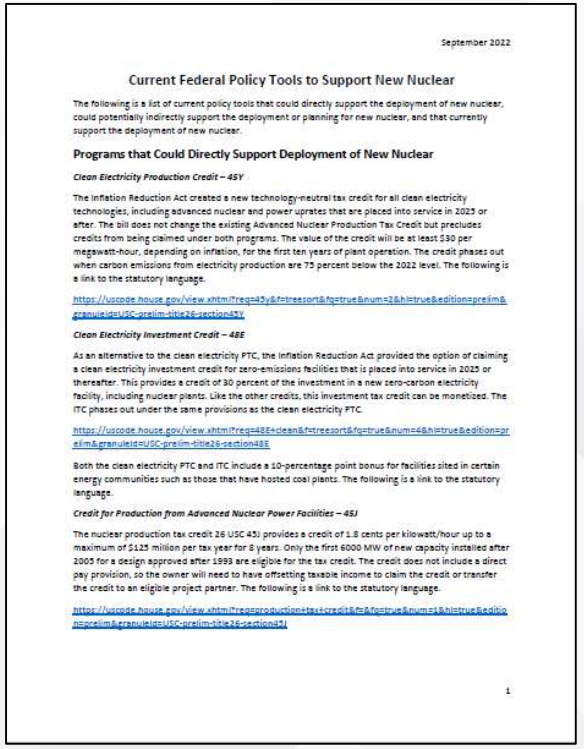
- $800 Million for utility use of light-water SMRs

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

1

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, Indiana, Kentucky, Louisiana, Maryland, Michigan, Ohio, Tennessee, New Hampshire, Nebraska, Montana, Pennsylvania, Florida and Texas
Recognizing Nuclear as a Clean Energy Resource	Idaho, Michigan, Minnesota, North Carolina, Tennessee, Utah, Virginia and Washington
Removing Barriers and Signaling Support	Repealing Nuclear Moratoriums: Wisconsin, Kentucky, Montana, West Virginia, Connecticut, Illinois repealed Signaling Regulatory Support: Indiana, Mississippi, North Carolina, 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

Advanced Reactor Licensing Progress

Approved

- NUSCALE Power for all humankind
- Kairos Power
- Natura Resources SUSTAINABLE ENERGY

Under Review

- NUSCALE Power for all humankind
- Kairos Power
- TerraPower

Pre-Application

- arc CLEAN TECHNOLOGY
- DEEP FISSION
- GENERAL ATOMICS
- GENERAL ATOMICS
- GE
- HITACHI
- HOLTEC INTERNATIONAL
- Kairos Power
- OKLO
- TERRESTRIAL ENERGY
- TerraPower
- USNC ULTRA•SAFE•NUCLEAR
- Westinghouse
- Westinghouse
- X energy

Updated 09/25/2024

New Designs = New Supply Chains

Current Fleet

- LEU Fuel Today and LEU+ Contracts Signed
- Mature Supply Chain
  - Tier-n Suppliers Known
  - Parts Quality

Robust and Resilient

New Reactors

- HALEU, LEU+, and LEU Fuel
  - Capacity Gap
- Lack of Systematic Planning
  - Primary Suppliers Not Fully Determined
  - Potential Tier-n Vulnerability

Development Needed

Overview of Nuclear Supply Chain

Step	Supply chain segments to meet the demand of the final product	Significant domestic suppliers	Cost competitive among US suppliers	Cost competitive between US suppliers vs. global suppliers	Is foreign supply source significant secure?	Likely best course of action
Mining and milling	Indium, Niobium, Yttrium, Hafnium	No	N/A	N/A	May be	Leverage intl. markets
	Chromium, Nickel	No	?	?	Yes	Leverage intl. markets
	Cadmium, Cobalt, Copper, Lead, Silver, Tin, Titanium, Tungsten, Vanadium, Zirconium	Yes	Yes	Yes	Yes	Expand existing US capability and leverage intl. markets
Processing	Steel	Yes	Yes	Yes	N/A	Expand existing US capability
	Concrete	Yes	Yes	Yes	N/A	Expand existing US capability
	Other	Yes	Yes	Yes	N/A	N/A
Component	Large component forging and manufacturing	No	?	?	Yes	Expand existing US capability and leverage intl. markets
	Other component forging and manufacturing	Yes	Yes	Yes	Yes	Expand existing US capability
Assembly	Module assembly	Limited	N/A	N/A	May be	Build US capability

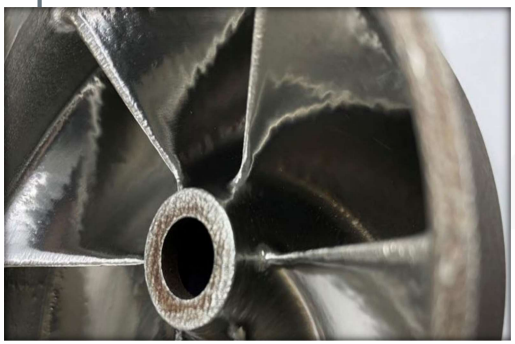
DOE LPO Liftoff Report

Key Enabling Tech – Adv Manufacturing

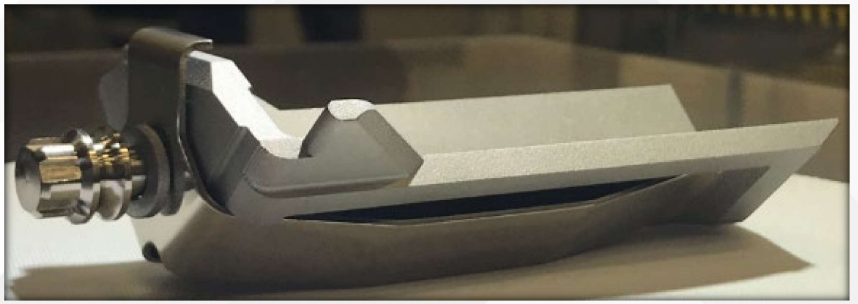
- Laser Powder Bed Fusion
- Powder Metallurgy – Hot Isostatic Pressing (PM-HIP)
- Electron Beam Welding (EBW)
- Cold Spray
- Directed Energy Deposition (DED)
- And many others…

Courtesy: Westinghouse

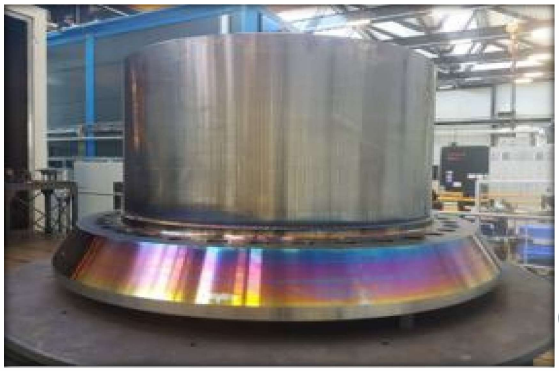
Courtesy: ORNL



Courtesy: Kairos

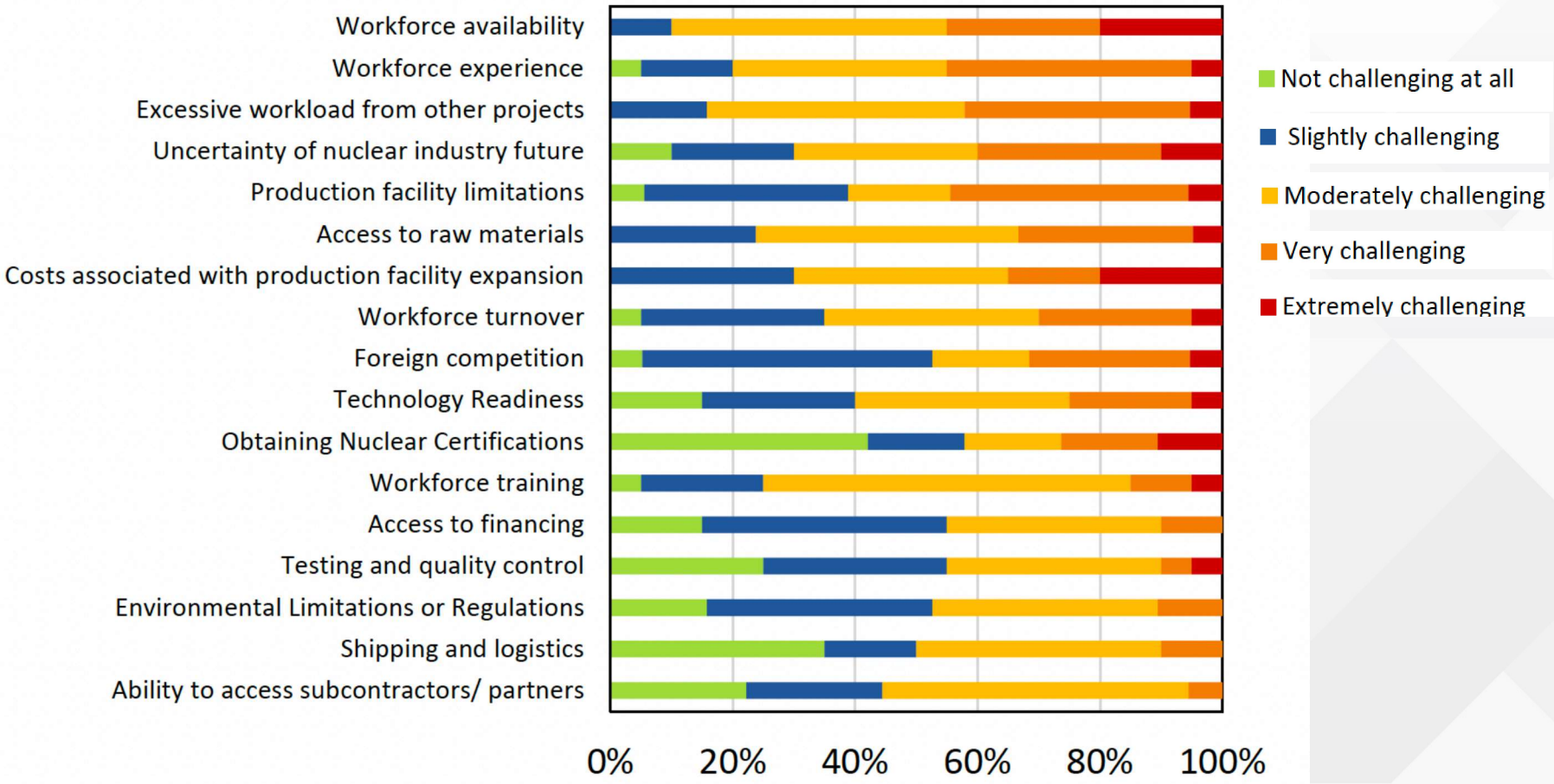


Courtesy: Framatome



Courtesy: EPRI

Supplier Concerns



Source: INL Supply Chain Report: https://nric.inl.gov/wp-content/uploads/2024/06/RPT-23-70928-Advanced-Reactor-Supply-Chain-Assessment.pdf

Quality Assurance

Moving from a “Barrier to Entry” to a “Key Enabler”

<u>Increasing Capabilities</u>

- New to nuclear supplier on-boarding
- Technology and innovation
- Sharing of best practices
- International collaboration

<u>Decreasing Challenges</u>

- Fewer safety-related components
- Acceptance of multiple QA Standards
- Streamlining requirements

QUESTIONS?