Northwest **Power** and **Conservation** Council

September 4, 2024

MEMORANDUM

TO: **Council members**

FROM: **Nate Clayville, ID State Staff**

SUBJECT: **Remarks from Nuclear Energy Institute (NEI) Staff: The Nuclear Landscape Looking Forward**

BACKGROUND:

Presenter: John Kotek, Senior Vice President, Policy and Public Affairs

Summary: Nuclear power is a carbon free, baseload energy source that runs at the highest capacity rate of any generating source nationwide at over 90%. As a result of those attributes, political dynamic shift in Europe resulting from the invasion of Ukraine, and the public's desire for carbon free power generation to combat climate change, utilities and their customers are looking to nuclear power to meet future load demand.

We've seen a rapid change in market conditions, public perception, and unprecedented assistance from Congress and States to support the industry. As a result, we are seeing more reactors stay online, secondary license renewal of the existing fleet, new reactors come online, and increased interest and development of advanced, small modular, and microreactors.

The United States is currently experiencing unprecedented load growth and nuclear can help meet that demand.

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Relevance: As the Council develops and maintains a regional power plan, insights from the nuclear energy sector could inform modeling and decisions on the future energy mix, particularly as the Council analyzes a suite of potential resources to meet future needs. Additionally, advancements in nuclear technology, such as small modular reactors, could play a crucial role in shaping the region's energy strategy, ensuring grid stability while meeting carbon reduction goals. This information would be valuable in guiding the Council's modeling and analysis that will ultimately inform the Council's policy recommendations in the evolving energy landscape.

This presentation was requested by the Council Chair as a means of supplementing the foundational knowledge of the Council members and staff.

Background: The Council has played a pivotal role in shaping the region's energy landscape. While past power plans have identified energy conservation and renewable resources as the cost-effective approach, the Council recognizes the potential role of that emerging technologies, such as small modular reactors, will play in meeting the region's long-term energy needs, particularly as it aims to reduce carbon emissions.

More Info: More information about the work and research being performed by the Nuclear Energy Institute can be found at https://nei.org.

The Growth of Nuclear Energy in the United States

Andrew Neill
Senior Director

John Kotek
Senior Vice President

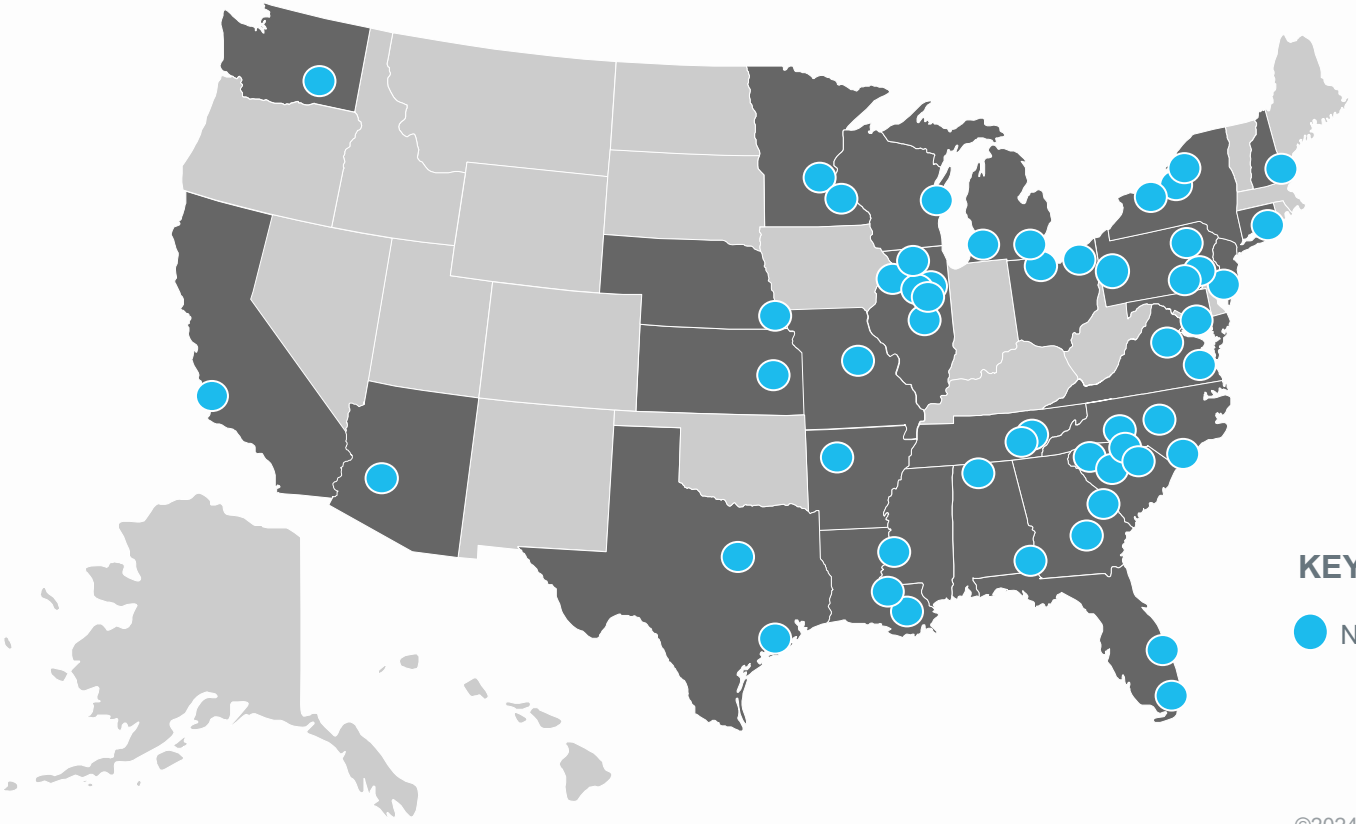
September 2024

NUCLEAR ENERGY INSTITUTE

About NEI

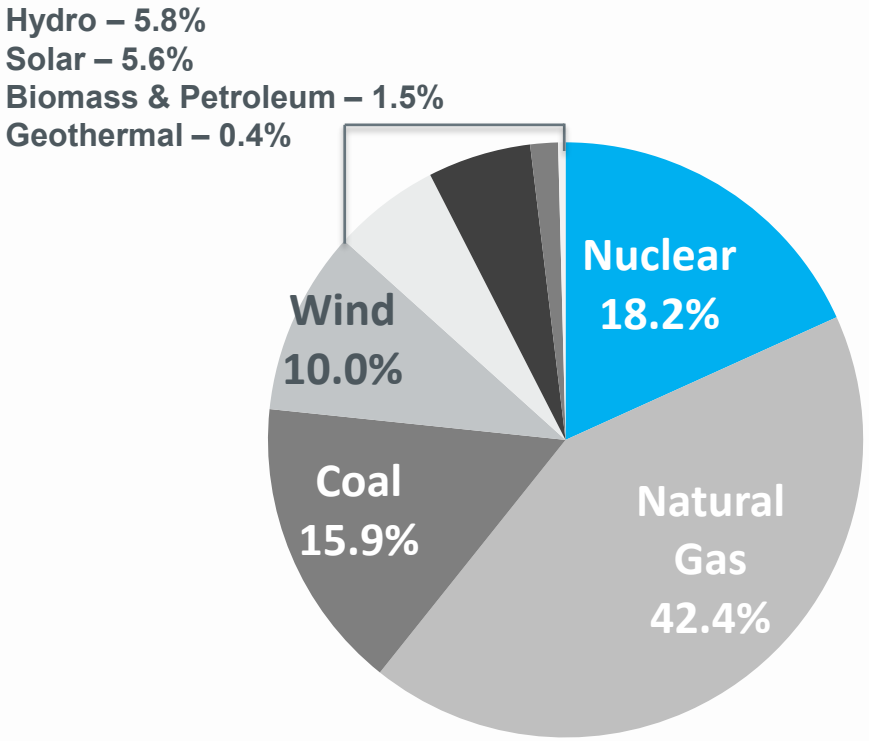
- Washington, D.C., policy and membership organization
- A unified industry voice before U.S. government, international organizations and venues
- A forum to resolve technical and business issues for the commercial industry
- A source of accurate and timely information to members, policymakers, the news media and the public
- 330+ members from more than a dozen countries

94 reactors at 53 plant sites across the country



Updated: May 2023

Nuclear generated 18% of U.S. electricity in 2023



Notes: Includes small-scale solar.
Source: U.S. Energy Information Administration
Updated: February 2024

THE EMISSIONS REDUCTION IMPERATIVE

REUTERS

ENVIRONMENT MARCH 20, 2018 / 10:29 AM / A YEAR AGO

McDonald's sets greenhouse gas reduction targets

Lisa Baertlein 3 MIN READ

(Reuters) - McDonald's Corp on Tuesday announced an approved, science based target to cut greenhouse gas emissions and battle climate change, saying it is the first restaurant company to do so.

Supply chains + Add to myFT

Blue chips act to cut supply chain greenhouse gas emissions

Rolls-Royce, Nestlé and Panasonic among larger companies taking action

Michael Pooler JANUARY 29, 2018 2

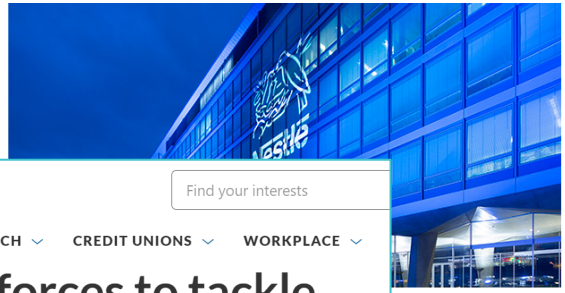
CLIMATE

Nestlé commits to net-zero target by 2050

E&E NEWS PM

Haley Weiss, E&E News reporter

Published: Monday, September 16, 2019



emissions by 2050 with a
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the Business Ambition for
.5 degrees Celsius above
cretary-general's Climate
g," Nestlé CEO Mark

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Levi's Plans to Slash Emissions in Global Supply Chain by 2025

The apparel giant aims to reduce greenhouse gas emissions at a sprawling set of factories and mills in 39 countries, sta
suppliers

Levi's will start its effort to cut greenhouse gas emissions through energy-efficiency programs at factories run by vendors in the first tier of its supply chain, such as this supplier facility in Mexico. PHOTO: PHOTO COURTESY OF LEVI STRAUSS & CO.

AMERICAN BANKER

Find your interests

BANKING POLICY PAYMENTS TECH CREDIT UNIONS WORKPLACE

Regional banks join forces to tackle climate change

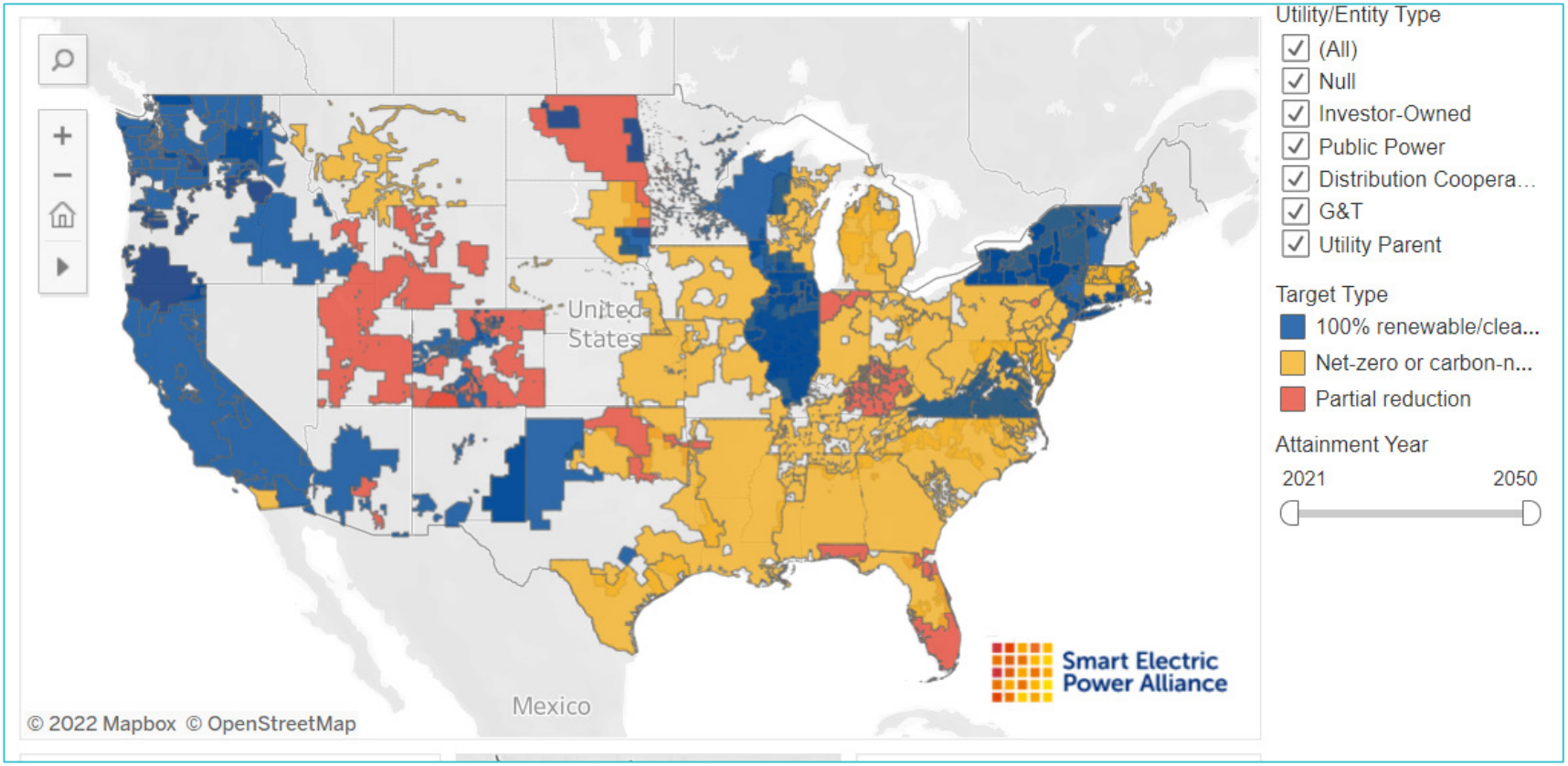
By Allissa Kline March 23, 2022, 5:28 p.m. EDT 2 Min Read

Two months after forming a consortium of large, international banks to address the risks associated with climate change, the Risk Management Association has established a similar group for midsize banks.

The RMA Regional Bank Climate Risk Consortium has launched with five members, including Zions Bancorp. in Salt Lake City, Utah, and Webster Financial in Stamford, Connecticut, RMA announced Wednesday in a press release. Like its counterpart for larger banks, the regional bank consortium will assist banks in creating guidelines for integrating climate risk

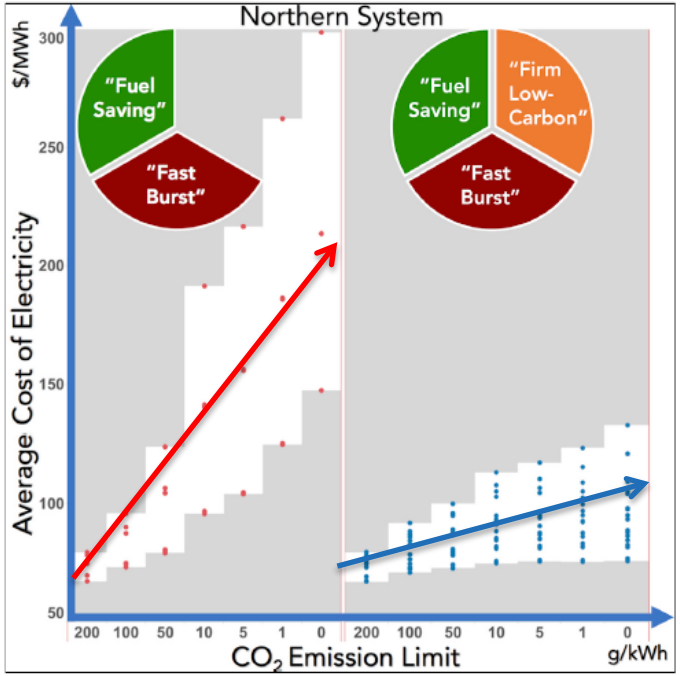
>8,700 COMPANIES WITH CARBON REDUCTION TARGETS

UTILITIES WITH EMISSIONS REDUCTION TARGETS



Source: https://sepapower.org/utility-transformation-challenge/utility-carbon-reduction-tracker/

FIRM, LOW-CARBON GENERATION FROM NUCLEAR ENABLES AFFORDABLE DECARBONIZATION AND SYSTEM RESILIENCE



Nestor A. Sepulveda, Jesse D. Jenkins, Fernando J. de Sisternes, Richard K. Lester

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rklester@mit.edu (R.K.L.)

HIGHLIGHTS

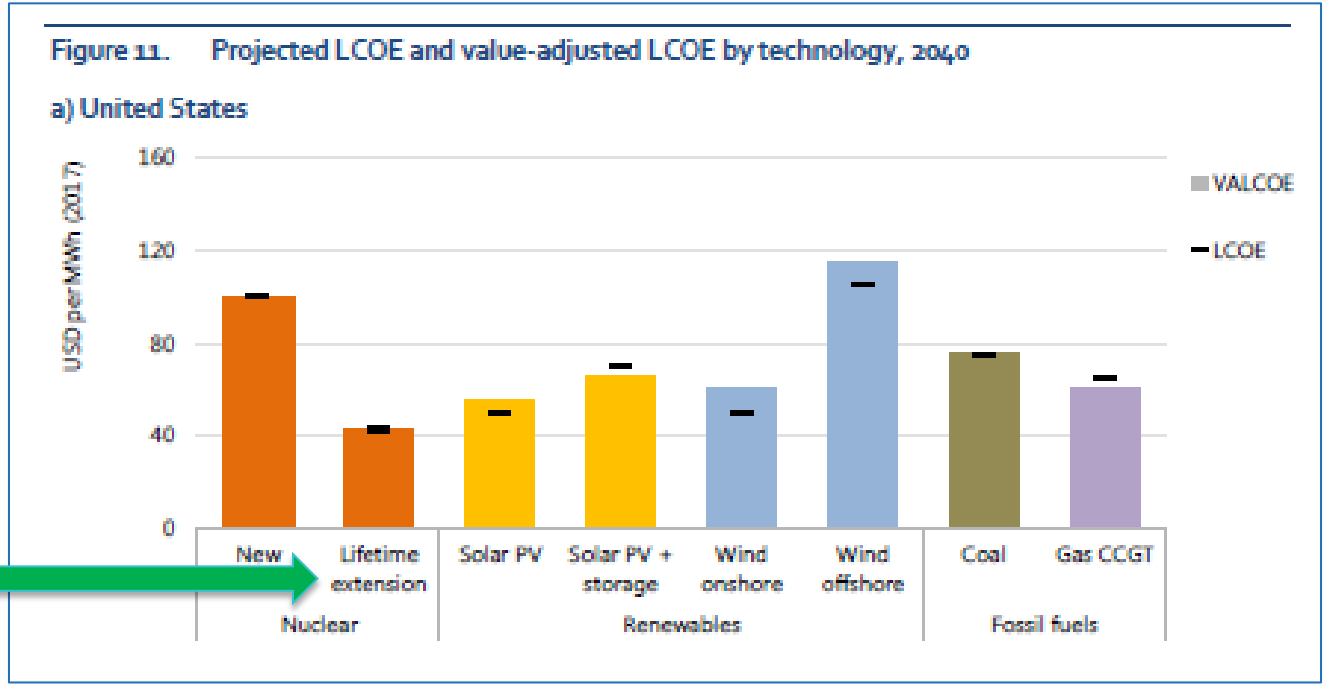
Firm low-carbon resources consistently lower decarbonized electricity system costs

Availability of firm low-carbon resources reduces costs 10%–62% in zero-CO_2 cases

Without these resources, electricity costs rise rapidly as CO_2 limits near zero

Batteries and demand flexibility do not substitute for firm low-carbon resources

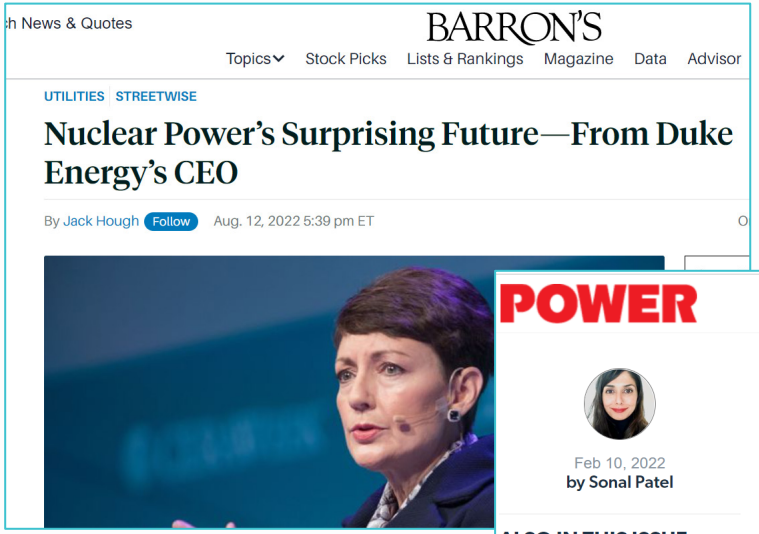
STEP ONE TO DECARBONIZATION: PRESERVE EXISTING NUCLEAR GENERATION

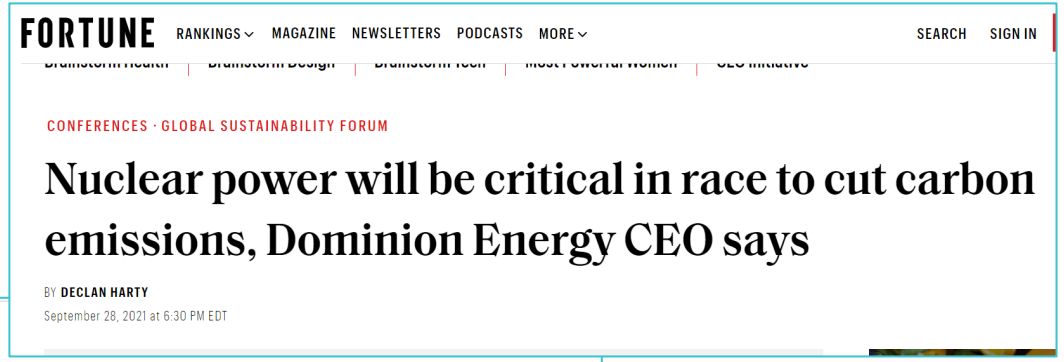


NUCLEAR LICENSE RENEWAL – MOST COST-EFFECTIVE CARBON REDUCTION

Source: https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

Utilities Including New Nuclear in Future Resource Planning





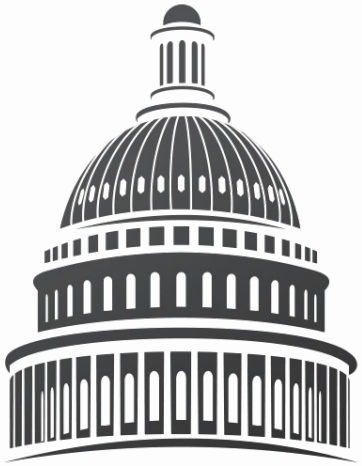
NUCLEAR GENERATION CREATES LONG-TERM, WELL-PAYING JOBS

Coal Plant Position	# Dedicated Coal Positions	SMR Position	# Dedicated SMR Positions	Position Type	Degree of Retraining Required
Operations Supervisor	5	Senior Reactor Operator	5	Supervisor	High
Control Room Operator	10	Reactor Operator	15	Operator	High
Field Operator	15	Non-Licensed Operator	25	Operator	Low
Lab Operator/Chemistry/Scrubber	4	Chem Tech	14	Craft	Medium
Maintenance Supervisor	2	Maintenance Supervisor	3	Supervisor	Medium
Mechanical Craft	12	Mechanical Craft	21	Craft	Low
I&C Craft	9	I&C Craft	10	Craft	Medium
Electrician Craft	5	Electrician Craft	11	Craft	Low
Technician	11	Technician	13	Laborer	Low
Security Officer	20	Security Officer	48	Laborer	Low
Sub-Total	**93**		**165**		
All Other Positions	14		72	42 are O&M Support (Planners, Outage, etc.)	Medium
Total On-Site Positions	**107**		**237**		
Possible Centralized Positions			33		
Total Positions			**270**		

Sources: NuScale; ScottMadden analysis

NUCLEAR GENERATION IN U.S. PAYS HIGHEST AVERAGE WAGES

Sourcehttps://www.scottmadden.com/content/uploads/2021/10/ScottMadden_Gone_With_The_Steam_WhitePaper_final4.pdf



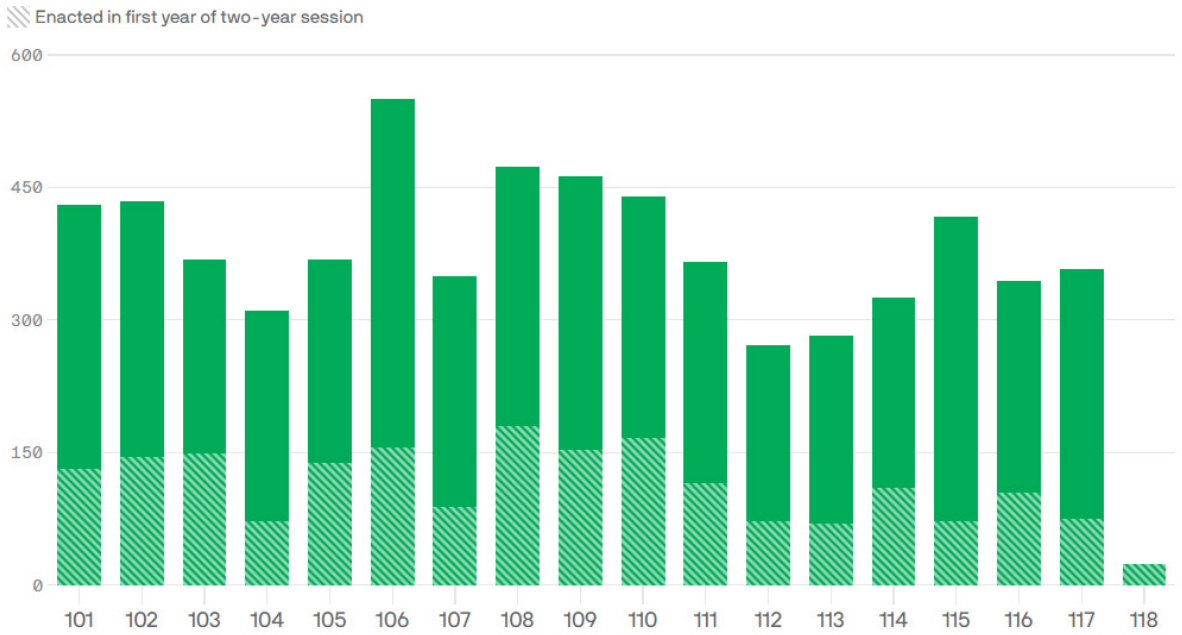
Legislative Wins in the Nuclear Industry

Capitol Hill stunner: 2023 led to fewest laws in decades

Andrew Solender

Bills enacted, by congressional session

101st Congress (1989) to 118th Congress (2023); As of Dec. 18, 2023



Data: Quorum; Chart: Simran Parwani/Axios

117th Congress (2021-2022)

Infrastructure Investment and Jobs Act
$6 billion for the Civil Nuclear Credit Program

$2.4 billion to fund ARDP awards from FY 2022 through 2025

Inflation Reduction Act
Nuclear Production Tax Credit

New Clean Generation Investment and Production Tax Credits

$700 million for domestic production of high-assay low-enriched uranium ("HALEU")

118th Congress (2023-2024)

Nuclear Fuel Security Act
LEU/HALEU domestic production authorizing legislation contained in FY 2024 National Defense Authorization Act (NDAA)

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

$800 Million for Small Modular Reactors

40 Year Reauthorization of the Price-Anderson Indemnification Act

NRC Chair Hanson re-appointed and confirmed

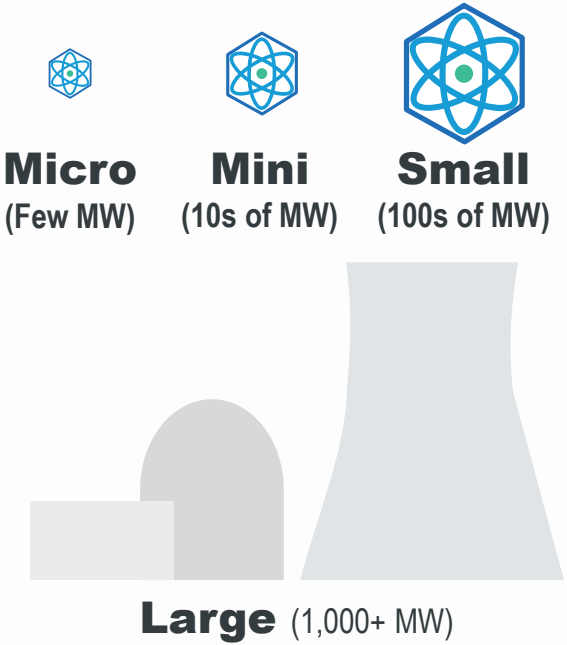
Prohibiting Russian Uranium Fuels Act

ADVANCE Act

TECHNOLOGY DEVELOPERS - NEI MEMBERS

Advanced Nuclear Versatility

Spectrum of Sizes/Options



Variety of Outputs

Multitude of Uses

Advanced Reactor Safety

Building upon a strong safety record

- Operating fleet: one of the safest industrial working environments
  - Strong-Independent Regulator, Strong Operational Performance
- Enhancing safety for advanced reactors*

Inherent Safety Features

- Rely on physics
  - Natural circulation
  - Gravity
- Below grade
- Higher melting points
- Atmospheric pressure

Reduce Risks

- Smaller source terms
- Minimize potential for accidents
- Mitigate consequences

Emergency Response

- Maintain safety without the need for
  - Power
  - Additional coolant
  - Human actions
- Emergency planning

*Features vary by design

Advanced Reactor Status

- Wide variety of new technologies being developed
- DOE funding 12 different designs, >$5B over 7 years
  - 3 Demonstration Plants
  - 9 Technology Development
- Over 20 projects planned or being considered in U.S. and Canada
- U.S. utilities evaluating nuclear in IRPs
  - Growing interest in conversion of coal power sites to nuclear
- Continued strong support in Congress
  - Infrastructure Investment and Jobs Act included $2.4B

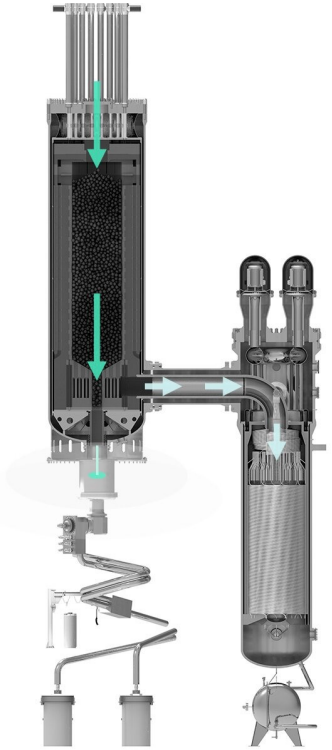
DOE ARDP Demonstration Awards

- Natrium Reactor
  - Terrapower/GE-Hitachi design
  - Liquid sodium fast reactor - 345 MWe
  - Metallic fuel
  - Molten salt thermal storage for peaking to 500 Mwe
  - Selected construction site in Kemmerer, WY near retiring coal plant

DOE ARDP Demonstration Awards

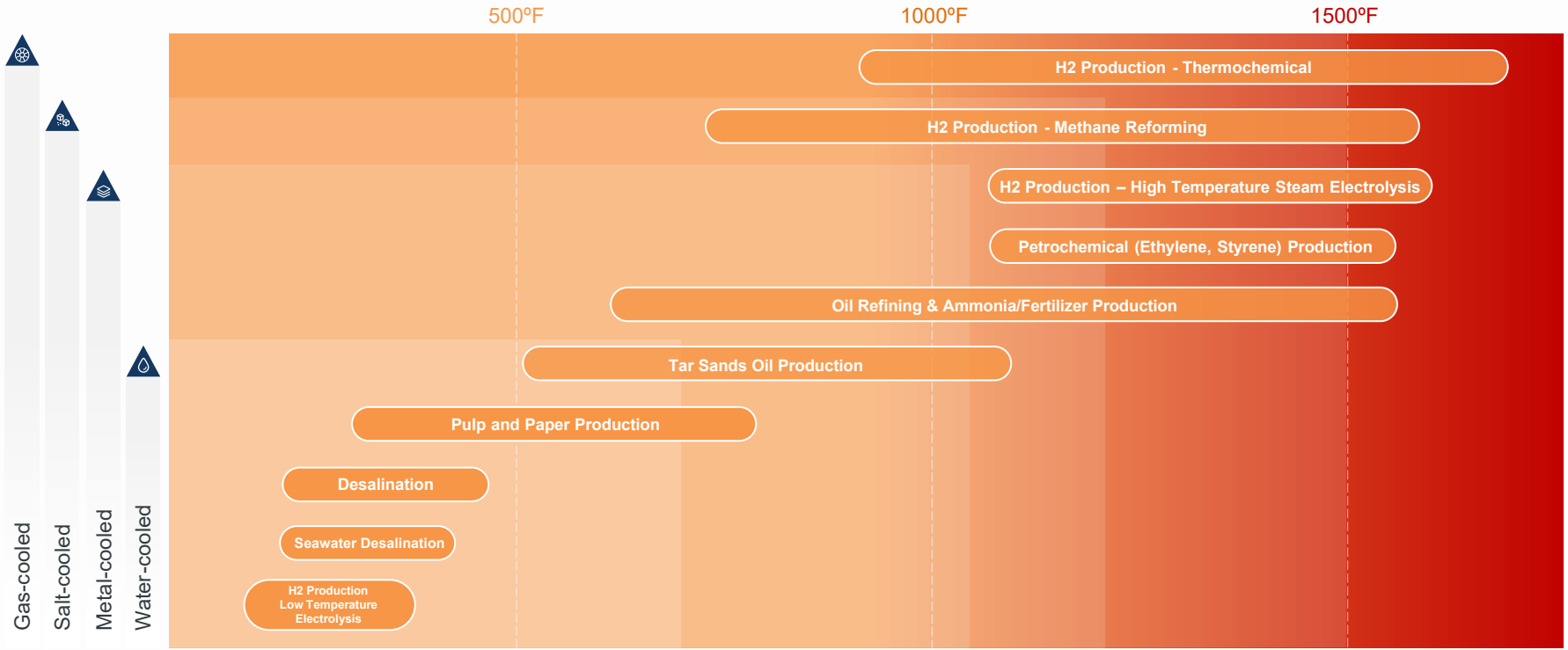
- Xe-100
  - Pebble bed Helium cooled gas reactor – 80 MWe
  - Four reactors
  - TRISO fuel
  - Planned construction at Dow facility in Seadrift, TX

TRISO Fuel Pebble Cutaway

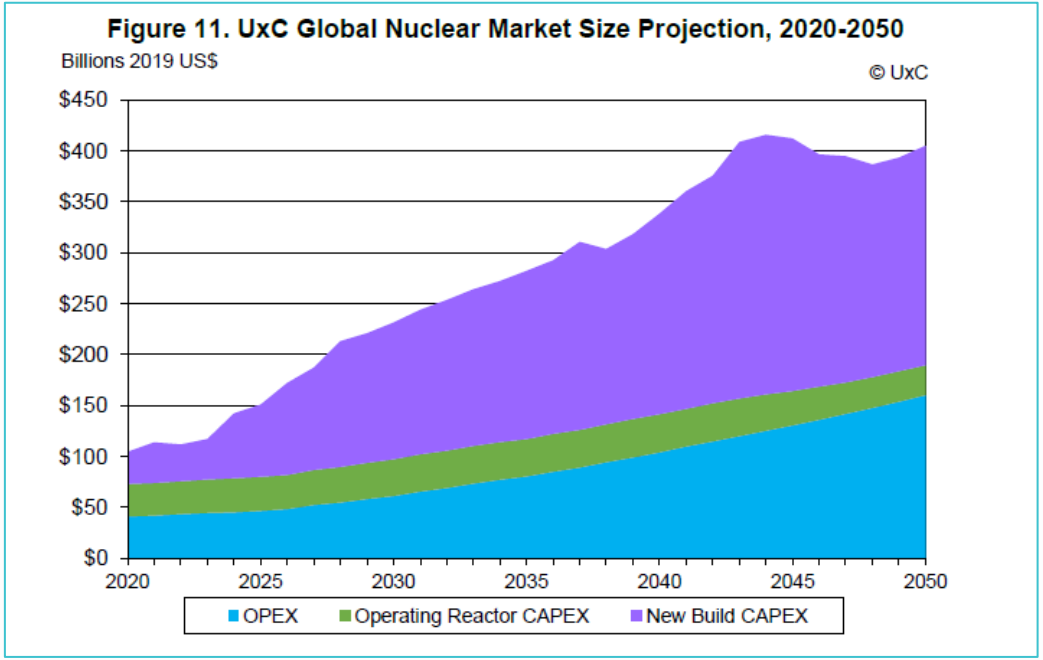


Nuclear Process Heat Capabilities

Process Heat Temperature Needs



GROWING GLOBAL MARKET FOR NEW NUCLEAR ENERGY SYSTEMS



ESTIMATED $8T+ GLOBAL NUCLEAR ENERGY MARKET THRU 2050

Source: https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/UxC-NEI-(IPCC-2050-Nuclear-Market-Analysis-PUBLIC)-2020-07-01.pdf

QUESTIONS?

By Third Way, GENSLER

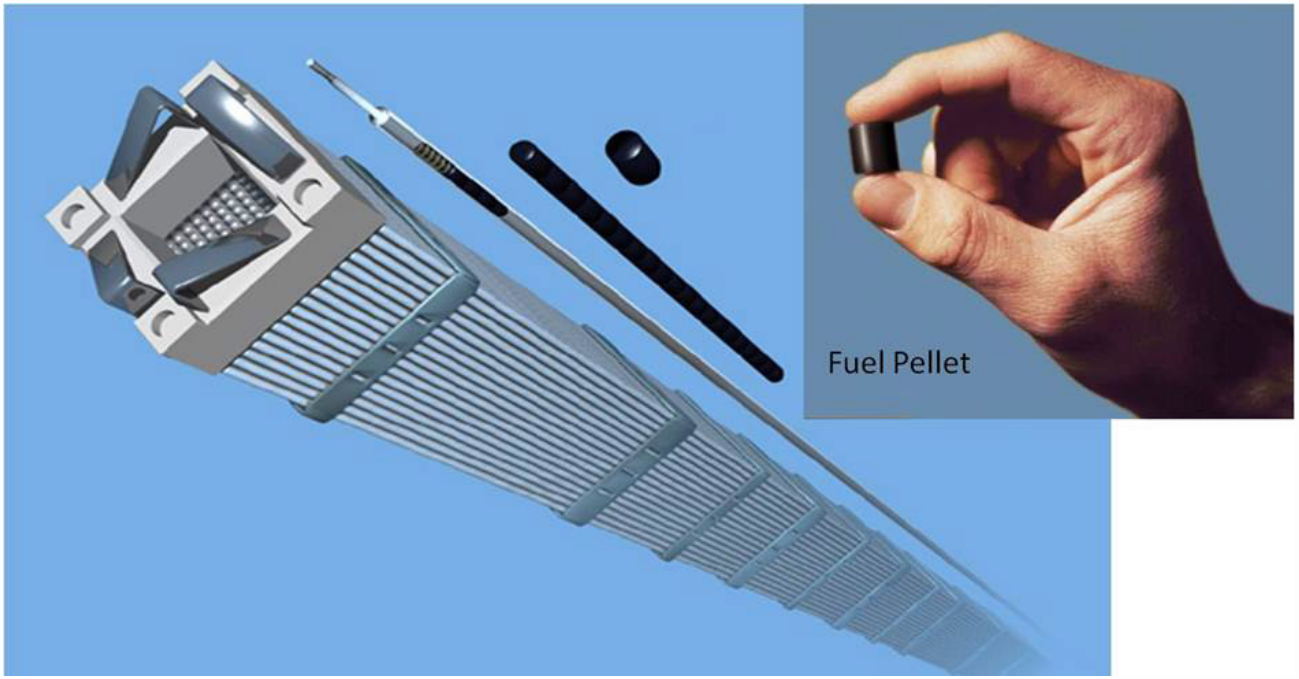
Backup Slides

Addressing Waste

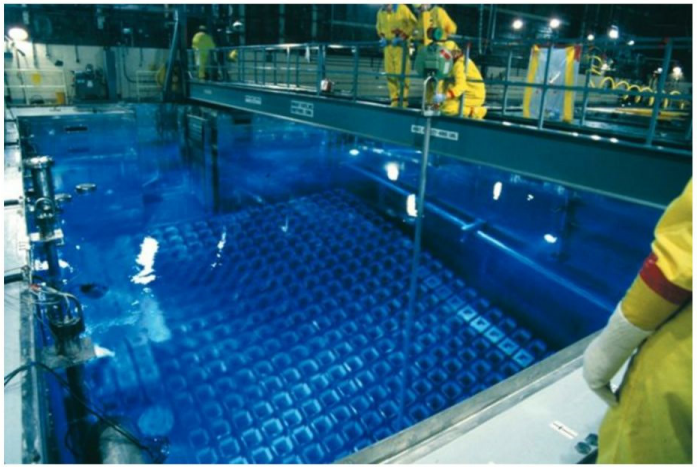
All Energy Sources Have Waste, and All Must Do Three Things to Address it

- Must be able to manage it safely
  - Used fuel is solid, compact and there is proven technology to store it safely
  - Over 1,300 used fuel shipments safely completed in U.S.
- Must be able to pay for it
  - U.S. law requires nuclear plants to fund used fuel management and decommissioning activities
  - Over $40 billion in Nuclear Waste Fund
- Must have a place to put it
  - Department of Energy required dispose of used fuel
  - Most micro-reactor companies will take back used fuel soon after refueling

Nuclear Fuel



(source: https://nuclear.duke-energy.com/2014/02/11/do-we-have-enough-nuclear-fuel)



(source: https://nuclear.duke-energy.com/2016/10/05/the-facts-about-used-nuclear-fuel)

Dry Cask Storage

Used Nuclear Fuel in the U.S.

Used Fuel Inventory*

- Approximately 87,000 MTU
- Increases 2 - 2.4k MTU annually

ISFSI** storage

- 153,840 assemblies
- 43,500 MTU (50%)
- 3,477 casks/modules loaded
- 73 Operating dry storage ISFSIs
- 20 sites where reactor operations have ceased

Vertical Storage

Horizontal Storage

*As of June 2021

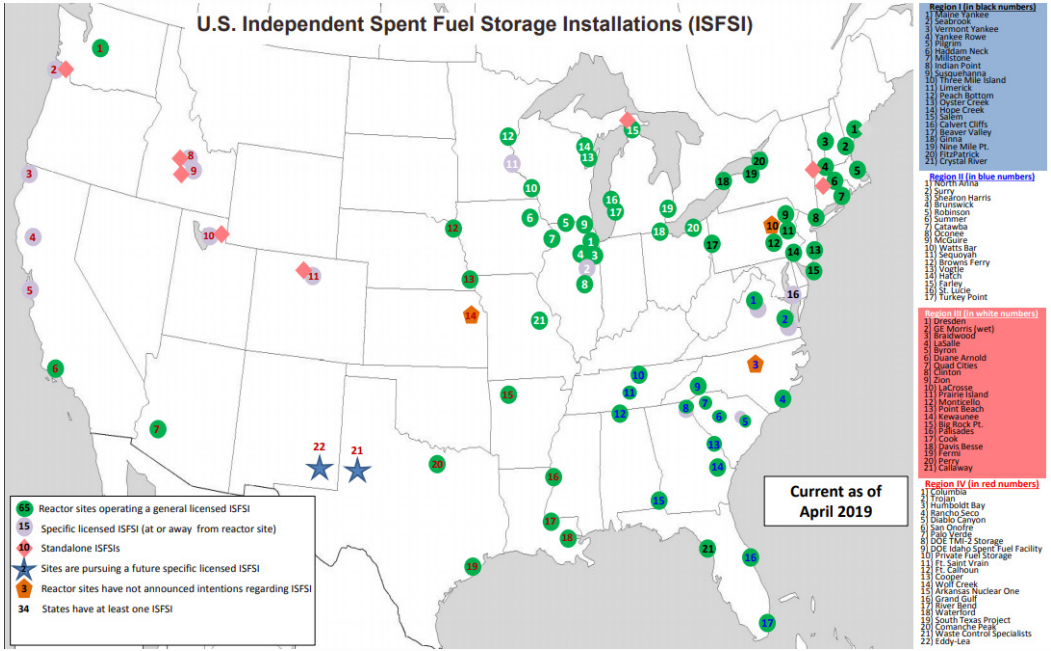
** ISFSI = Independent Spent Fuel Storage Installation

Dry Cask Storage (continued)

Used Nuclear Fuel in the U.S.

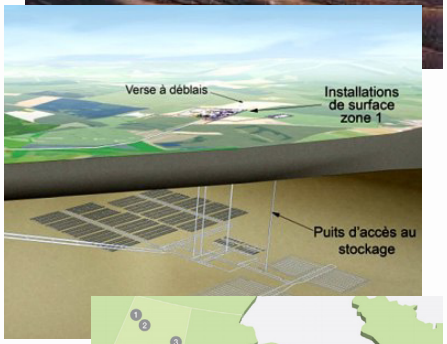
Long-term commitment

- First Casks Loaded in 1986
- Licenses being extended to 60 years
- Licenses extensions approved at 32 sites
- Licenses renewable for additional 40-year periods
- NRC determined casks safe for “at least” 100 years



Geologic Repository or Final Disposal

- Nations making progress on spent nuclear fuel disposal
  - Finland – repository licensed and under construction
  - Sweden – repository approved for constructing
  - France – site identified, in public consultation toward pilot phase
  - Canada – List of 22 candidate sites narrowed down to 2, geologic investigations under way
  - Switzerland – geologic investigations supporting siting process underway
  - U.S. – Yucca Mountain designated by law, alternatives being considered
- Consolidated Interim Storage
  - France, Sweden, and Switzerland all have deployed CIS
  - U.S. companies pursuing CIS solutions



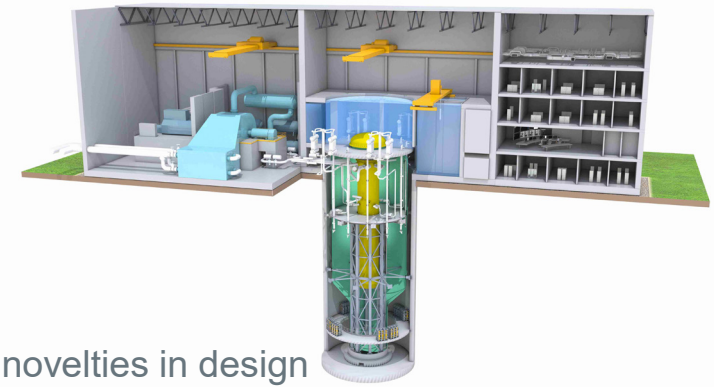
The 40 used fuel casks hold all the fuel from 29 years of Connecticut Yankee operations

If the electricity produced by this fuel instead came from natural gas, the emitted CO_2 would fill the Superdome. More than 3,000 times.

(source: http://www.connyankee.com/html/fuel_storage.html)

GEH BWRX-300

Light-Water SMR

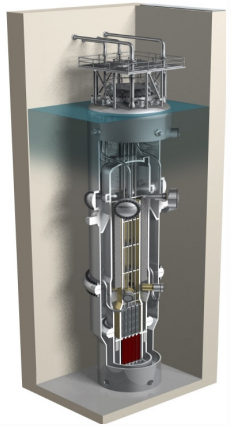


- Design
  - 300 MWe
  - Cost competitive with natural gas
  - Existing fuel design
  - Novel construction techniques – work with NRIC
- Licensing
  - Leverages NRC approved ESBWR
  - 9 Topical Reports with NRC (most approved) – addresses novelties in design
  - NRC/CNSC Joint Review – Coordination with Poland
  - CNSC review of OPG construction permit ongoing – submitted in 2022
  - TVA expected to submit construction permit in 2024
- Project Development
  - OPG contract for Darlington around 2030
  - TVA plans at Clinch River early 2030s
  - Orlen-Synthos in Poland (24 total) – Project Phoenix
  - Others: SaskPower, Estonia, GDA in UK, Czech, Sweden, others in discussion

NuScale VOYGR™ Reactor

Light-Water SMR

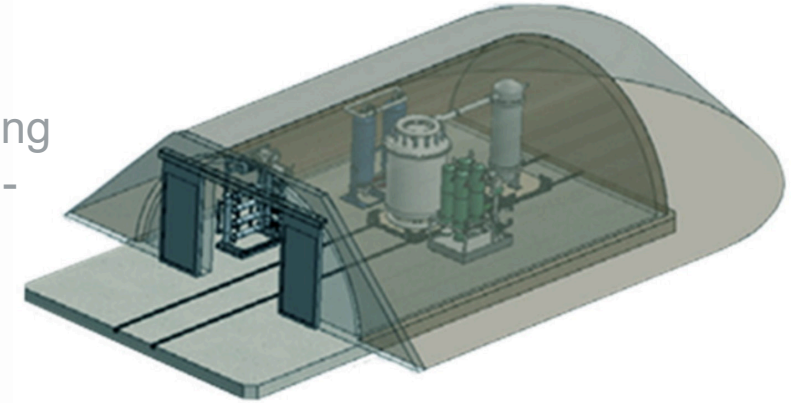
- Design
  - Module = 77 MWe
  - Plant (4 to 12 modules) = 308 MWe to 924 MWe
  - Individual modules adjust output rapidly
  - Existing Fuel Design (Framatome)
  - Ability to safely shut down and self-cool, indefinitely
  - Air cooling for condensers is an option
- Licensing
  - Design Certification (50 MWe version) approved in 2020
  - NRC approval of 77 MWe expected in 2025
  - DOE support for design and licensing
- Project Development
  - Standard Power plans for Ohio and Pennsylvania
  - Romania
  - Others: Dairyland, AECI, Nucor, Romania (DOE FEED), Poland, Bulgaria, Czech, Prodigy Marine (Canada), Jordan, others



BWXT Advanced Technologies – BANR

High Temperature Gas Reactor (HTGR)

- 17 MWe
- Factory fabrication
  - transported to site in intermodal shipping container(s) such as on railcar or semi-trailer
- Requires HALEU – TRISO fuel
- Possible higher temperature, non-electricity applications
- Cooperation agreement with Tata Chemicals to assess micro-reactors for heat and electricity at Green River, WY – trona ore mine



Holtec SMR-300

- Design
  - 300 MWe
  - Existing Fuel Design (Framatome)
  - Passive shutdown safety
  - Reactor located deep underground
  - Combined nuclear and solar with heat storage
  - DOE Risk Reduction award
  - Partners: Mitsubishi, Hyundai, Kiewit
- Licensing
  - 3 Topical Reports and 18 White Papers in NRC review
  - Construction permit application planned in 2024
- Project Development
  - Owner and Operator: Palisades, Oyster Creek
  - Entergy MOU – specific site not identified
  - UK GDA, Ukraine

Westinghouse AP300

- Design
  - 300 MWe
  - Smaller version of AP1000 (1 loop, instead of 4)
  - Leverages operating experience and supply chain for AP1000
  - Achieve and maintain safe shutdown without operator action, backup power or pumps
- Licensing
  - Design Certification application to NRC expected in 2025
- Project Development
  - UK GDA
  - UK Community Energy Partner by early 2030s

X-energy Xe-100

High Temperature Gas Cooled SMR

- Design
  - 80 MWe 320 MWe
  - Standard Plant = 4 reactors @ 80 MWe each
  - Requires HALEU for TRISO fuel
  - Online Refueling (220,000 pebbles)
  - High temperatures for expanded non-electricity applications
- Licensing
  - 11 Topical Reports, 11 White Papers with NRC
  - Construction Permit expected in 2024
- Project Development
  - ARDP (DOE Award of $1.2B for first plant and fuel facility)
  - DOW's Seadrift, TX site for cogeneration around 2030
  - Energy Northwest plans for future plant
  - ENEC, Jordan, Alberta, UK

TerraPower/GEH - Natrium™ Reactor

Liquid Sodium Fast Reactor (SFR)

- Design
  - 345 MWe
  - Molten Salt Heat Storage = Peaking Output 500 MWe
  - Requires HALEU for metallic fuel
  - High temperatures for expanded non-electricity applications
- Licensing
  - 12 Topical Reports, 10 White Papers with NRC
  - Construction permit application to NRC submitted 2024
- Project Development
  - ARDP (DOE Award of $2B for first plant and fuel facility)
  - PacifiCorp project in Kemmerer, WY around 2030
  - PacifiCorp IRP for four more Natriums in early 2030s

Kairos Power – Hermes Test Reactor

- Design
  - 35 MWth – will not produce electricity
  - Molten Salt coolant
  - Requires HALEU for TRISO pebble fuel
  - High temperatures for expanded non-electricity applications
- Licensing
  - Hermes (1) – received construction permit from NRC in 2023
  - Hermes 2 (2 units) – construction permit submitted to NRC in 2024
- Project Development
  - DOE Risk Reduction Award
  - Hermes (1) and Hermes 2 in East Tennessee (near Oak Ridge)
  - Hermes (1) construction begins 2024, expected operations in 2026
  - Commercial design (140 MWe) expected in early 2030s