

Clean • Safe • Secure • Affordable

Carol Lane

Government Relations

X-energy

April 12 ,2022

Intrinsic Safety: Our Fuel



Pebble Fuel Element
(60mm)

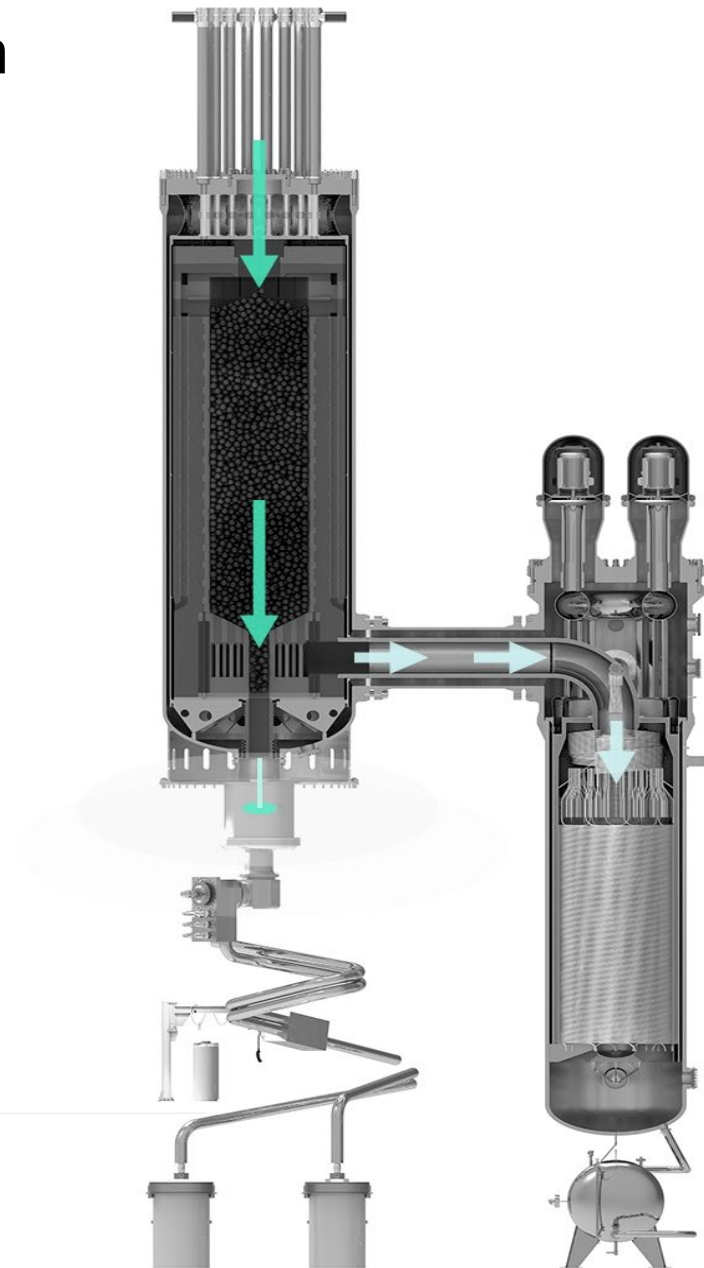
TRISO Fuel particle
(≈1mm)

Relying on inherently safe designs allows for a drastic reduction of components.

Reduction of components enables predictability on costs & significant reduction of regulation barriers, as well as a much smaller physical plant footprint.

Why is this important?

- Results in a Levelized Cost of Electricity well under \$60/MWh-e and deployment in less than five years.
- 80 megawatt-electric modules optimized for the 'sweet-spot' size
- Standard 4-pack provides 320 MWe with load-following capabilities like a natural-gas plant
- High-quality outlet steam at 565°C and 16.5 MPa in the standard design with higher temperatures attainable
- Deployment for **electricity or process heat**



→ **1/10th the components of a traditional nuclear plant**

Xe-100 Reactor (80 MWe)

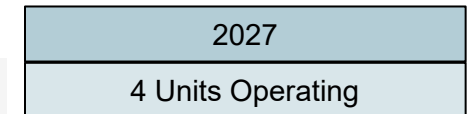
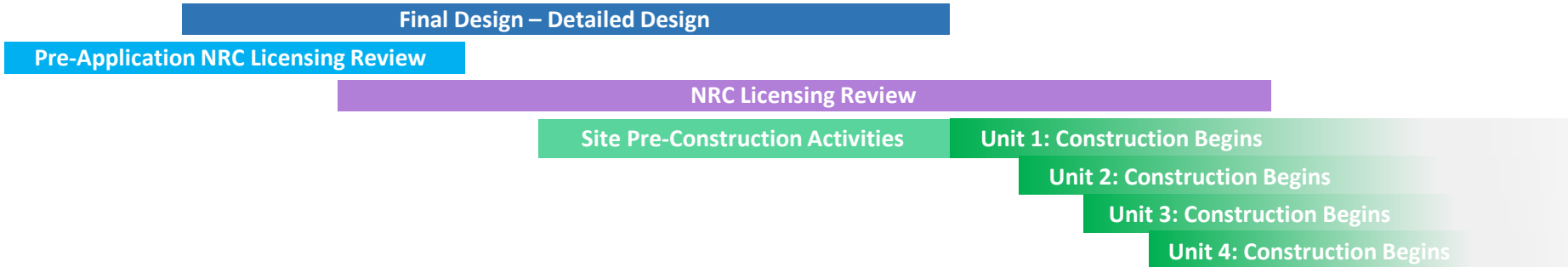
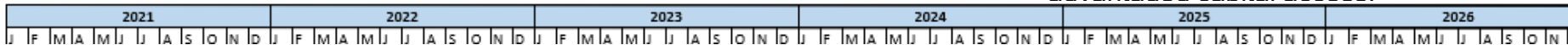
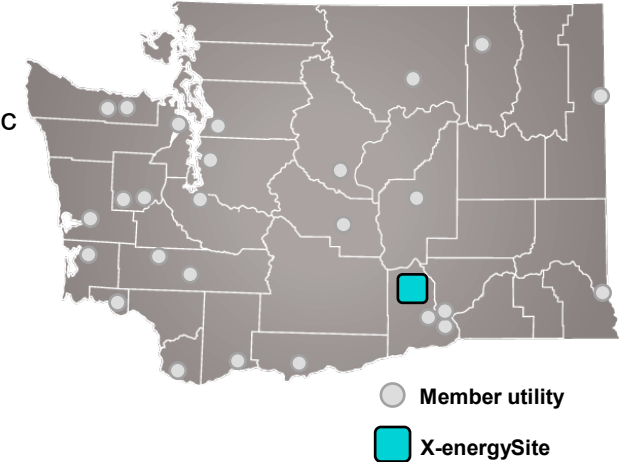
Advanced Reactor Demonstration Project

- In May 2020, the Department of Energy announced the Advanced Reactor Demonstration Program (ARDP)
- X-energy and TerraPower were selected as program winners in October 2020
- Program designed as a public-private partnership:
 - Government provides winning bids with 50% cost share for first-of-a-kind advanced nuclear plant
 - Plant must be commercial (*not* demonstration)
 - Plant must be ready for deployment by 2027
 - ✓ Government motive? Kick-start advanced nuclear industry
- **X-energy partnered with Energy Northwest, a top-tier customer awarded \$1.2B from the Department of Energy**

Energy Northwest



- Membership includes 28 public power utilities, including 23 of Washington state's 29 public utility districts.
- **State law mandates zero carbon grid by 2045, with limited additional upside in Washington state for renewables.**
- EN is a public agency with tax-advantaged capital access.



(1) Right size

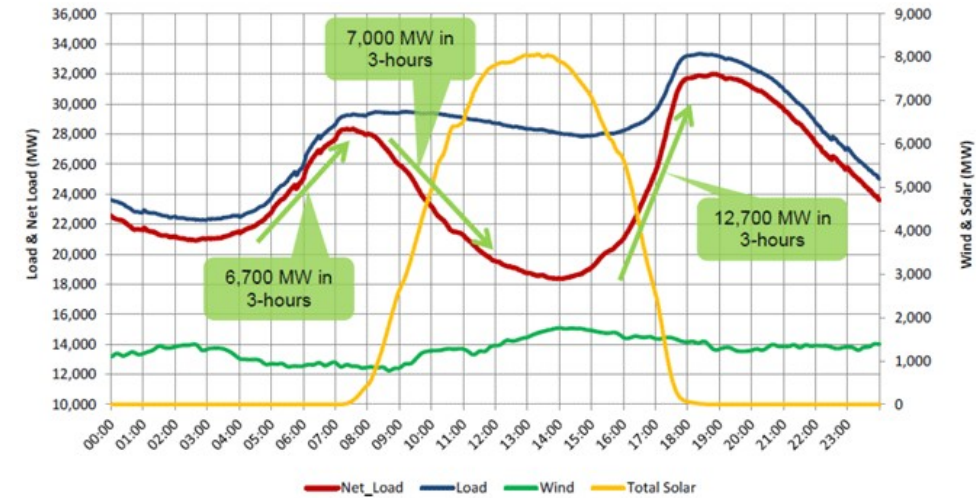
The reactor size of 200MWt (80MWe) has been designed to address the largest possible market providing a good fit for replacement of existing carbon-based heat sources such as coal and gas.

(2) Broad range of applications

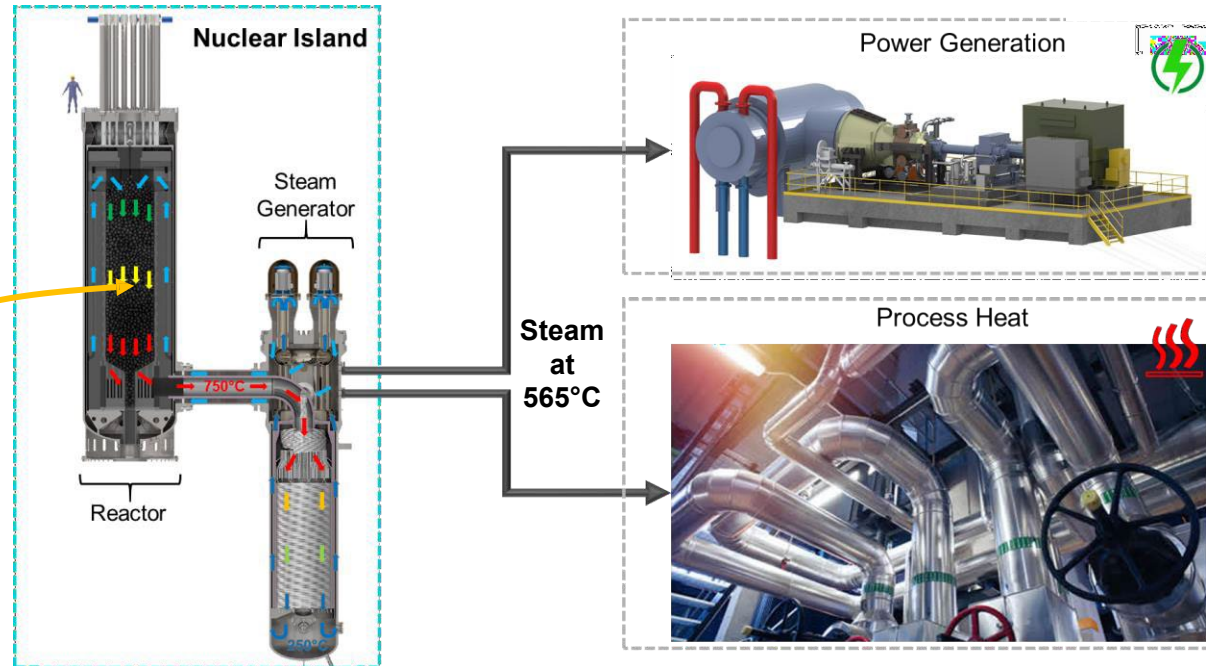
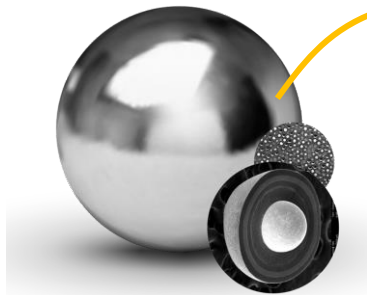
The nuclear island has been designed to be independent of the end use making our solution deployable for electricity and many other process heat applications, such as:

- Hydrogen production;
- Petrochemical processing;
- Desalination; and
- District heating.

The Xe-100 can do both simultaneously or switch between applications.



Heat is generated in the pebble fuel through fission and transferred to the steam generator using helium that cannot become radioactive.



(3) Flexible power delivery

Designed to be capable of fast and efficient load following thus supporting the intermittency of solar and wind



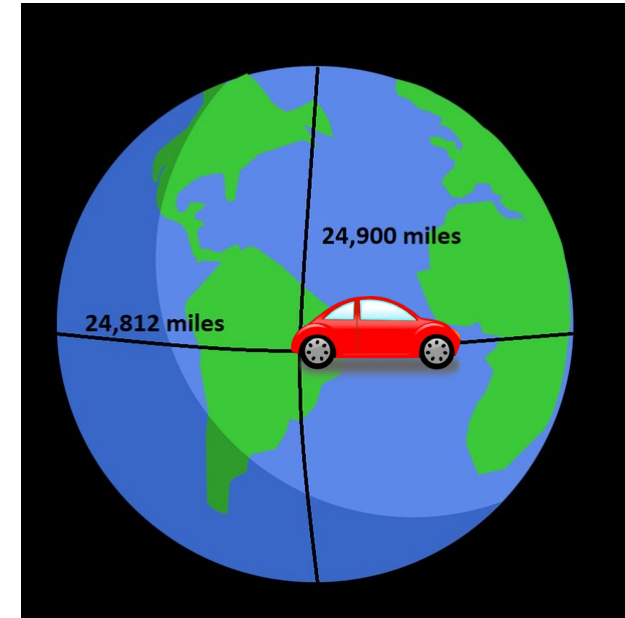
The Power of the Pebble



1 pebble produces 27.4 megawatt hours



This would also power 28 Maryland homes for a month



This is enough electricity to power an electric car for 98,640 miles which is 4 times the circumference of the Earth

Photo sources:

- <https://www.quora.com/How-many-miles-around-is-the-earth>
- <https://www.pexels.com/search/houses/>

Next-Generation Nuclear in a Low Carbon Energy System

**NMSU CPUC Current Issues
Conference**

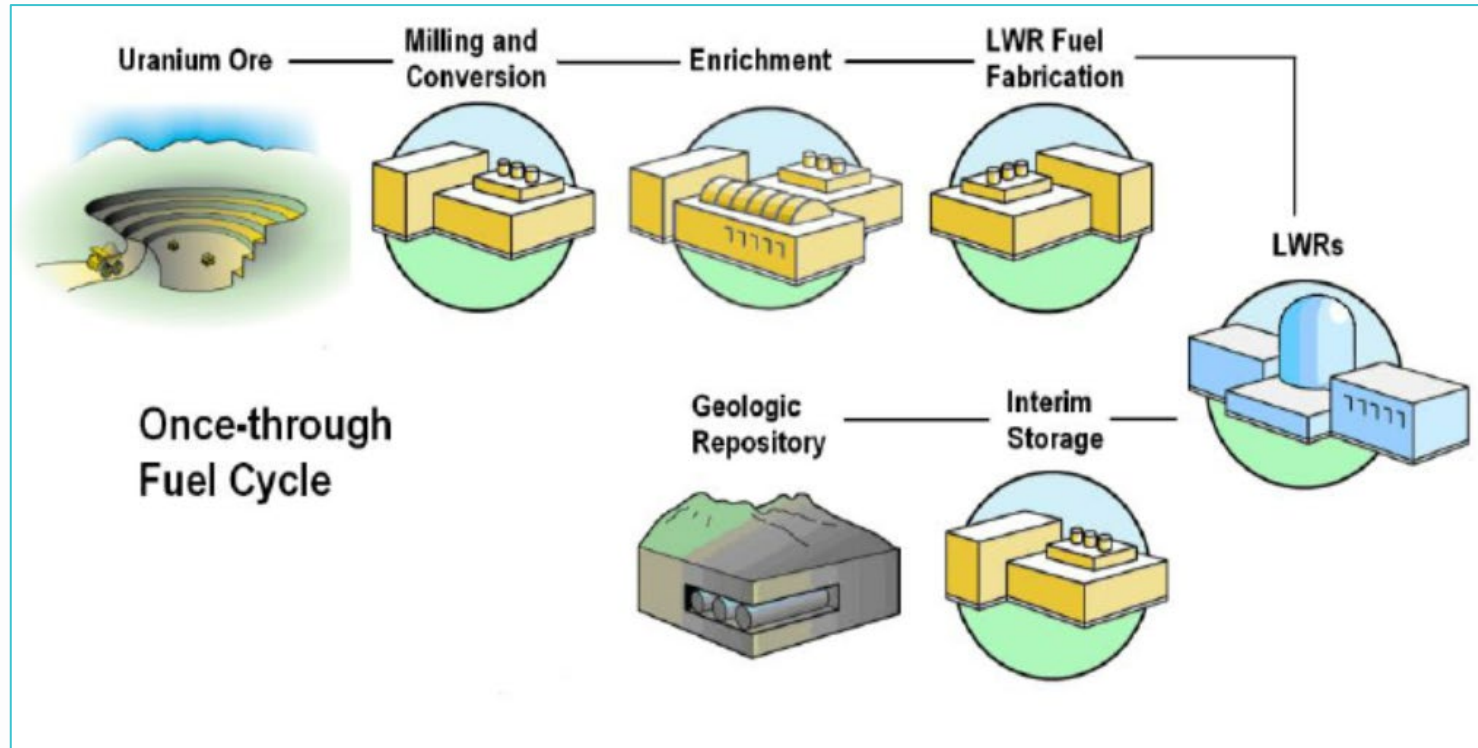
John Kotek

Senior VP, Policy & Public Affairs

April 12 2022

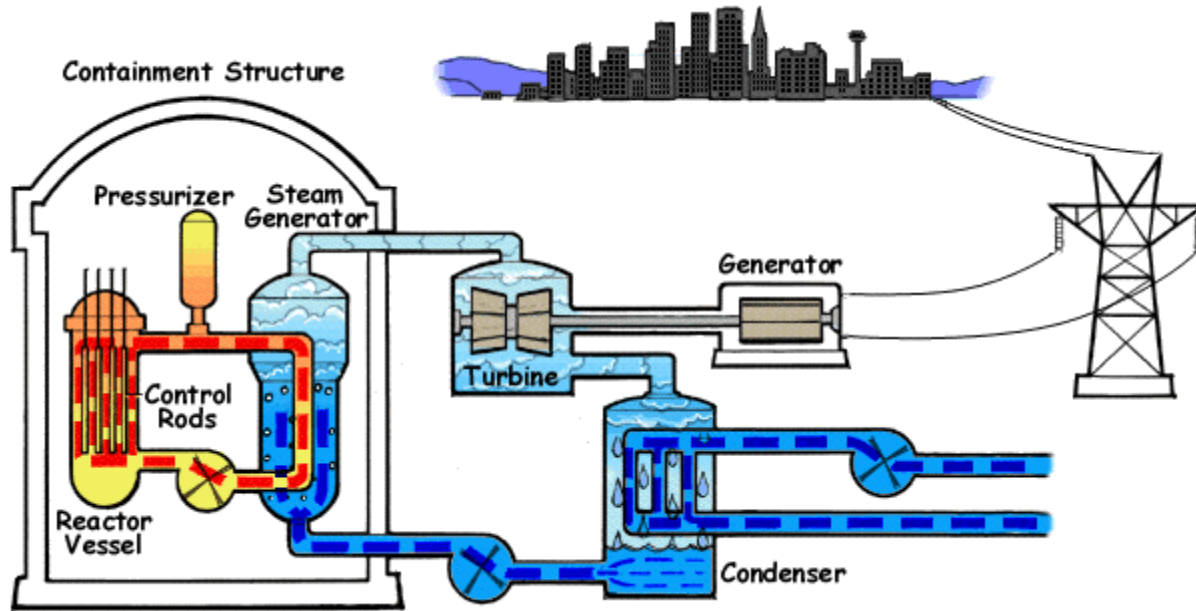


The Nuclear Fuel Cycle



Source: Wigeland, R & Dixon, Brent. (2020). Identification, Description, and Characterization of Existing and Alternative Nuclear Energy Systems.

How a Pressurized Water Reactor works...



Source: <https://www.nrc.gov/reading-rm/basic-ref/students/animated-pwr.html>

THE EMISSIONS REDUCTION IMPERATIVE

REUTERS

ENVIRONMENT MARCH 20, 2018 / 10:28 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



The number of large companies taking serious action to tackle greenhouse gas

CLIMATE

Nestlé commits to net-zero target by 2050

Haley Weiss, E&E News reporter

Published: Monday, September 16, 2019

E&E NEWS PM



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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, starting with 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.

CONTENT

How to Provide Part 1

For each company, see the website postcard below.



Supply chains

ing Rolls-Royce with taking profit that nations.

Toyota wants zero carbon emissions in all factories by 2050

Marcus De Guzman [View More Articles](#)

Clean, zero emission Toyota factories may soon be a reality

Toyota
May 31, 2019 09:41

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XPANDER
Expand your Possibilities

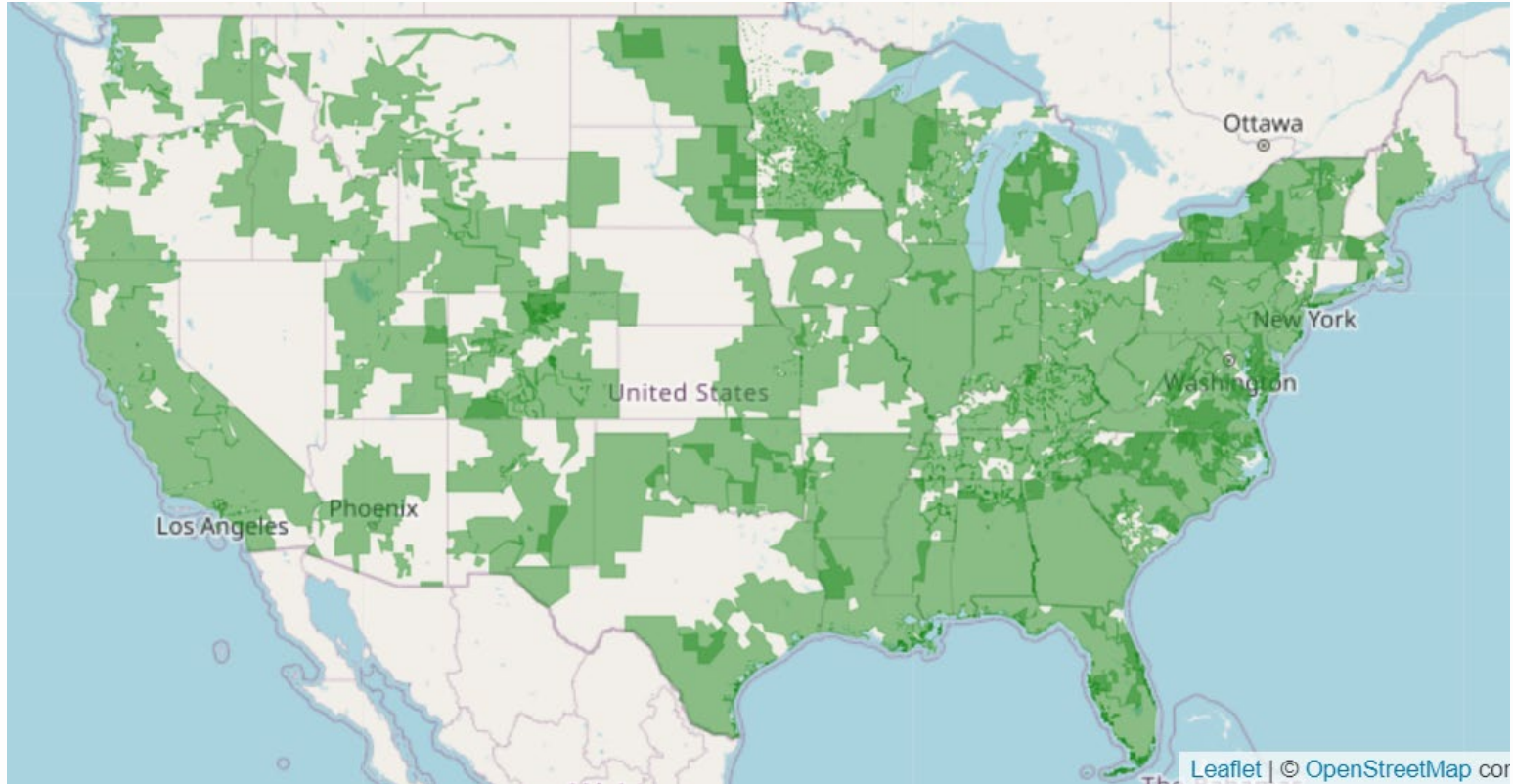
Let's face it, manufacturing cars is no easy feat. Aside from the fact that you have to build a whole fleet of them, you'll also need plenty of resources and energy to manufacture batches of them. But using energy means you're also producing CO2 emissions, which is never good.

That's right, aside from automobiles, car factories also use plenty of energy that result in more CO2 emissions that harm the environment and add more greenhouse gases that pollute the air. So how does Toyota plan to combat that? By setting a goal of achieving 35% reduced CO2 emissions in global plants worldwide by 2030, and having zero CO2 emissions in all manufacturing plants by 2050.

Part of the "Toyota Environmental Challenge 2050", the automaker is looking at not just reducing their carbon footprint from their cars, but also from their manufacturing facilities. To do this, Toyota has been finding ways of recycling and using alternative means of generating energy.

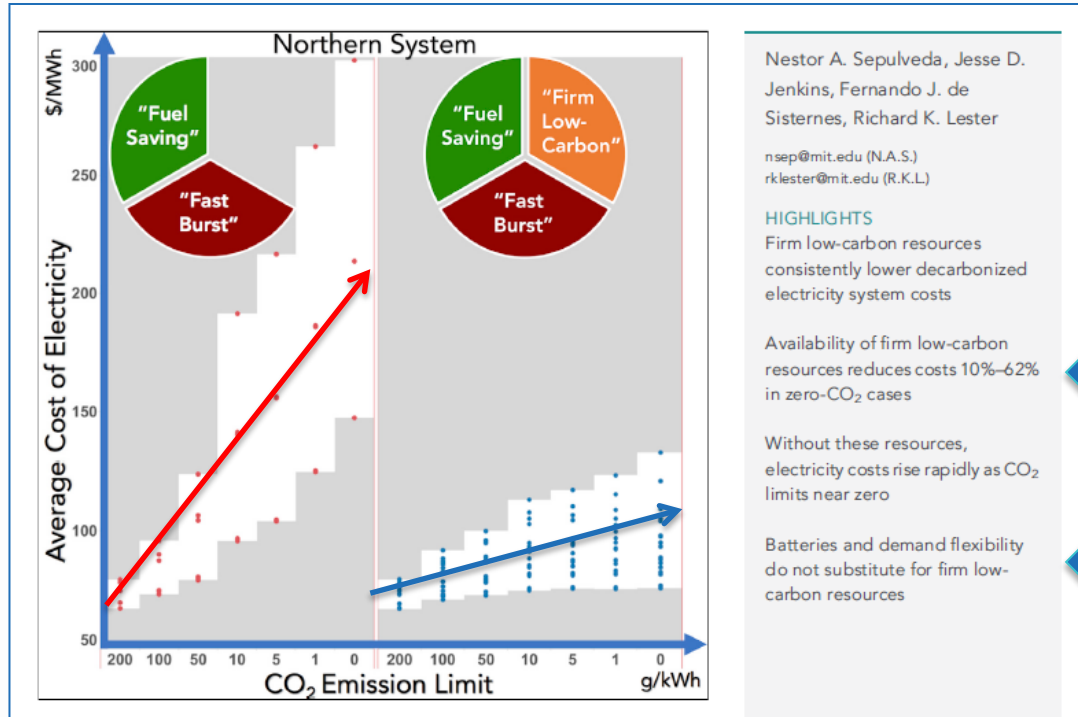
MORE THAN 2,800 COMPANIES GLOBALLY WITH EMISSIONS-REDUCTION COMMITMENTS

UTILITIES WITH EMISSIONS REDUCTION PLEDGES

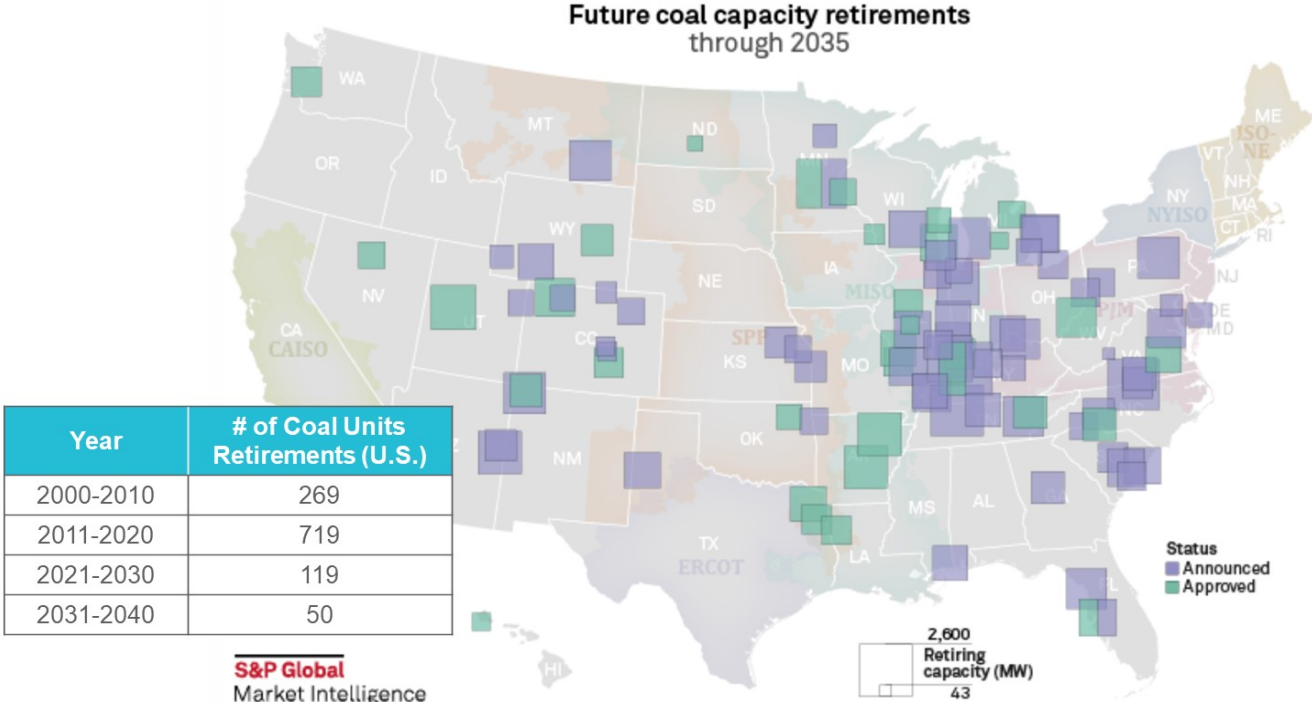


Source: <https://sepapower.org/utility-transformation-challenge/utility-carbon-reduction-tracker/>

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



DECARBONIZATION WILL DRIVE FURTHER COAL PLANT CLOSURES – INCREASING RISKS TO RELIABILITY



MANY OF THESE PLANTS ARE OF SIMILAR SIZE TO SMRs/ADVANCED REACTORS

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. IS HIGHLY UNIONIZED, PAYS GREATEST AVERAGE WAGES

PRESIDENT BIDEN, U.S CONGRESS EMBRACE NUCLEAR ENERGY

Biden American Jobs Plan:

- Recognizes important role of existing nuclear
- Pledges support for demonstration projects, manufacturing infrastructure investments

Bipartisan Infrastructure Bill:

- Operating nuclear plant credit program
- Advanced reactor demonstration funding
- Large-scale H2 demos

Build Back Better Bill:

- Tax credits for existing reactors
- Tax credits for all new clean generation
- Expanded federal loan guarantees



2022 Innovation States: Policies

West Virginia

Nuclear Moratorium Repeal

Indiana

SMR project enabling

Alaska

Micro-reactor project enabling

Nebraska, Colorado, Oklahoma, Kentucky, Minnesota

SMR studies

Virginia, Ohio, New Jersey, New Hampshire

SMR task forces

Missouri

Repeal moratorium on CWIP

Wyoming

Support for the Natrium project

Montana

Conducting SMR study

Illinois, Connecticut, Minnesota

Proposed nuclear moratorium
repeals

2022 Innovation States

NEW NUCLEAR DEPLOYMENT ACTIVITIES

- Idaho
- Washington
- Wyoming
- Tennessee

Types of Advanced Reactors

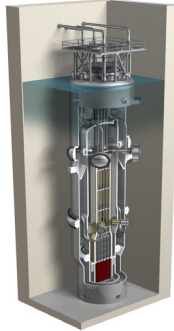
Range of sizes and features to meet diverse market needs

Micro Reactors
(< 20MW)



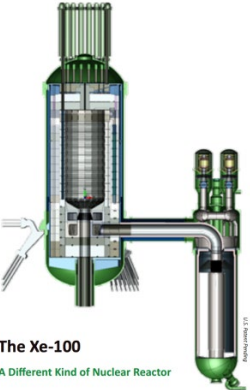
Oklo (shown)
Approximately a dozen in development

LWR SMRs
<300MW



NuScale (shown)
GEH X-300
Holtec SMR-160

High Temp Gas Reactors



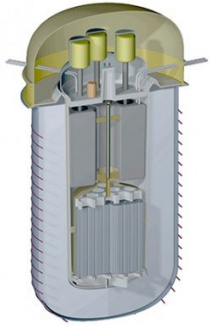
The Xe-100
A Different Kind of Nuclear Reactor
X-energy (shown)
Several in development

Liquid Metal Reactors



TerraPower Sodium (shown)
Several in development

Molten Salt Reactors



Terrestrial (shown)
Several in development



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

Advanced Reactor Enablers

DESIGN TO PURPOSE



SIMPLER

- Passive Safety
- Less Equipment
- Smaller Facility
- Regulatory Efficiency

OFF-THE-SHELF

- Readily Available Equipment
- Proven Performance

FASTER CONSTRUCTION

- Smaller Structures
- Assembly vs. Construction
- Construction Best Practices

FACTORY-BUILT

- 60-80% of Equipment
- U.S. Supply Chain

U.S. JOBS

- Transferrable Skills
- Manufacturing, Construction, & Operations

Department of Energy Advanced Reactor Demonstration Program

Advanced Reactor Demonstrations

- Technical feasibility that the demonstration can be operational in five to seven years
- 50/50 cost share – awards for 7 years with possible 3 year extension
- DOE share \$3.2 billion (combined)
- TerraPower and X-energy
- Reactors and fuel fabrication facilities

UAMPS

- Utah Associated Municipal Power Systems (UAMPS) plans to construct and operate a NuScale reactor at Idaho National Lab around 2029
- DOE approved \$1.4 billion multi-year cost share in October 2020 for UAMPS



ARDP Demonstration Awards

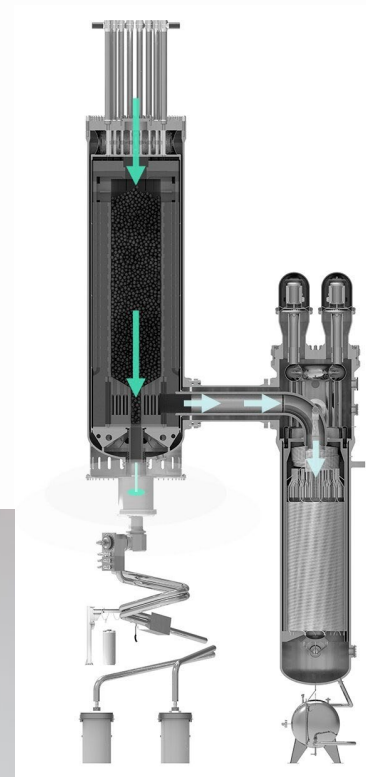
-  TerraPower™
Natrium Reactor
 - Liquid sodium fast reactor - 345 MWe
 - Metallic fuel
 - Molten salt thermal storage for peaking to 500 MWe



ARDP Demonstration Awards

- **Xenergy[®]** Xe-100
 - Pebble bed Helium cooled gas reactor – 80 MWe
 - Four reactors
 - TRISO fuel

TRISO Fuel Pebble Cutaway



Summary of New Commercial Reactor Projects in U.S. With Target Dates Before 2030

- Vogtle 3 and 4 - Georgia
- Oklo Aurora - Idaho
- UAMPS with NuScale - Idaho
- TerraPower Sodium - Wyoming
- X-energy Xe-100 - Washington
- Kairos Power Test Reactor - Tennessee
- Southern Company Molten Chloride Reactor Experiment - Idaho

Also – GE-Hitachi with OPG, USNC with Chalk River Lab in Canada

MOVING BEYOND ELECTRICITY

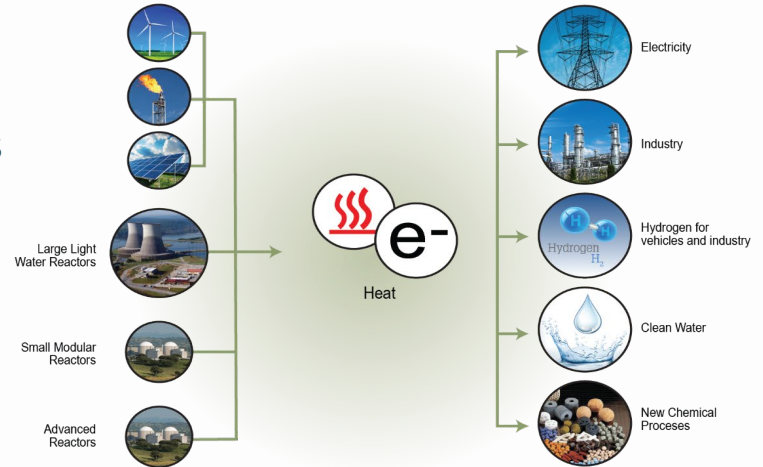
TODAY

Electricity focused



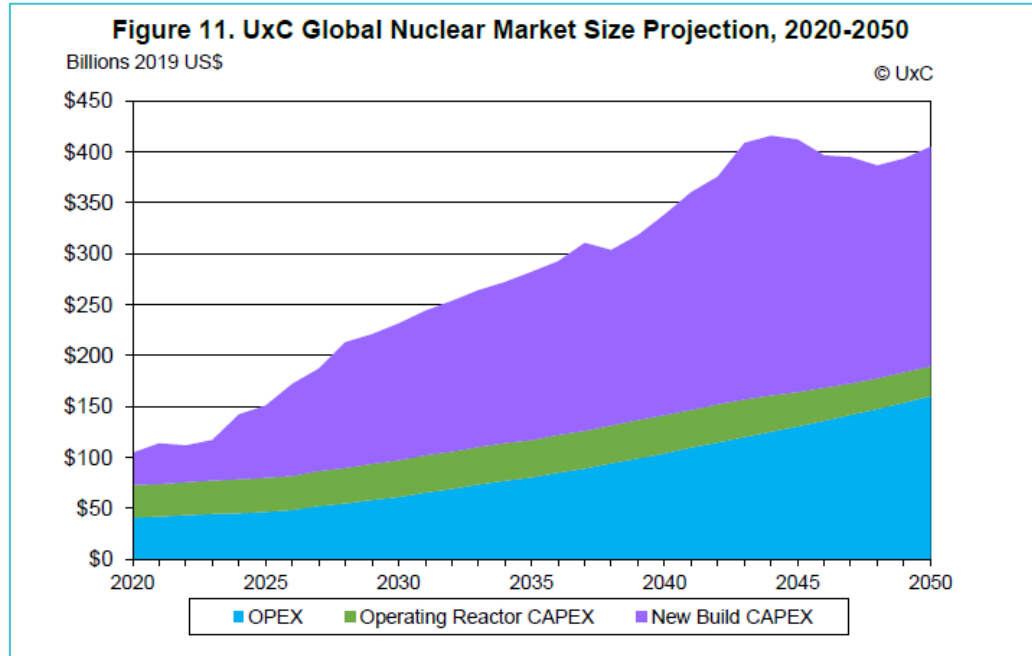
FUTURE

Integrated grid system that leverages contributions from nuclear fission **beyond** electricity sector



Tomorrow's nuclear will produce more than electricity

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

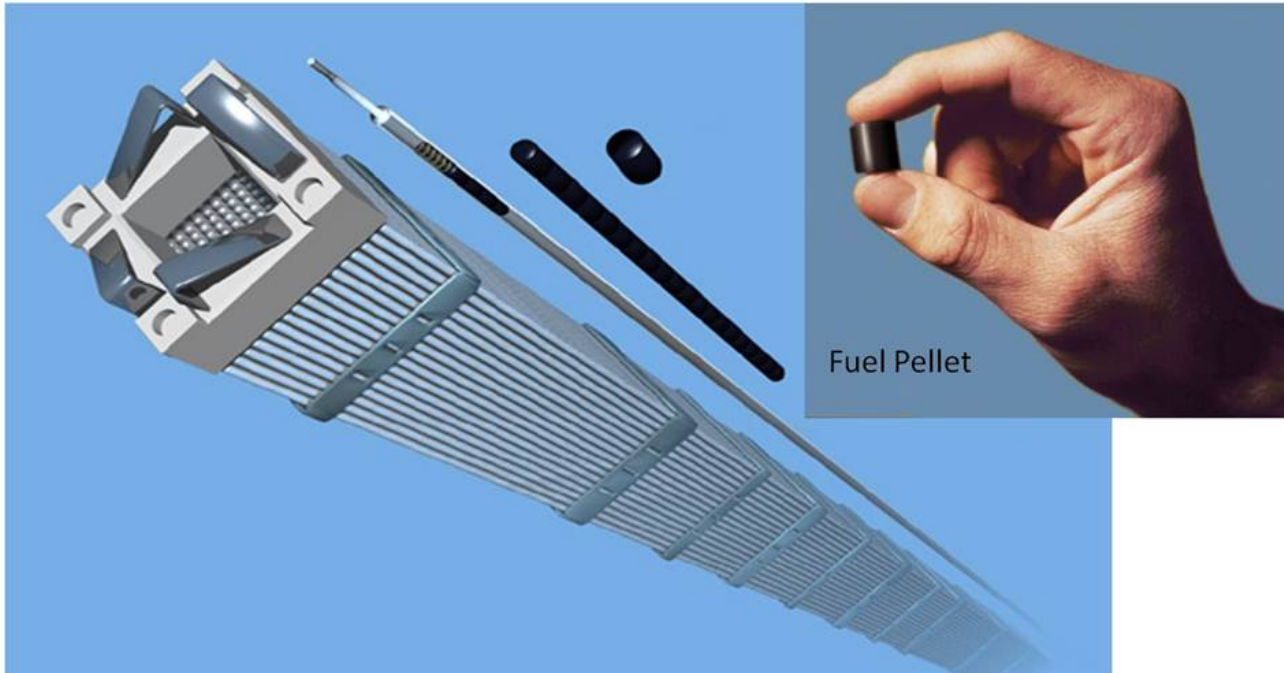
KEY TAKEAWAYS

- Consumers and policymakers (U.S. and abroad) increasingly demanding low-carbon electricity; states and utilities responding with deep decarb goals
- Growing understanding that new nuclear is extremely valuable to deep decarbonization
 - Least-cost, most reliable low-carbon systems include firm clean generation
 - State and federal policy actions needed to incentivize investment, drive down costs
 - Nuclear can help decarbonize non-electric energy uses
- Tremendous opportunities in domestic and global markets

**WIND + SOLAR + NUCLEAR + STORAGE IS THE BALANCED MIX
THAT WILL GET US TO A LOW-CARBON FUTURE**

QUESTIONS?







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



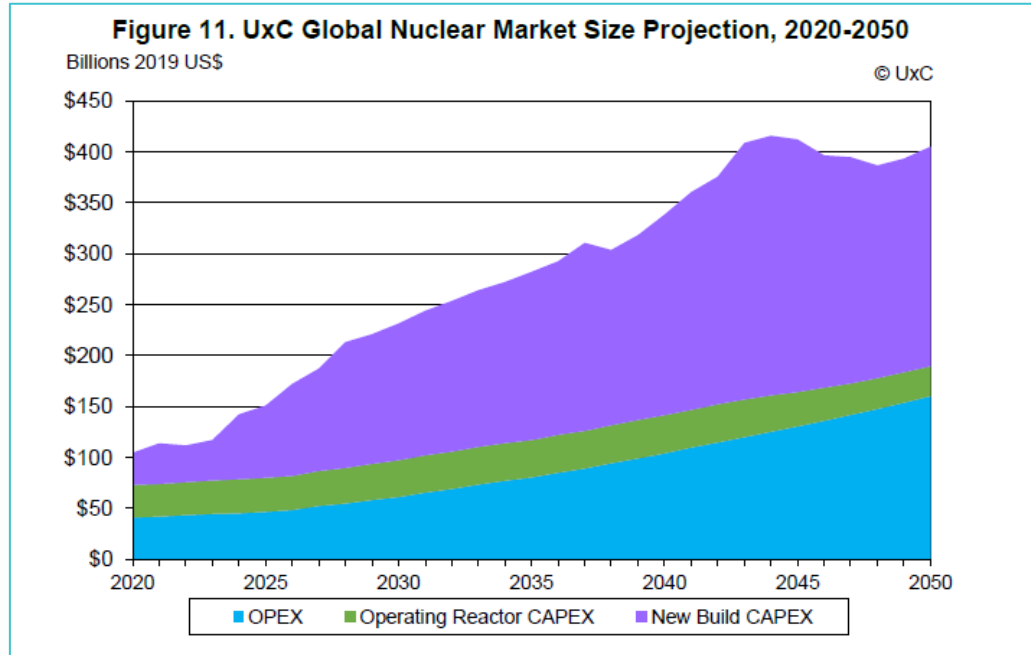
If the electricity produced by this fuel instead came from natural gas, the emitted CO2 would fill the Superdome. More than 3,000 times.

TOWARD A DURABLE, INTEGRATED SPENT FUEL MANAGEMENT PROGRAM

- Congress – consider the future of the NWPA
- Biden Administration:
 - Take steps to stand up an organization to resume management of the nuclear waste program
 - Seek Congressional authorization and funding to begin implementation of an integrated nuclear waste management system that allows for private consolidated interim spent fuel storage approaches

\$>\$40B AVAILABLE IN THE NUCLEAR WASTE FUND

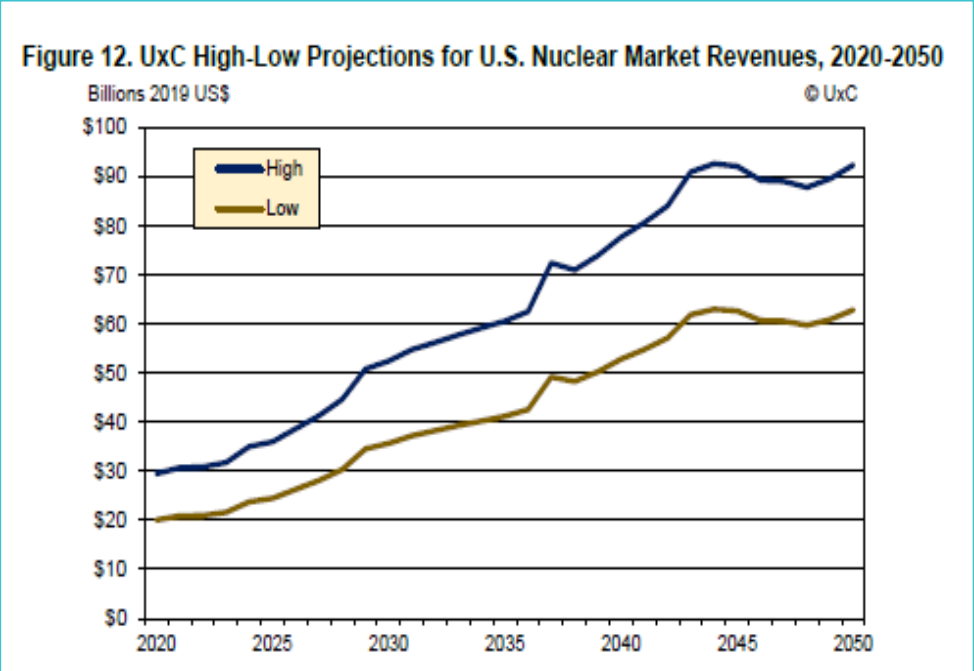
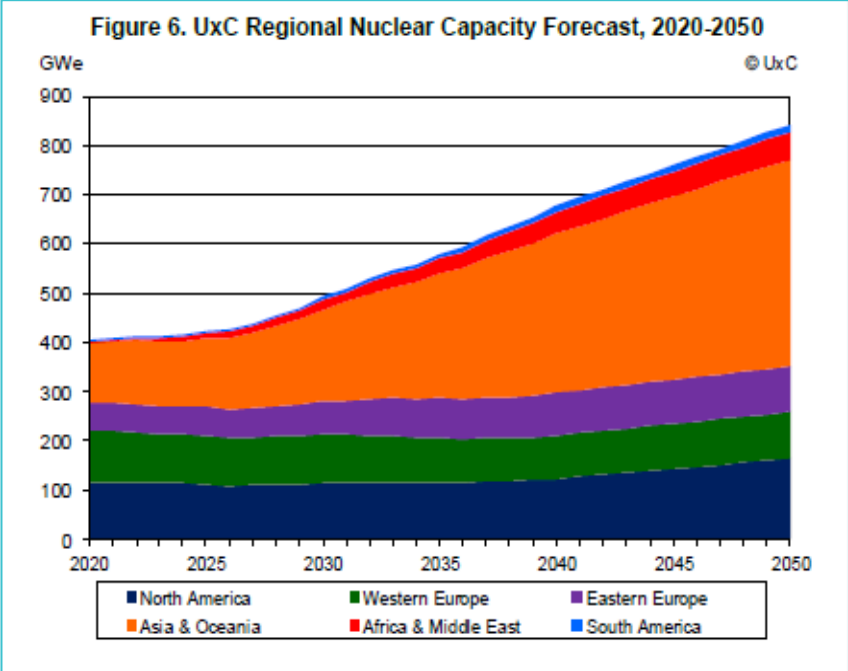
THE U.S. CAN CAPTURE GROWING GLOBAL MARKET FOR NEW NUCLEAR ENERGY SYSTEMS



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

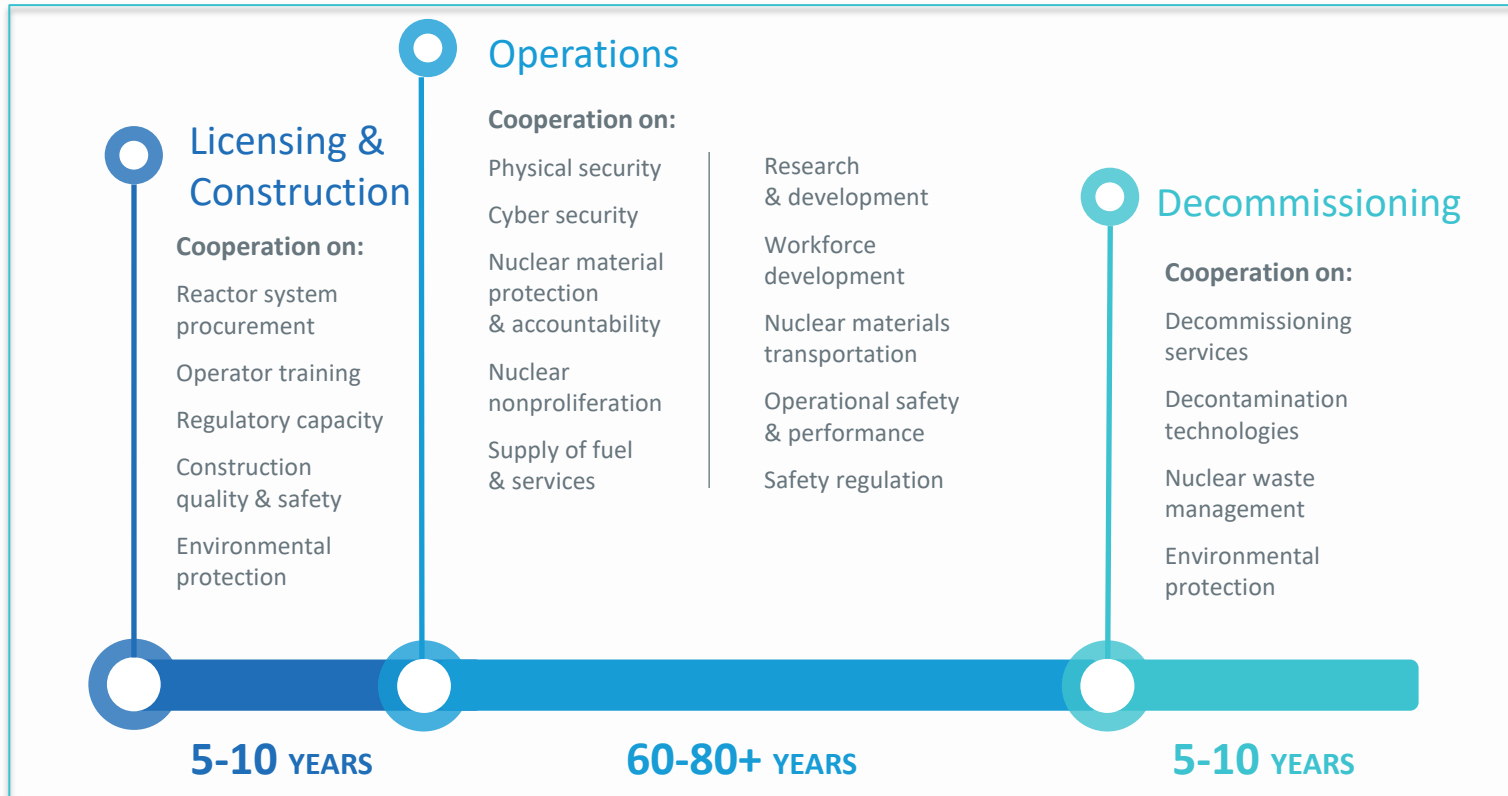
USG ADVOCACY CAN HELP U.S. VENDORS CAPTURE GROWING GLOBAL MARKET FOR NEW NUCLEAR ENERGY SYSTEMS



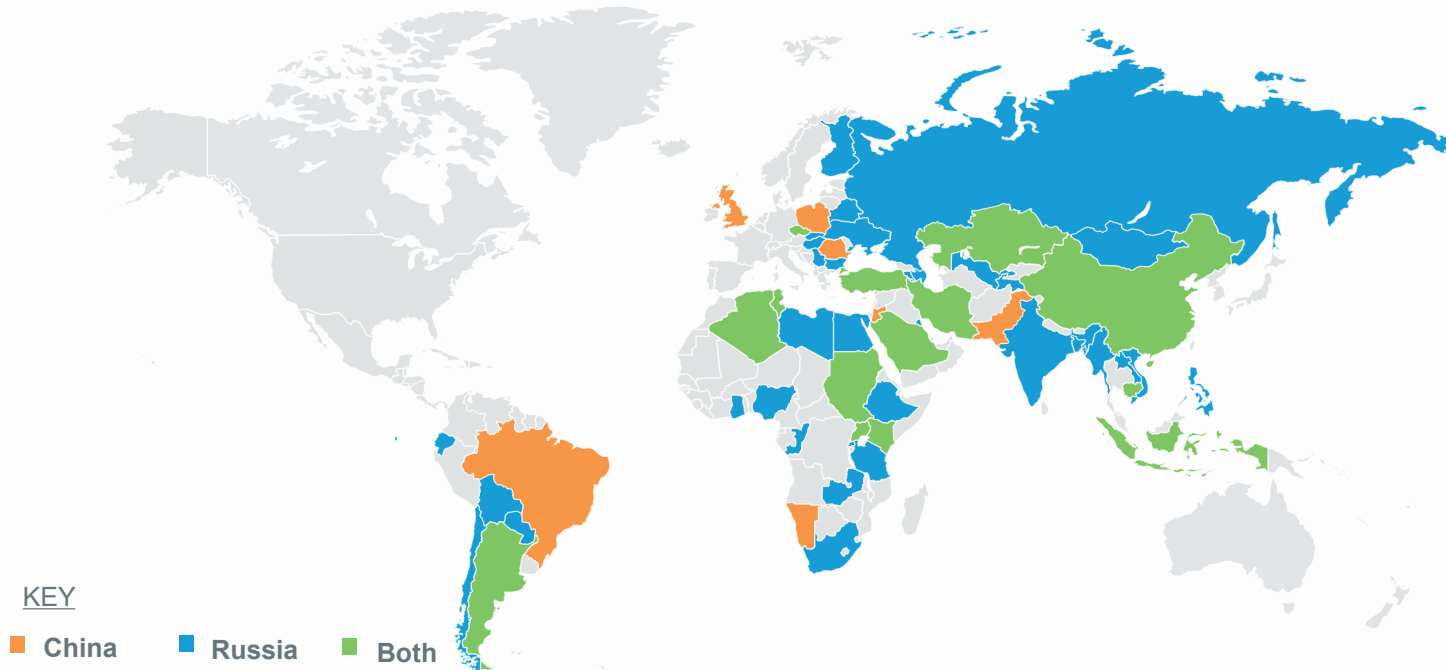
ESTIMATED \$1.3-1.9T OPPORTUNITY FOR U.S. VENDORS THRU 2050

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

CIVIL NUCLEAR EXPORTS CREATE A CENTURY-LONG RELATIONSHIP



RUSSIA AND CHINA ARE SEEKING TO DOMINATE THE CIVIL NUCLEAR EXPORT MARKET



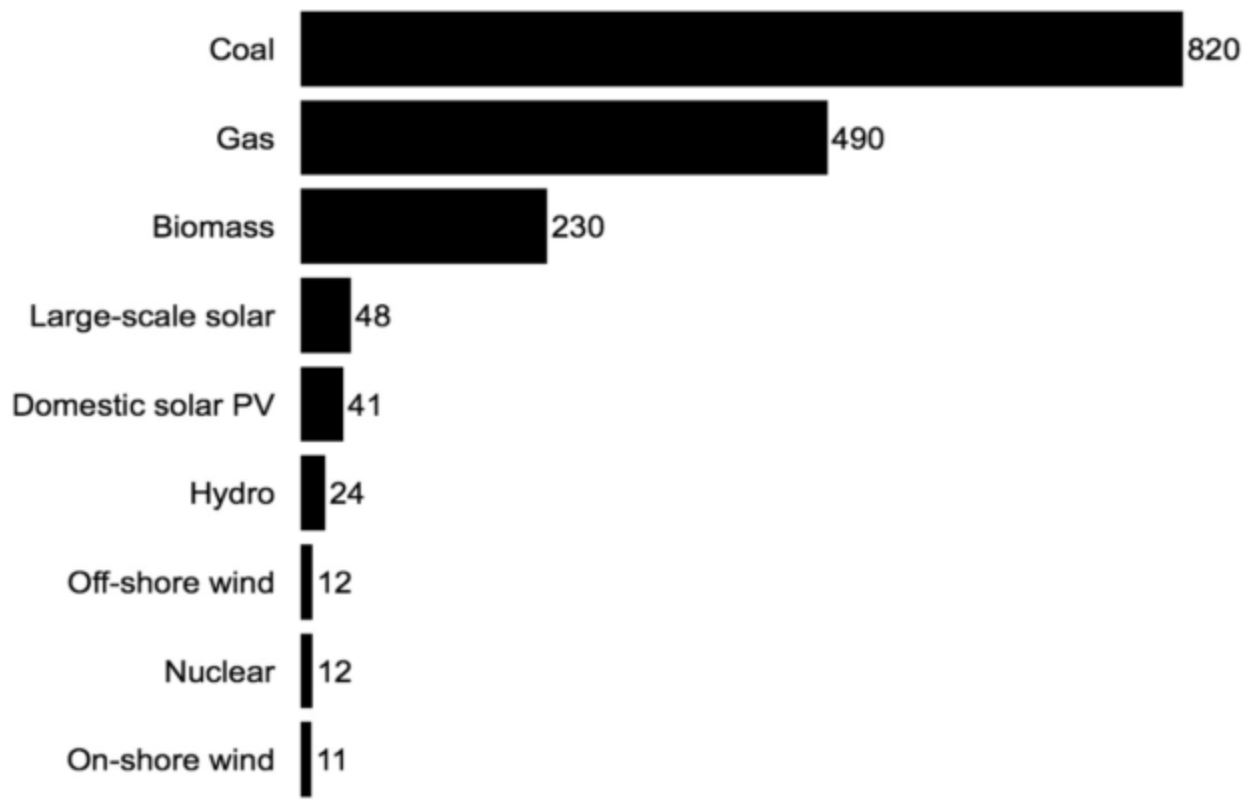
BOTH RUSSIA AND CHINA HAVE NUCLEAR ENERGY AGREEMENTS WITH MUCH OF AFRICA, ASIA AND SOUTH AMERICA

A USG STRATEGY TO COMPETE AND WIN IN THE CIVIL NUCLEAR MARKETPLACE

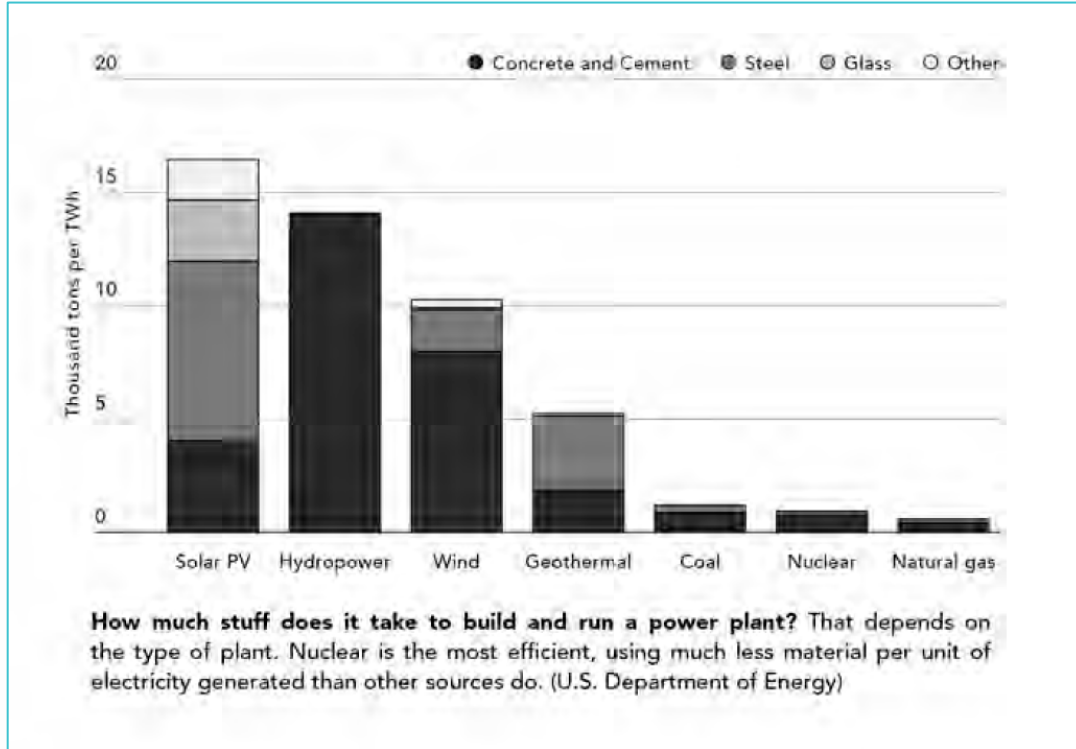
- Ensure high-level coordination across USG and re-establish a senior nuclear energy policy position in the EOP
- Elevate nuclear engagement and advocacy in bilateral dialogues and through intergovernmental agreements
- Continue to employ ExIm Bank, USDFC and USTDA and enhance their competitiveness
- Ensure that nuclear energy is included in international and multinational standards for clean energy development and financing
- Continue to improve the speed and predictability of DOE's export control licensing process

**ACCORDING TO U.S. DOC, EVERY \$1B IN CIVIL NUCLEAR EXPORTS
CREATES 5,000 TO 10,000 U.S. JOBS**

Life cycle emissions from electricity generation, gCO₂/KWh



Raw Material Inputs per TWh



Source: *How to Avoid a Climate Disaster*, Bill Gates, 2021

“COMPARED TO WHAT?”

To enact any of the pathways, we need to build infrastructure significantly faster than we ever have before.

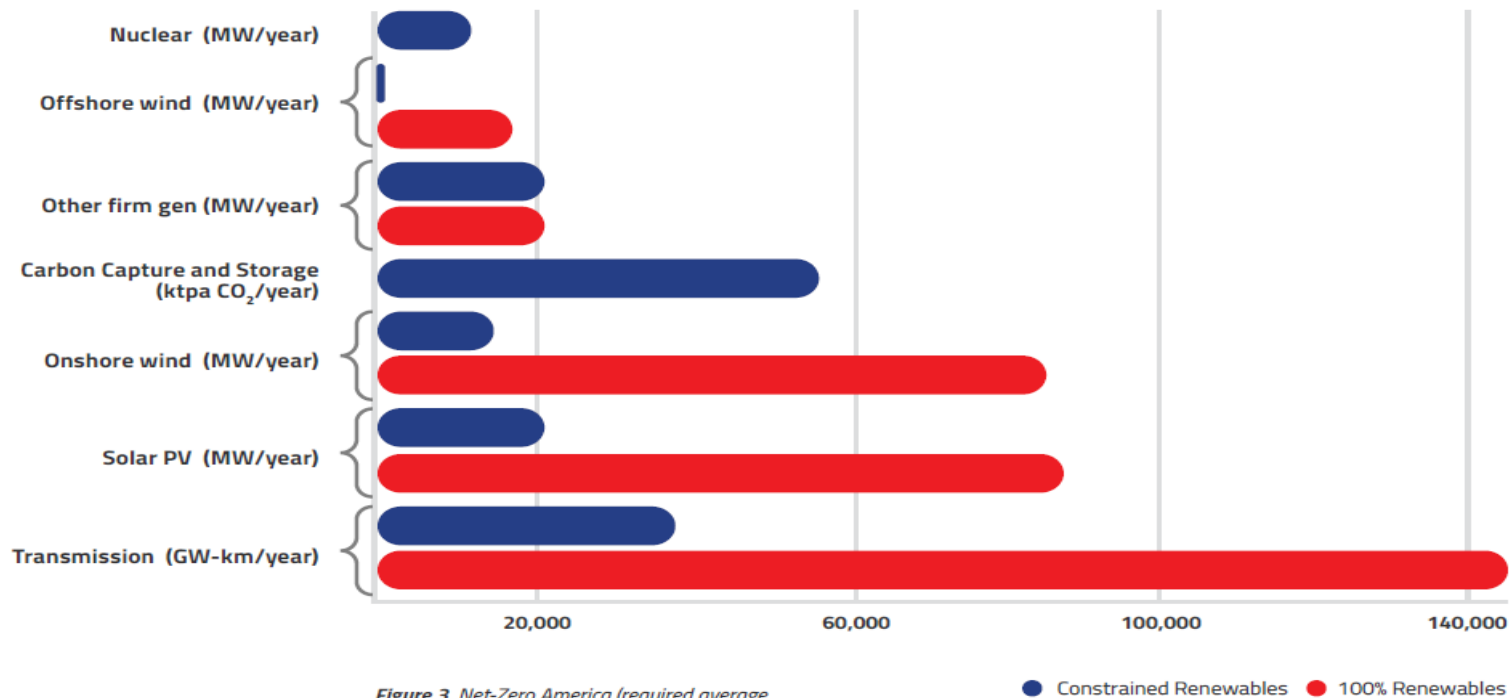


Figure 3 Net-Zero America (required average annual capacity increase in the constrained and 100% renewables pathways)