

The Future of Nuclear Energy in a Low-Carbon Energy System

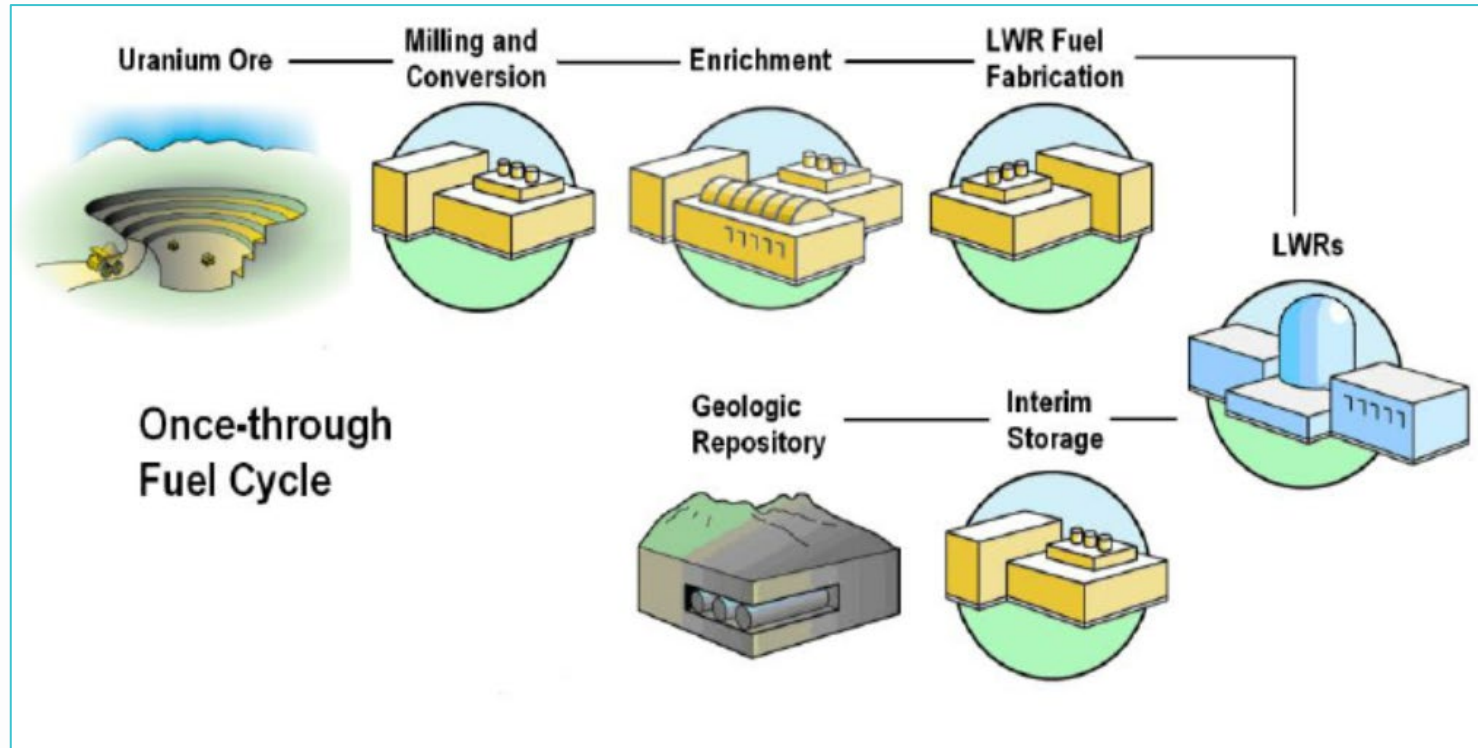
Presentation to Maryland Commission on Climate Change, Mitigation Working Group

John Kotek
Senior VP, Policy & Public Affairs

June 2022

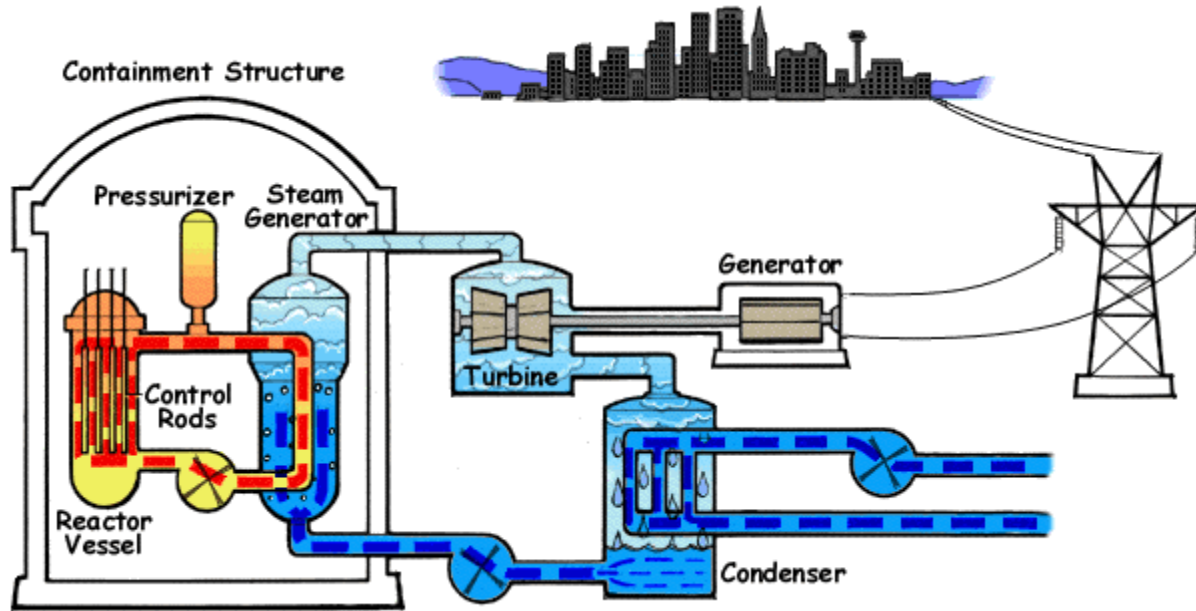


The Nuclear Fuel Cycle



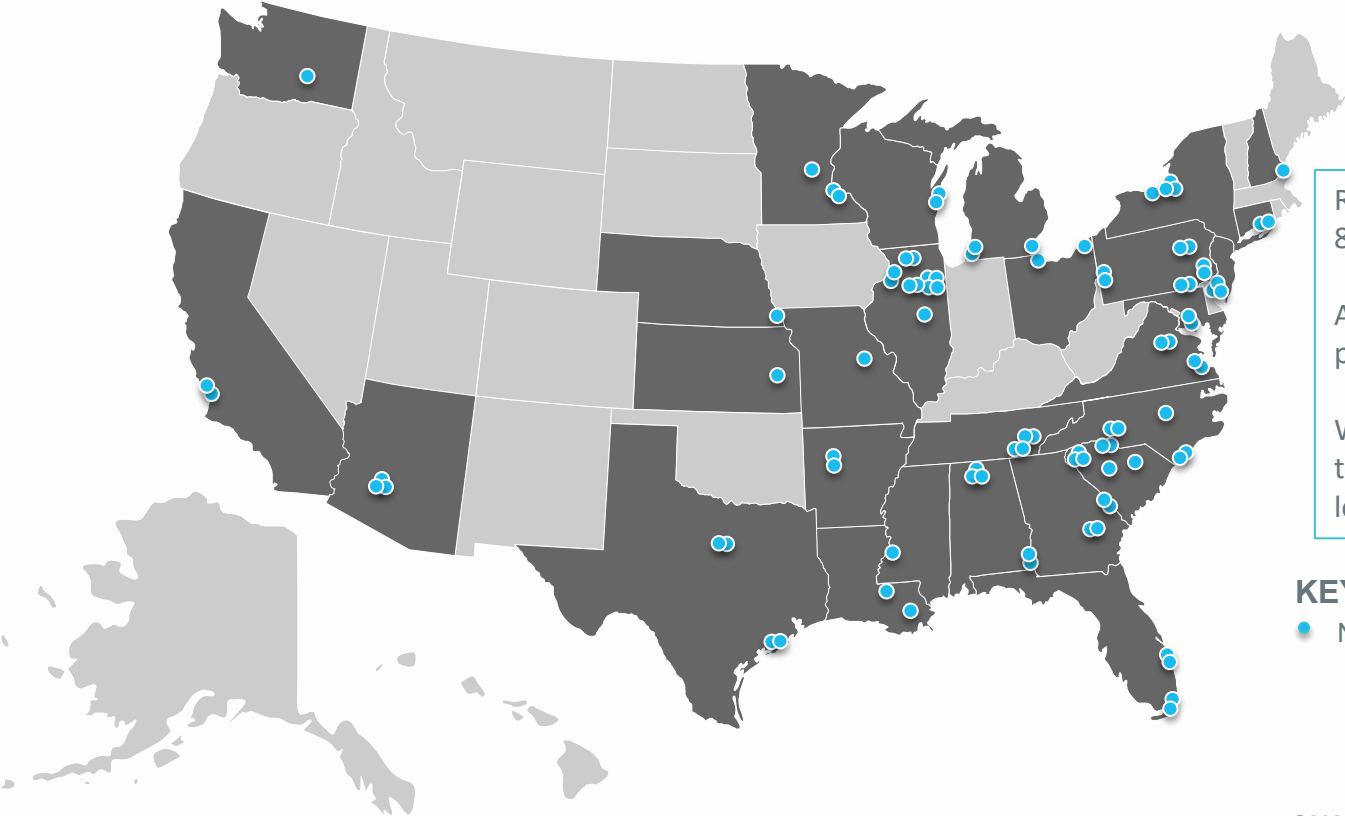
Source: Wigeland, R & Dixon, Brent. (2020). Identification, Description, and Characterization of Existing and Alternative Nuclear Energy Systems.

How a Pressurized Water Reactor works...



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

92 reactors at 53 plant sites across the country



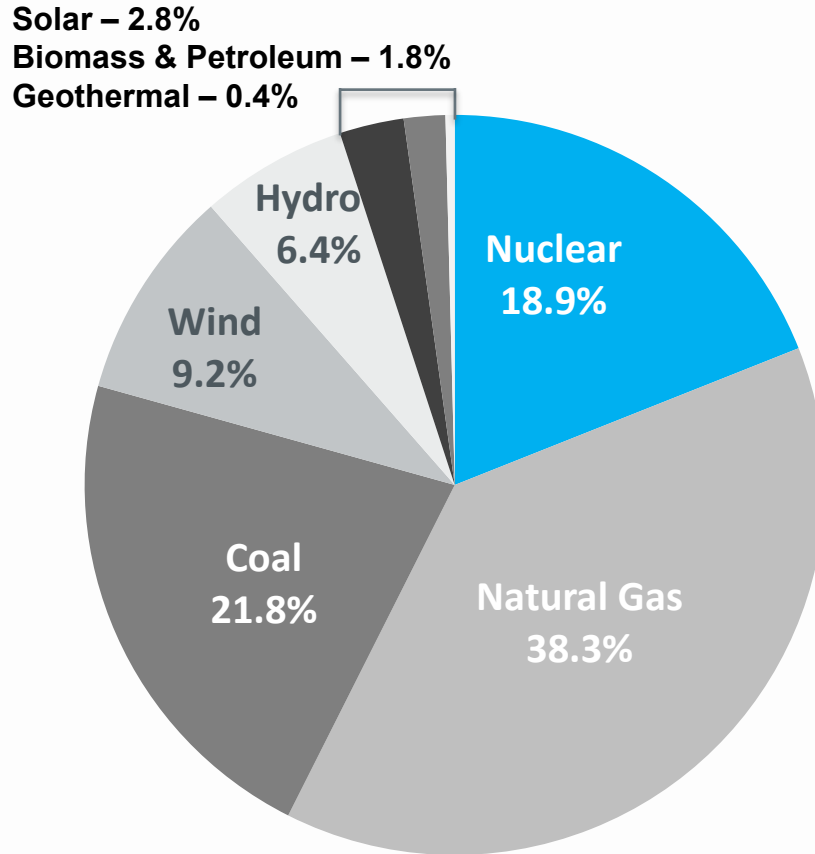
Reactors can operate for 80 years (at least)

About 500 direct jobs per reactor

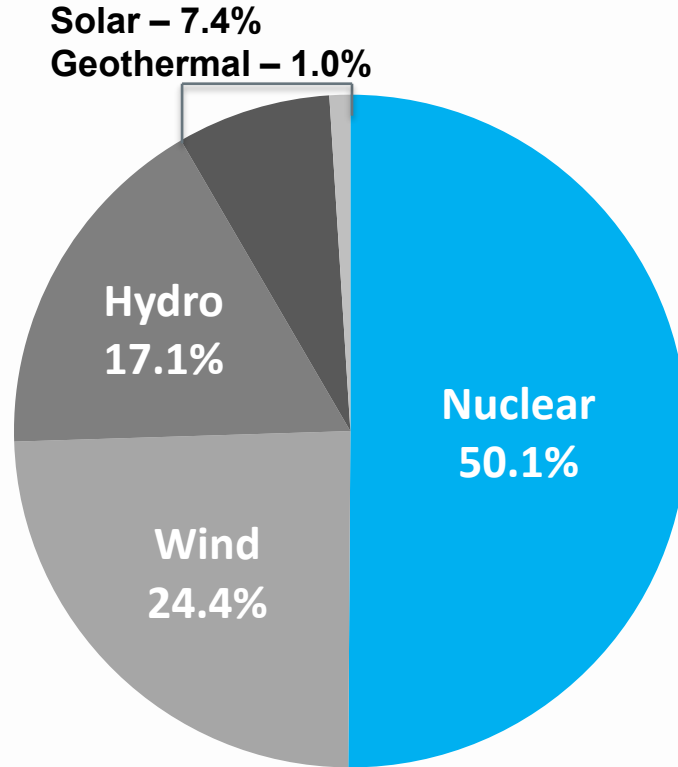
Wages about 1/3 higher than average jobs in local area

- KEY**
- Nuclear power reactor

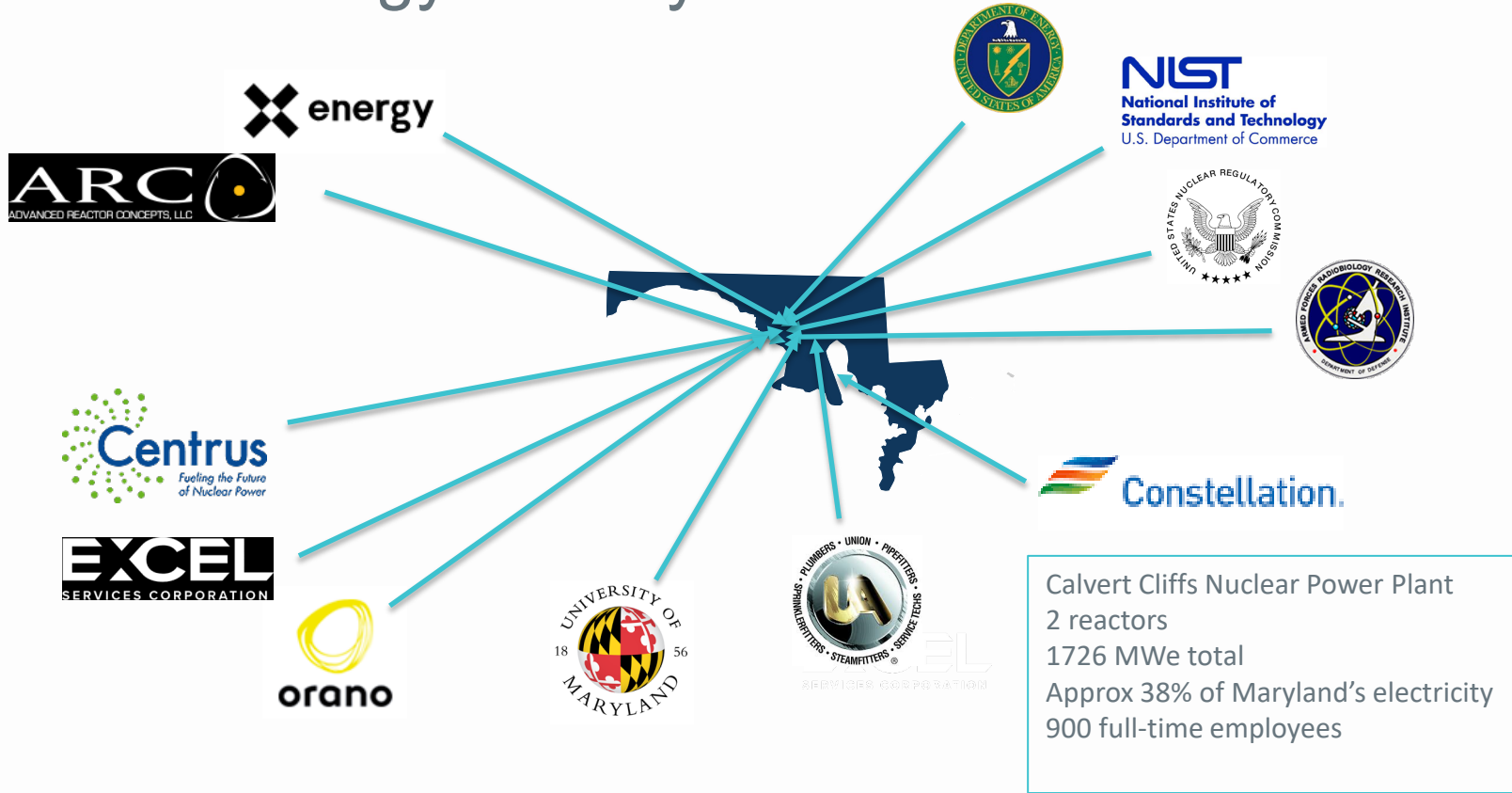
Nuclear generated 19% of U.S. electricity in 2021



Nuclear power continued to provide the majority of U.S. emissions-free electricity in 2021



Nuclear Energy in Maryland



Calvert Cliffs Nuclear Power Plant
2 reactors
1726 MWe total
Approx 38% of Maryland's electricity
900 full-time employees

THE EMISSIONS REDUCTION IMPERATIVE

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

CLIMATE

Nestlé commits to net-zero target by 2050

Haley Weiss, E&E News reporter
Published: Monday, September 16, 2019




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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.

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Toyota wants zero carbon emissions in all factories by 2050

Marcus De Guzman

Clean, zero emission Toyota factories may soon be a reality

Toyota
May 31, 2019 09:41

f t in F e +

Advertisement



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.

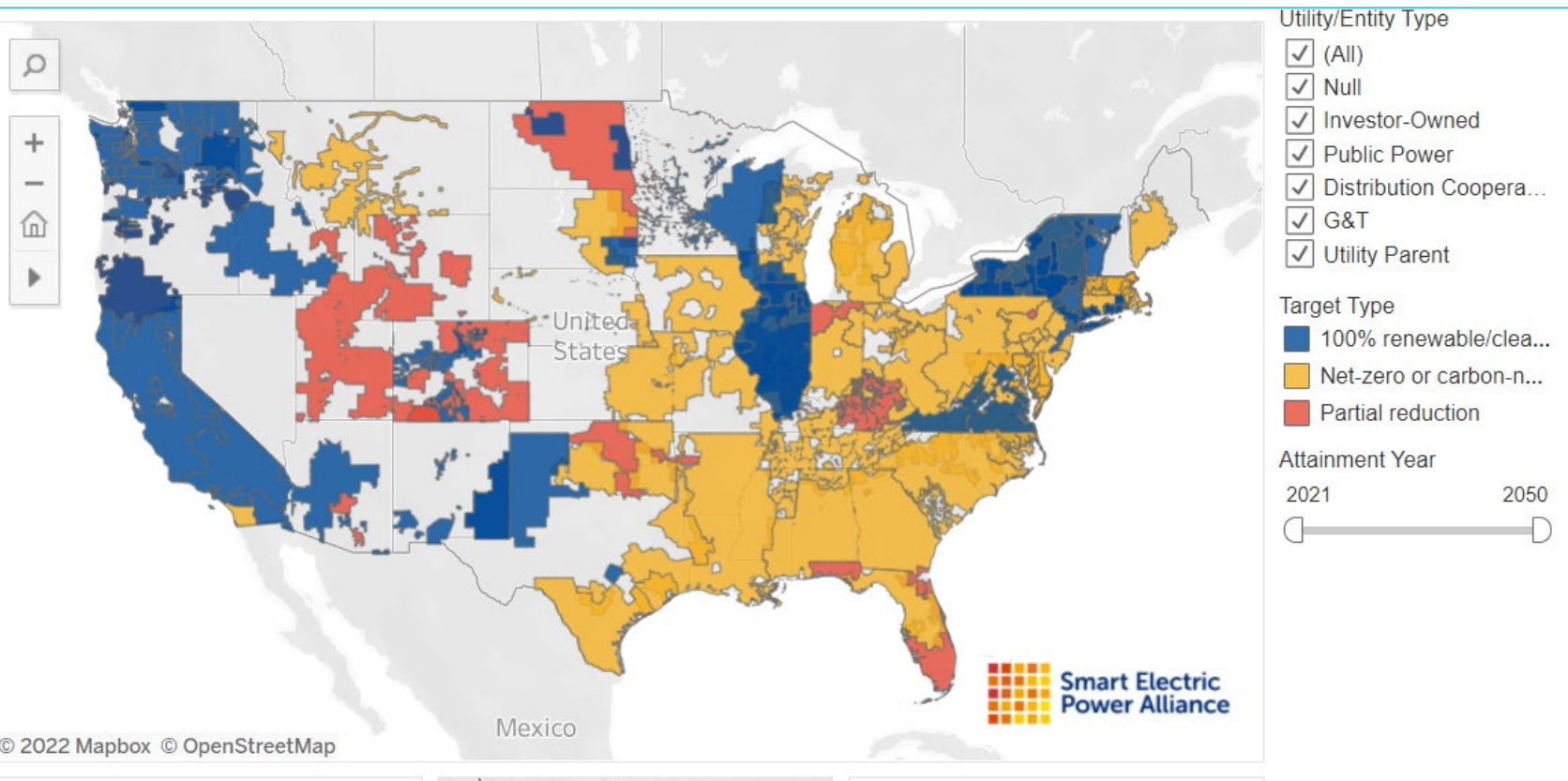
That's right, aside from automobiles, car factories also use plenty of energy that result in more CO2 emissions that harm the environment and add more greenhouse gases that pollute the air. So how does Toyota plan to combat that? By setting a goal of achieving 35% reduced CO2 emissions in global plants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

>3,000 COMPANIES WITH SCIENCE-BASED CARBON REDUCTION TARGETS

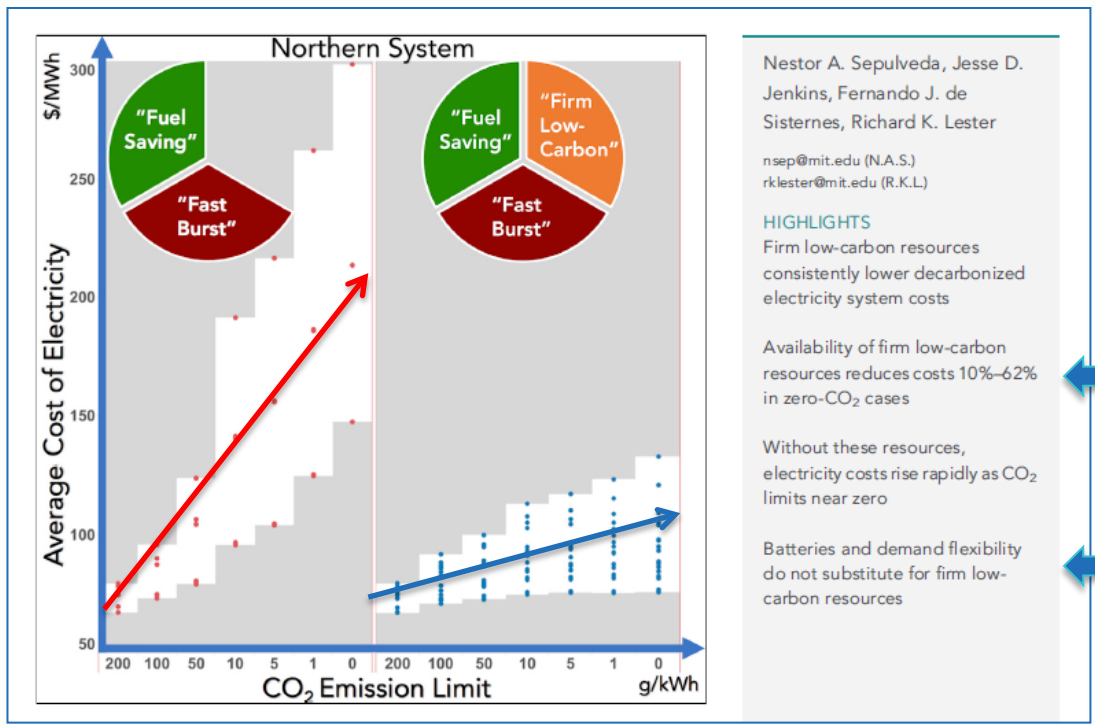


UTILITIES WITH EMISSIONS REDUCTION TARGETS



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

Firm, Low-carbon Generation (like nuclear) Enables Affordable Decarbonization



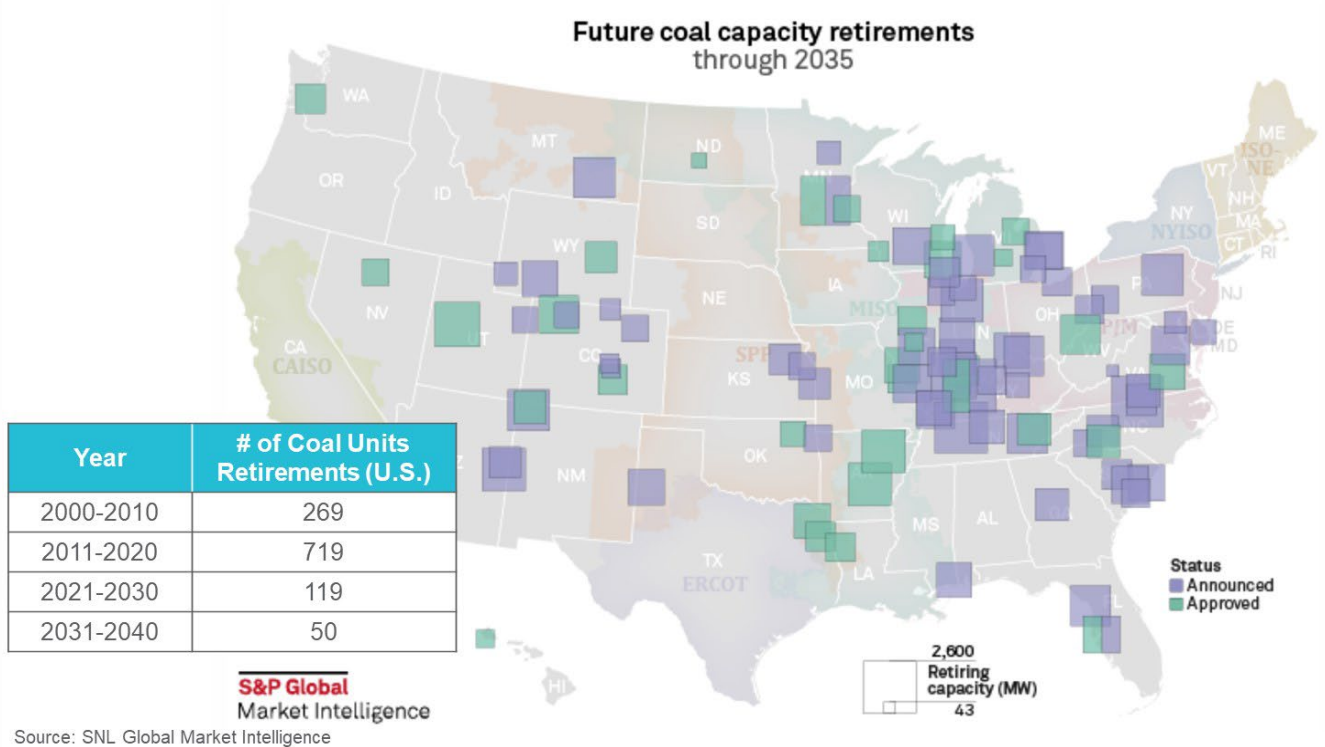
Nestor A. Sepulveda, Jesse D. Jenkins, Fernando J. de Sisternes, Richard K. Lester

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HIGHLIGHTS

- Firm low-carbon resources consistently lower decarbonized electricity system costs
- Availability of firm low-carbon resources reduces costs 10%–62% in zero-CO₂ cases
- Without these resources, electricity costs rise rapidly as CO₂ limits near zero
- Batteries and demand flexibility do not substitute for firm low-carbon resources

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. PAYS HIGHEST AVERAGE WAGES

BIPARTISAN LEADERS 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 and Connecticut

Nuclear Moratorium Repealed

Indiana

SMR project enabling

Alaska

Micro-reactor project enabling

Nebraska, Colorado, Oklahoma,

Kentucky, Minnesota, Michigan

SMR studies

Missouri

Repeal moratorium on CWIP

Wyoming

Support for the Natrium project

Illinois, Minnesota

Proposed nuclear moratorium
repeal

Virginia, Ohio, New Jersey, New

Hampshire

SMR task forces

S

2022 Other State Policies

IMPACTING NUCLEAR

Maryland

Climate Solutions Now Act

Louisiana

Climate plan

North Carolina

Decarbonization plan

Virginia, Pennsylvania

RGGI

Arizona

Clean Energy Standard

Nebraska

SLR, advanced nuclear licensing and reprocessing nuclear fuel studies

Oklahoma

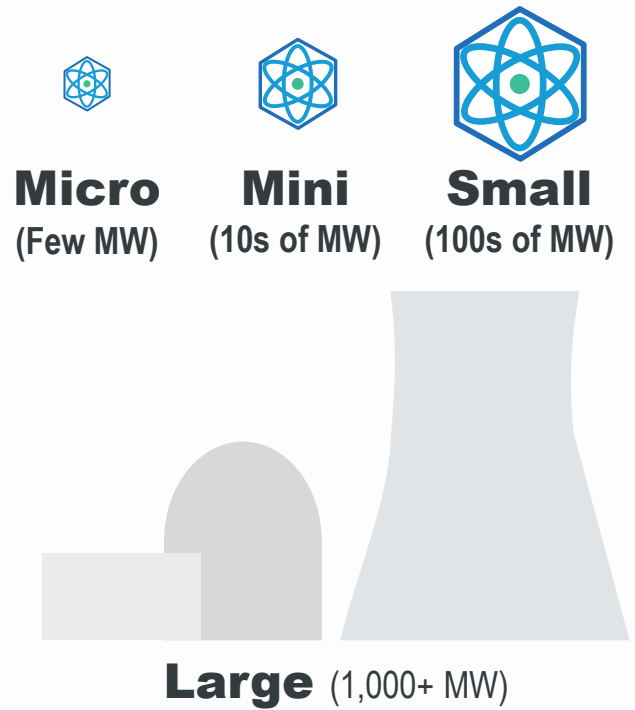
Agreement with municipalities

TECHNOLOGY DEVELOPERS - NEI MEMBERS

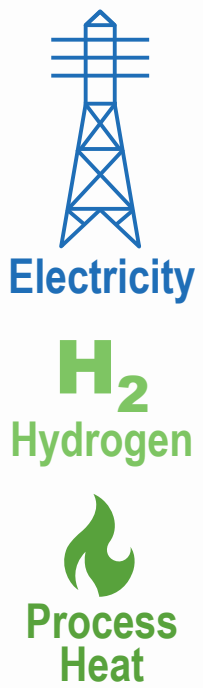


Nuclear Provides Versatile Solutions

Spectrum of Sizes/Options



Variety of Outputs



Multitude of Uses





READILY AVAILABLE EQUIPMENT

- Off-the-shelf Equipment
- Proven Performance

FACTORY-BUILT

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

FASTER CONSTRUCTION

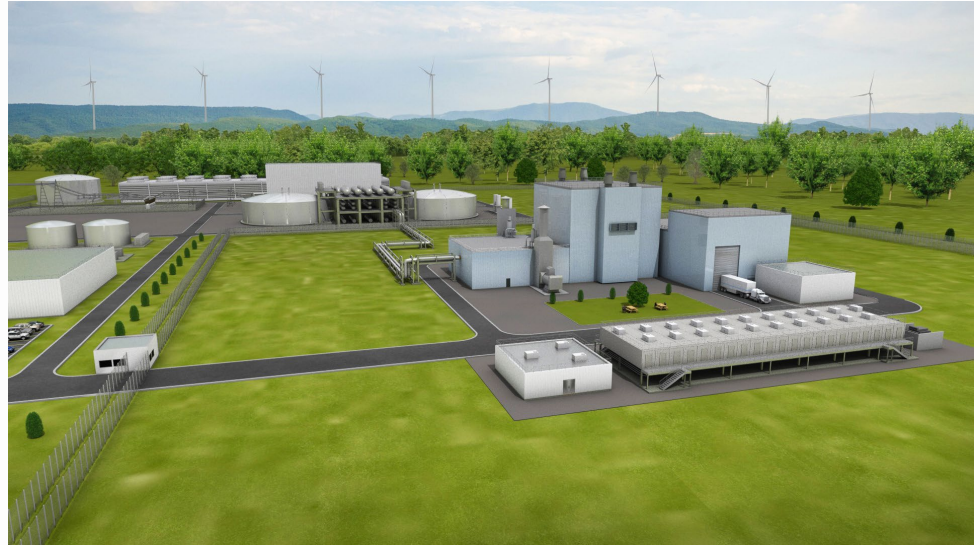
- Smaller Structures
- Assembly vs. Construction
- Modern Construction Methods

IMPROVED PERFORMANCE

- Higher Thermal Efficiency
- Design and Construction Best Practices
- Operational Excellence

ARDP Demonstration Awards

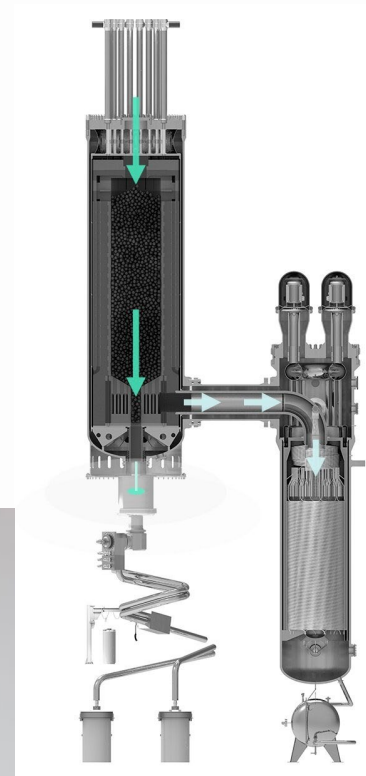
- **TerraPower™**
Natrium Reactor
 - Liquid sodium fast reactor - 345 MWe
 - Metallic fuel
 - Molten salt thermal storage for peaking to 500 MWe



ARDP Demonstration Awards

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

TRISO Fuel Pebble Cutaway



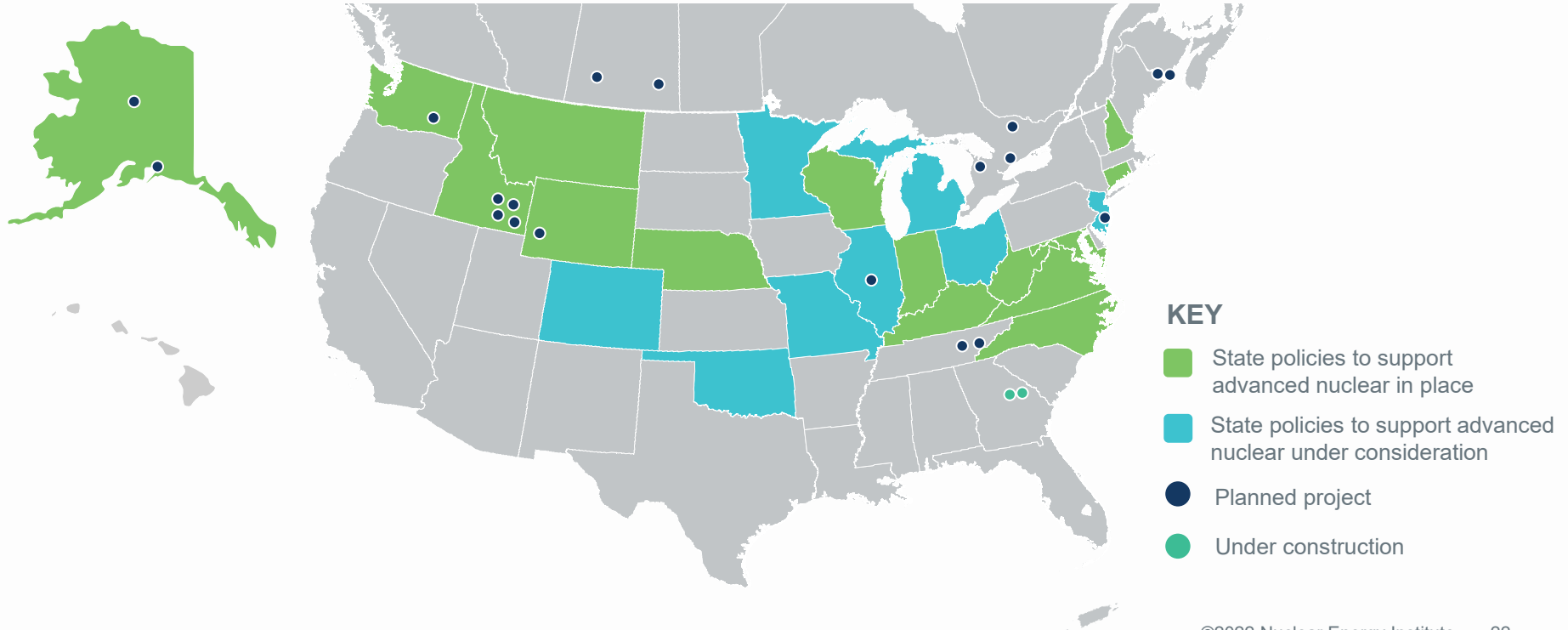
UAMPS

- 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



Advanced Nuclear Deployment Plans

Projects in planning or under consideration in U.S. and Canada; >30 globally



MOVING BEYOND ELECTRICITY

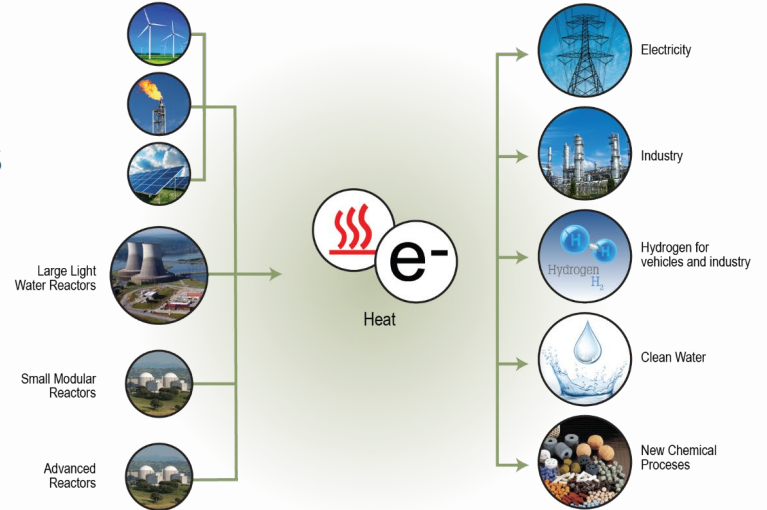
TODAY

Electricity focused



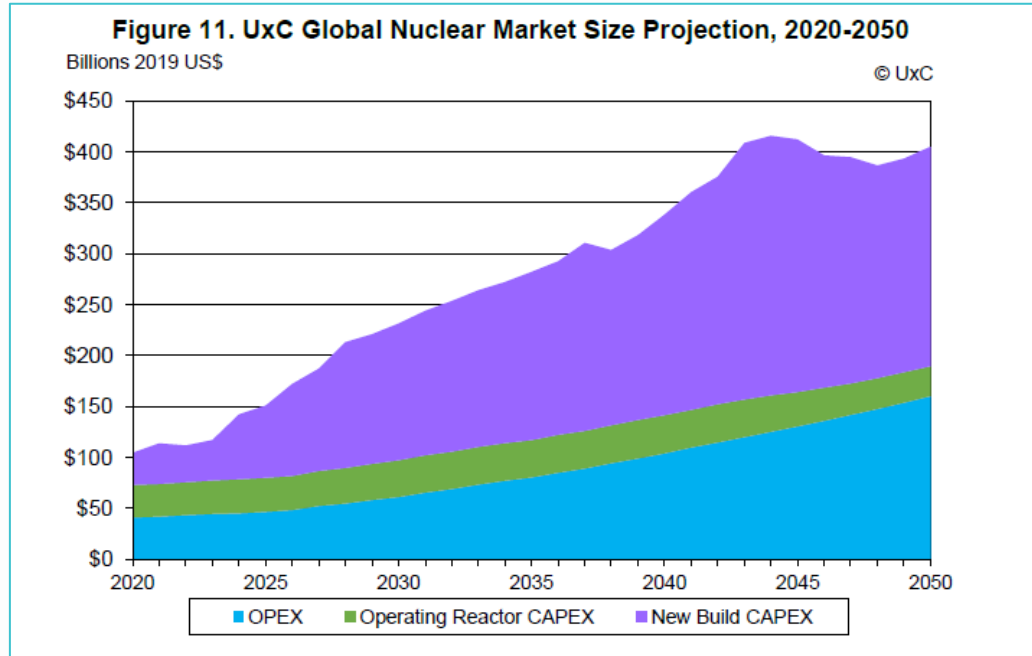
FUTURE

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)

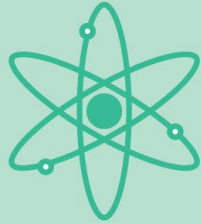
Developer	Utility / User	Location	Size	Target Online
Westinghouse AP-1000	Polska Grupa Energetyczna	Poland	6 @ 1,100 MWe	TBD
	CEZ	Czech Rep.	1-4 @ 1,100 MWe	TBD
	Energoatom	Ukraine	5 @ 1,100 MWe	TBD
	Nuclear Power Corporation	India	6 @ 1,100 MWe	TBD
	Bulgaria Energy Holding	Bulgaria	1-2 @ 1,100 MWe	TBD
	TBD	Slovenia	1,100 MWe	TBD
	Various	China	Up to 20 @ 1,100 MWe	TBD
NuScale	KGHM Polska Miedz	Poland	6 @ 77MW	2029
	Nuclearelectrica	Romania	6 @ 77MW	2028
GEH BWR X-300	OPG	ON, Canada	300 MW	2028
	Synthos & Orlen	Poland	300 MW (>10 plants)	Early 2030s
ARC	NB Power	NB, Canada	100 MW	2030
Moltex	NB Power	NB, Canada	300 MW	2032
TBD	SaskPower	Sask., Canada	~300 MWe (4 plants)	2032 to 2042

KEY TAKEAWAYS

- Consumers and policymakers (U.S. and abroad) increasingly demanding low-carbon electricity; states and utilities responding with ambitious goals
- Growing understanding that new nuclear is extremely valuable to a cleaner energy system
 - 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 CLEAN ENERGY FUTURE**

QUESTIONS?

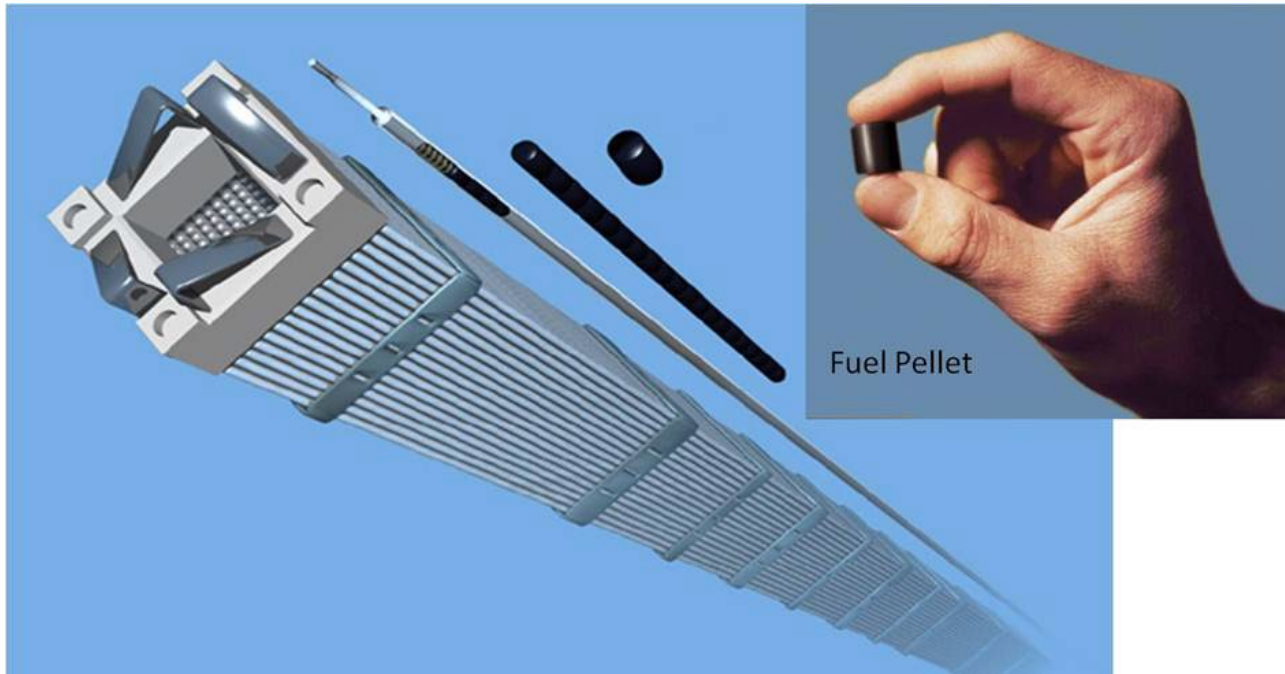


NUCLEAR ENERGY ASSEMBLY

Washington, D.C.

June 20-22

nei.org/nea



(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>)



Google earth

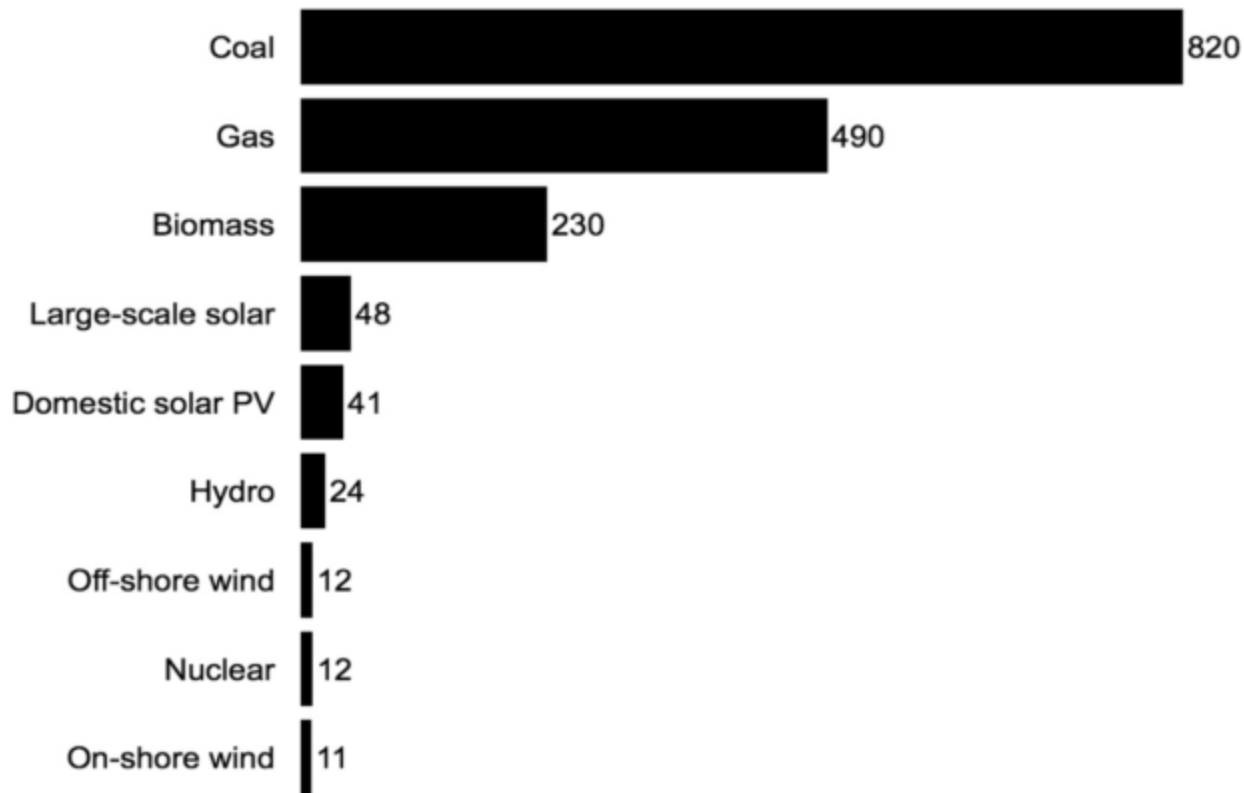
The 40 used fuel casks hold all the fuel from 29 years of Connecticut Yankee operations



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

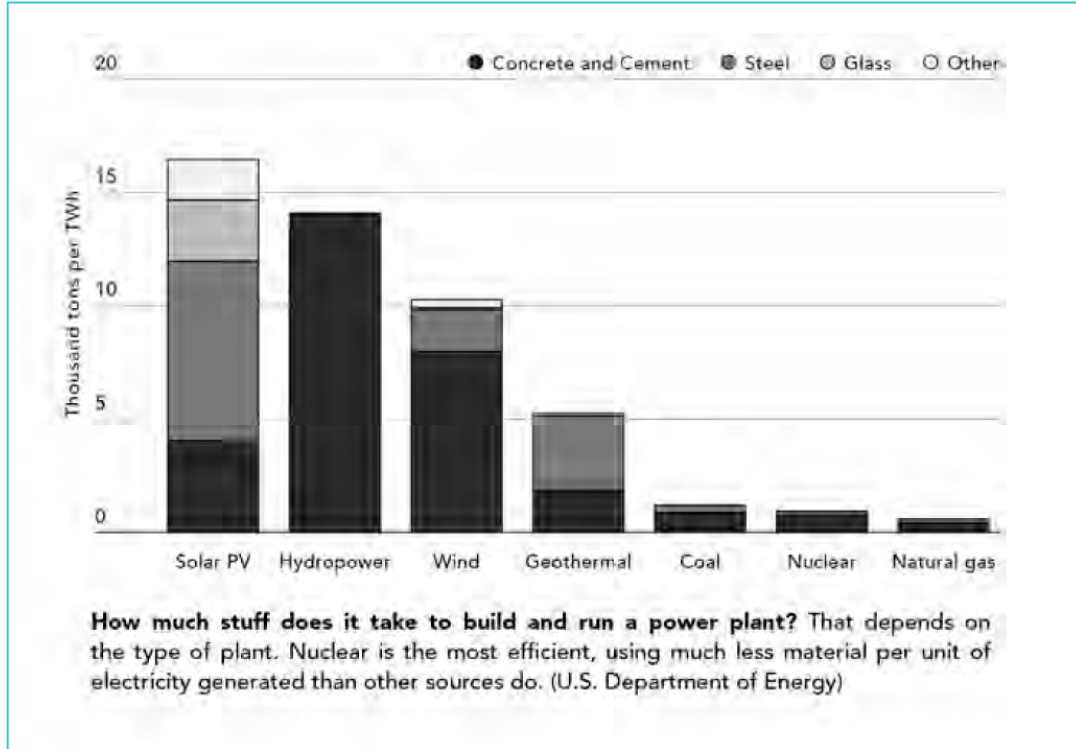
(source: http://www.connyankee.com/html/fuel_storage.html)

Life cycle emissions from electricity generation, gCO₂/KWh



Source: IPCC 2018

Raw Material Inputs per TWh



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