

Role of Nuclear National Governor's Association

Christine King
Director, Gateway for Accelerated Innovation in Nuclear

Oct 27, 2021

christine.king@inl.gov
Mobile 650-283-4235



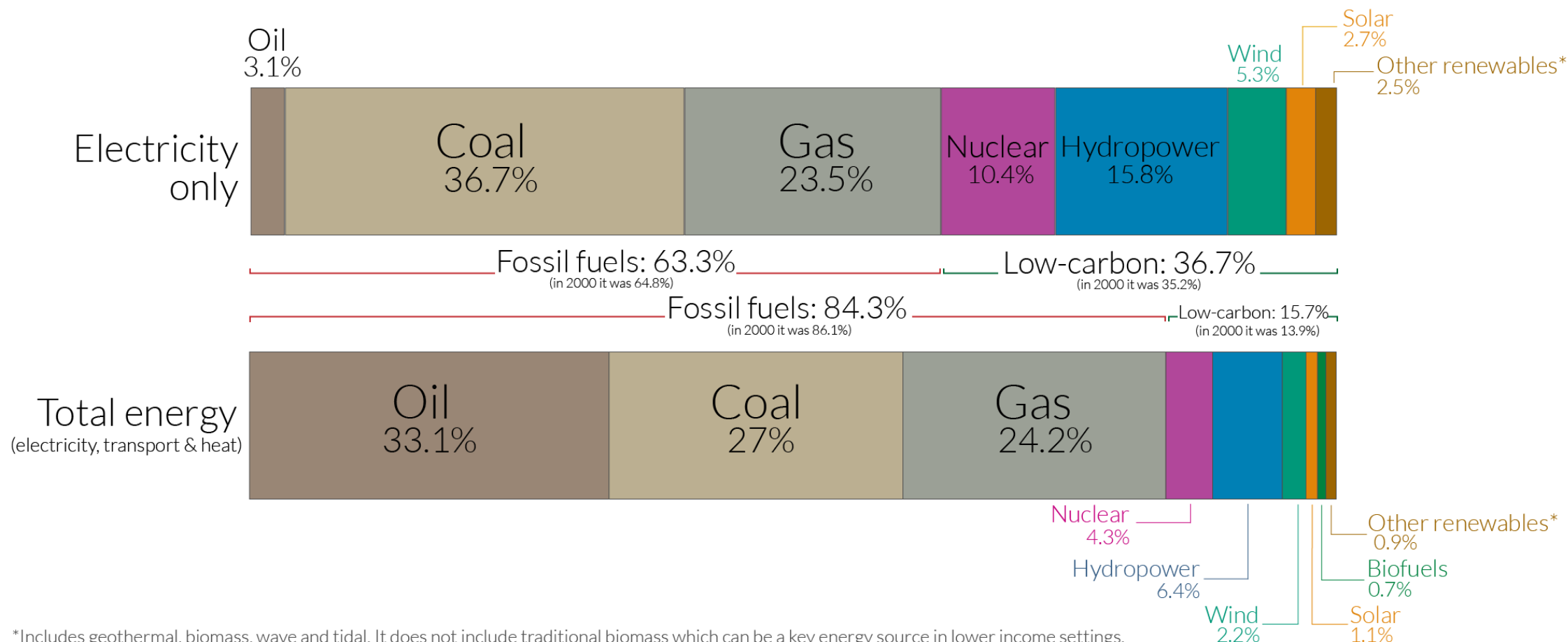
Gateway for Accelerated Innovation in Nuclear

- Initiative from Department of Energy: Office of Nuclear Energy
- Mission is to simplify private industry's access to the assets of the DOE complex: expertise, historical data and facilities.
- Accelerated must match advanced nuclear developer pace and reflect the market window (next 5-10 years).
- Innovation is not just about technology. Be creative in all spaces with a bias toward taking risks.
- Focus on initiating and completing projects that support commercial deployment.



More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does

Our World
in Data



*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

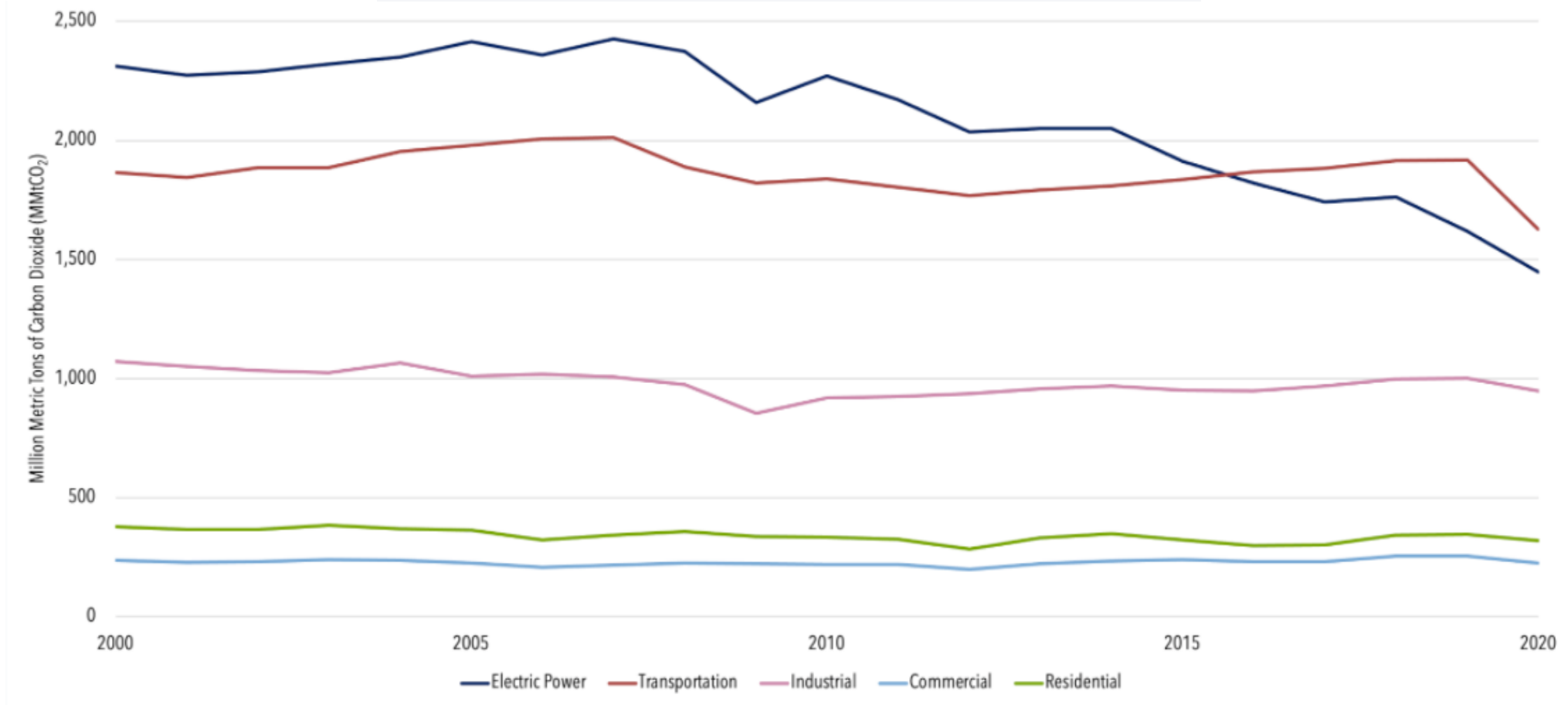
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.

Licensed under CC-BY by the author Hannah Ritchie.

Carbon Emission Trends for Energy

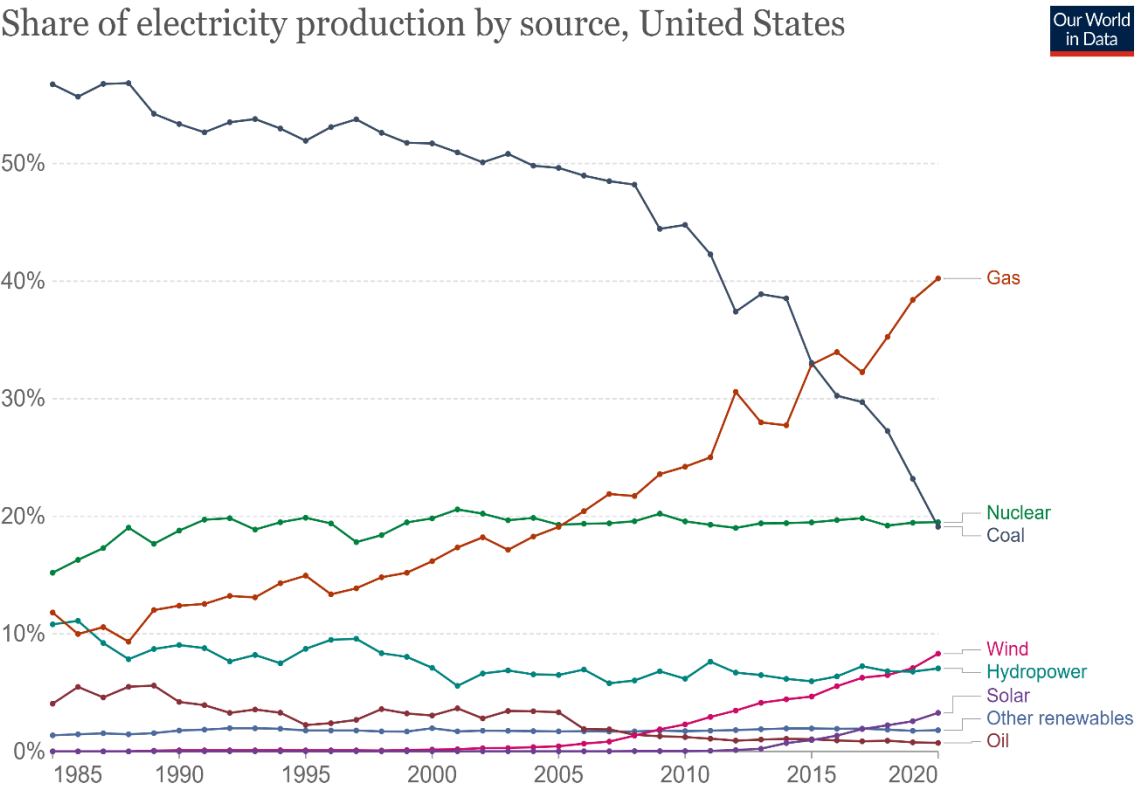
Energy-Related Carbon Dioxide Emissions by
Sector (MMtCO₂), 2000–2020



Source: Monthly Energy Review EIA 2021

What has really changed for electricity?

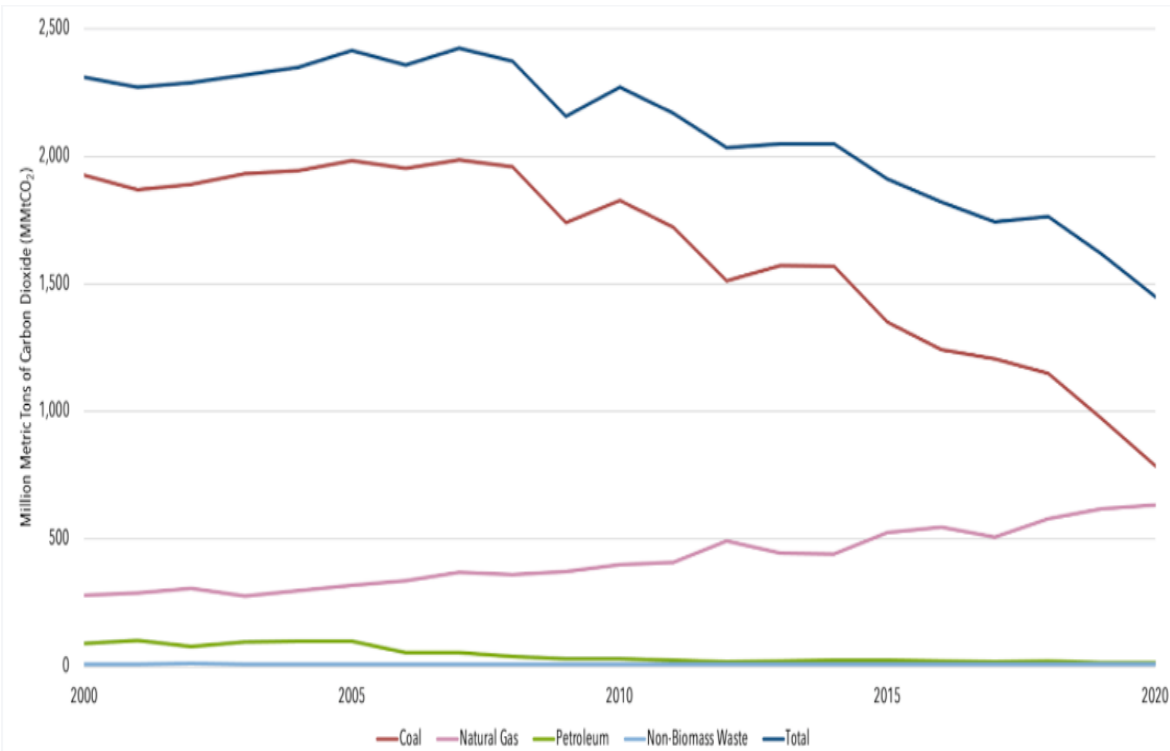
Share of electricity production by source, United States



Source: Our World in Data based on BP Statistical Review of World Energy & Ember

OurWorldInData.org/energy • CC BY

Trends in CO2 Emissions in the U.S. Power Sector, 2000–2020



Source: Monthly Energy Review EIA 2021

Deployment Constraints May Determine Future Energy Mix

Primary Energy Source	Key Deployment Challenges	2050 Build-out Across the Range of Modeling Scenarios
Renewables	Resource availability, siting, social license, and transmission requirements	1,700 – 5,500 gigawatts
Nuclear	Commercial status of new technology, ability to rapidly scale deployment in light of siting challenges and complex regulatory requirements, socio-political acceptance, and need for resolution of waste disposal issue	11 – 113 gigawatts
Gas	Need to limit methane emissions from extraction, address local environmental impact, social license, infrastructure and other constraints on CO2 injection rate for geologic sequestration	0 – 30 trillion cubic feet
Biomass	Limits on feedstock types and volumes that can be considered carbon-neutral	350 – 700 million metric dry tons

Infrastructure Needs for 2050

Double	Build at least 102 gigawatts (GW) of wind
Double	Build at least 174 GW of solar
Min 10X- Max 30X	Manufacture and sell 15 million to 45 million zero-emission vehicles
8X capacity today	Capture over 212 million metric tons (MMT) and sequester more than 165 MMT of CO2 annually by 2030
Replace 10B gal Diesel	Produce over 1.4 quads of zero-carbon fuels annually by 2030
<ul style="list-style-type: none"> • Begin construction on pipelines • Invest in innovation 	

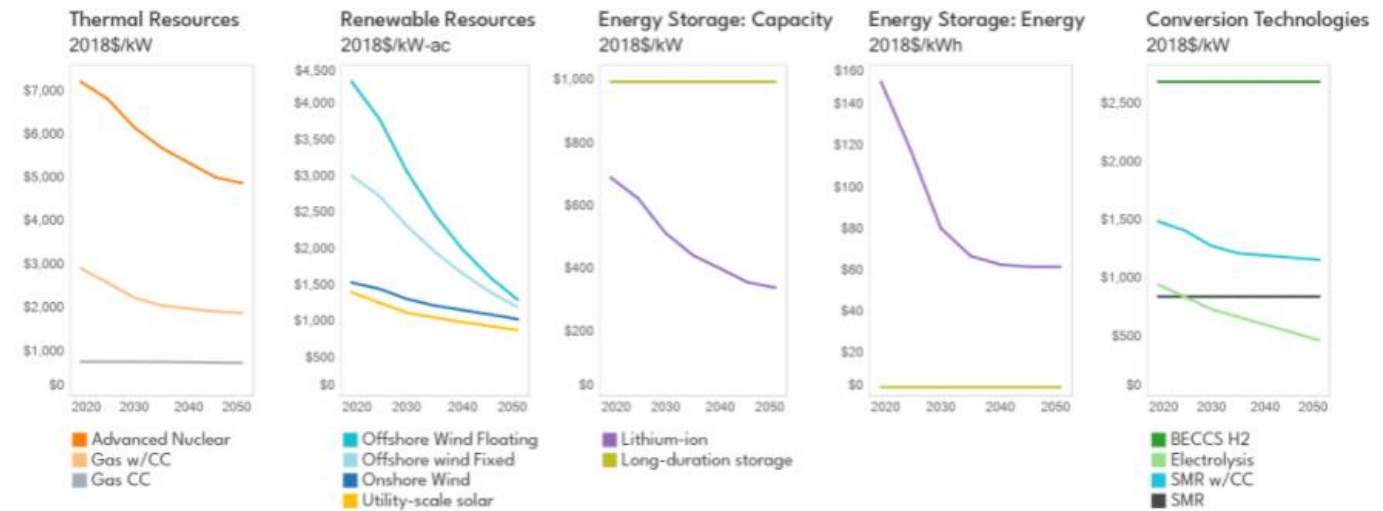


Figure 2. Capital cost trajectories for key technologies. Trajectories generally reflect continued cost reductions for low-carbon technologies.

Continue cost reductions for low carbon technologies

Preserve infrastructure where we can

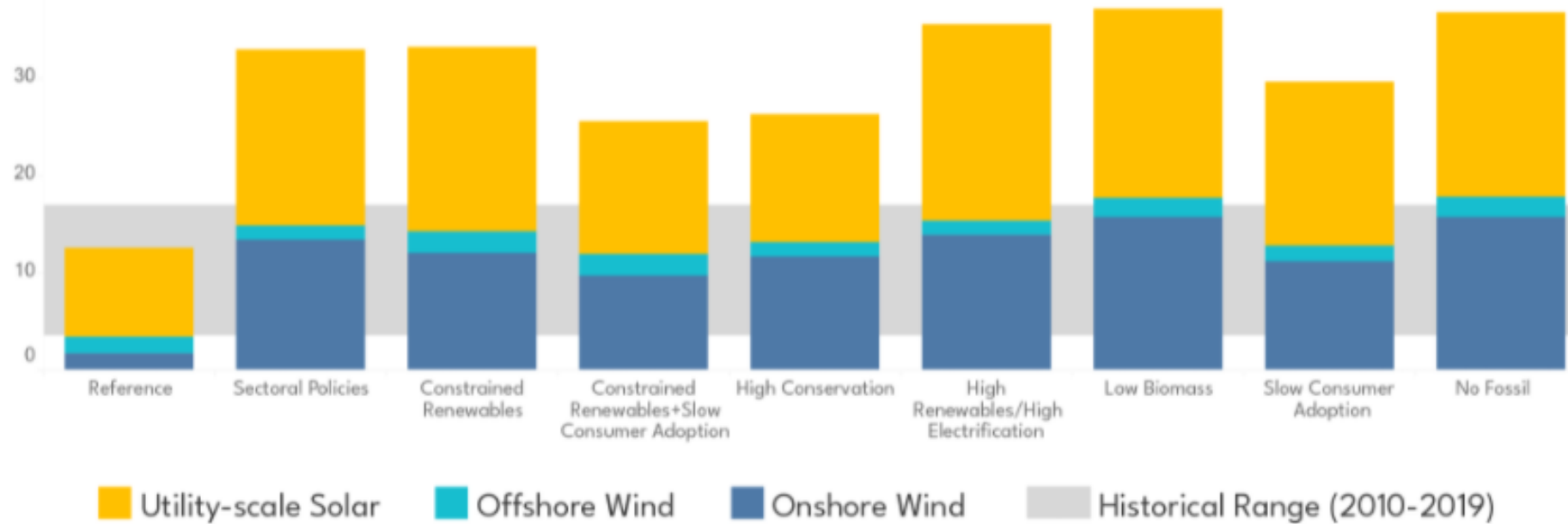
PATHWAYS TO NET-ZERO EMISSIONS

Decarb America Research Initiative
Key Takeaways

FEBRUARY 4, 2021

Buildout of wind and solar

Average Annual Build: 2021-2030
GW per year



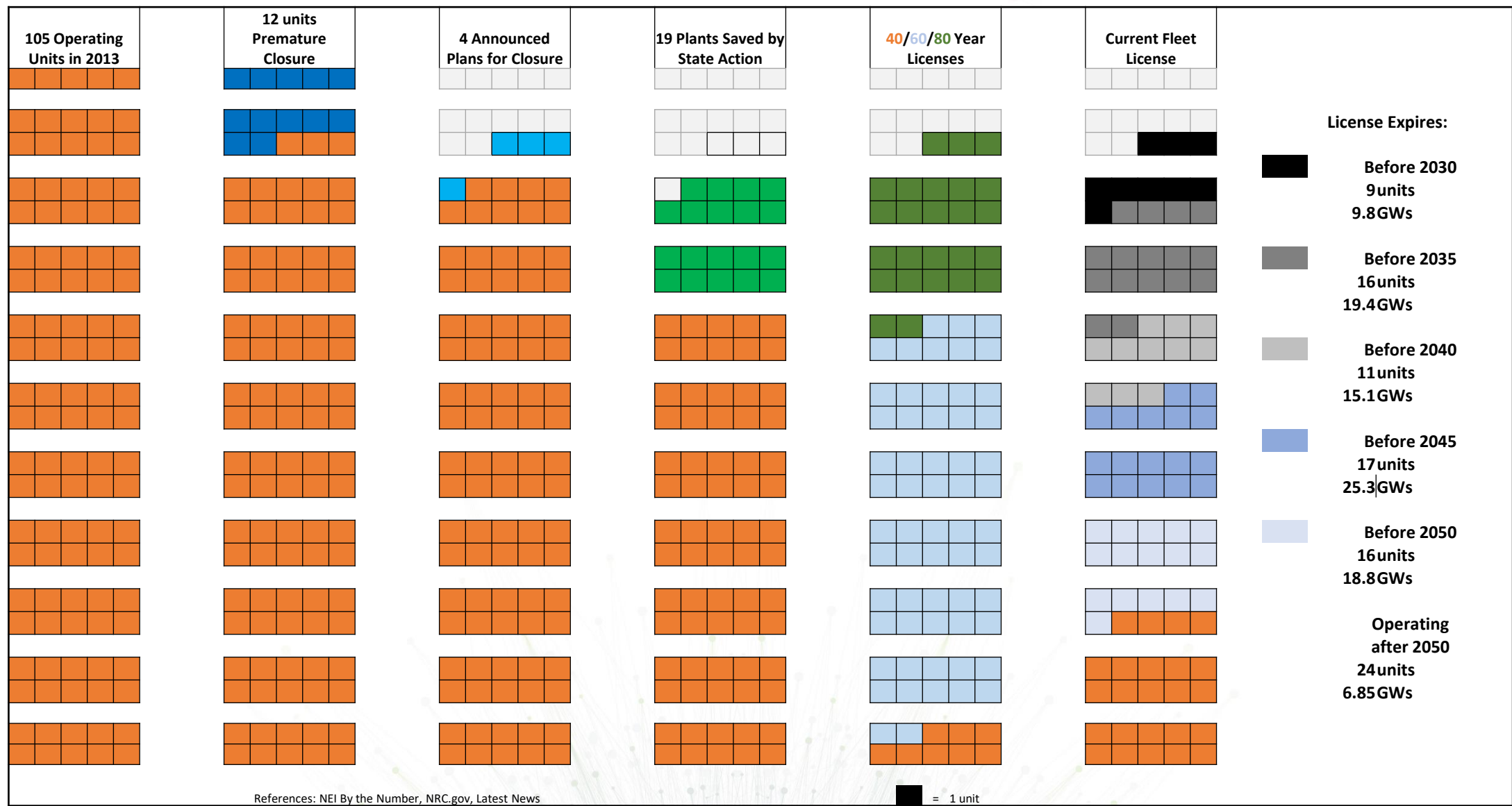
To reach net-zero, new clean energy infrastructure will have to be deployed at extraordinary rates.

**ENERGY
INFRASTRUCTURE
NEEDS FOR A NET-
ZERO ECONOMY**

Decarb America Research
Initiative
Key Takeaways

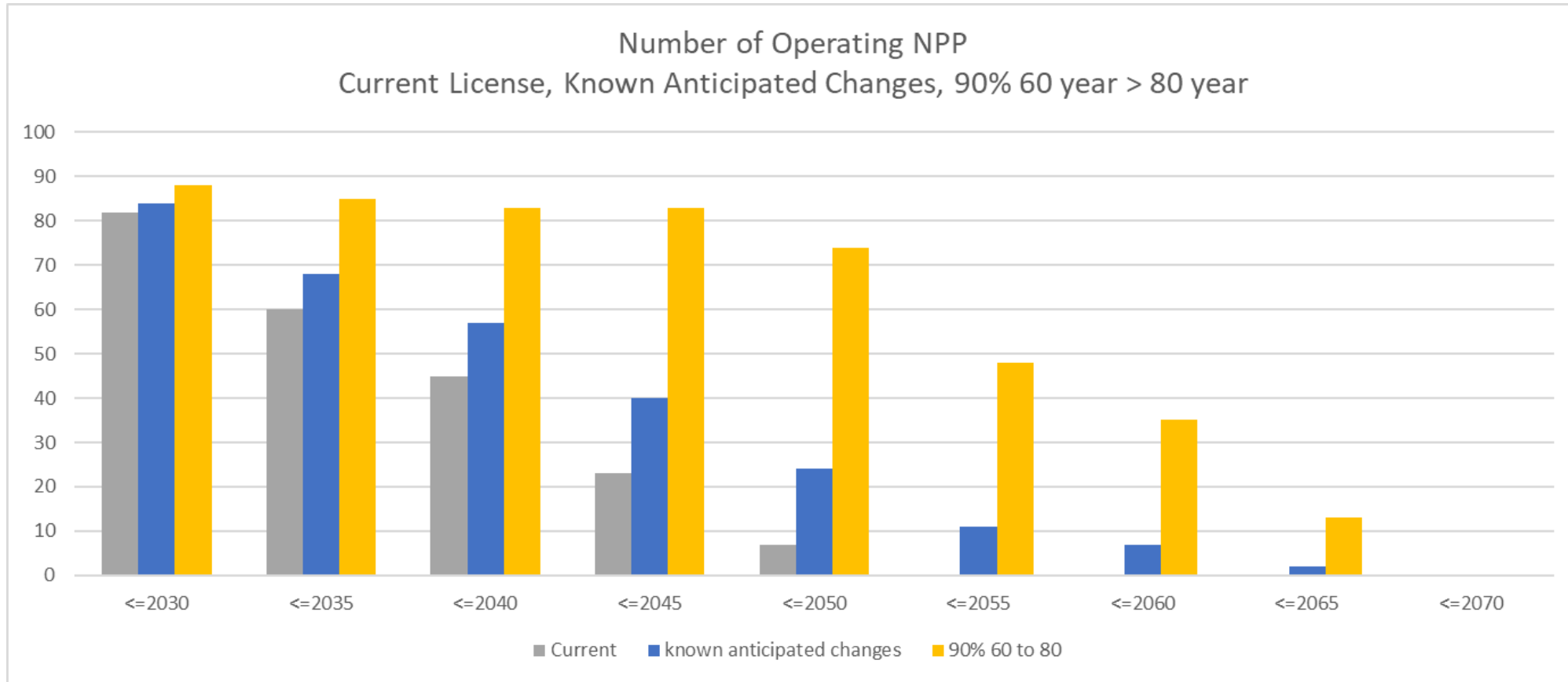
FEBRUARY 4, 2021

Existing Nuclear Fleet



References: NEI By the Number, NRC.gov, Latest News

Existing Nuclear Fleet – Extend to 80 Year License



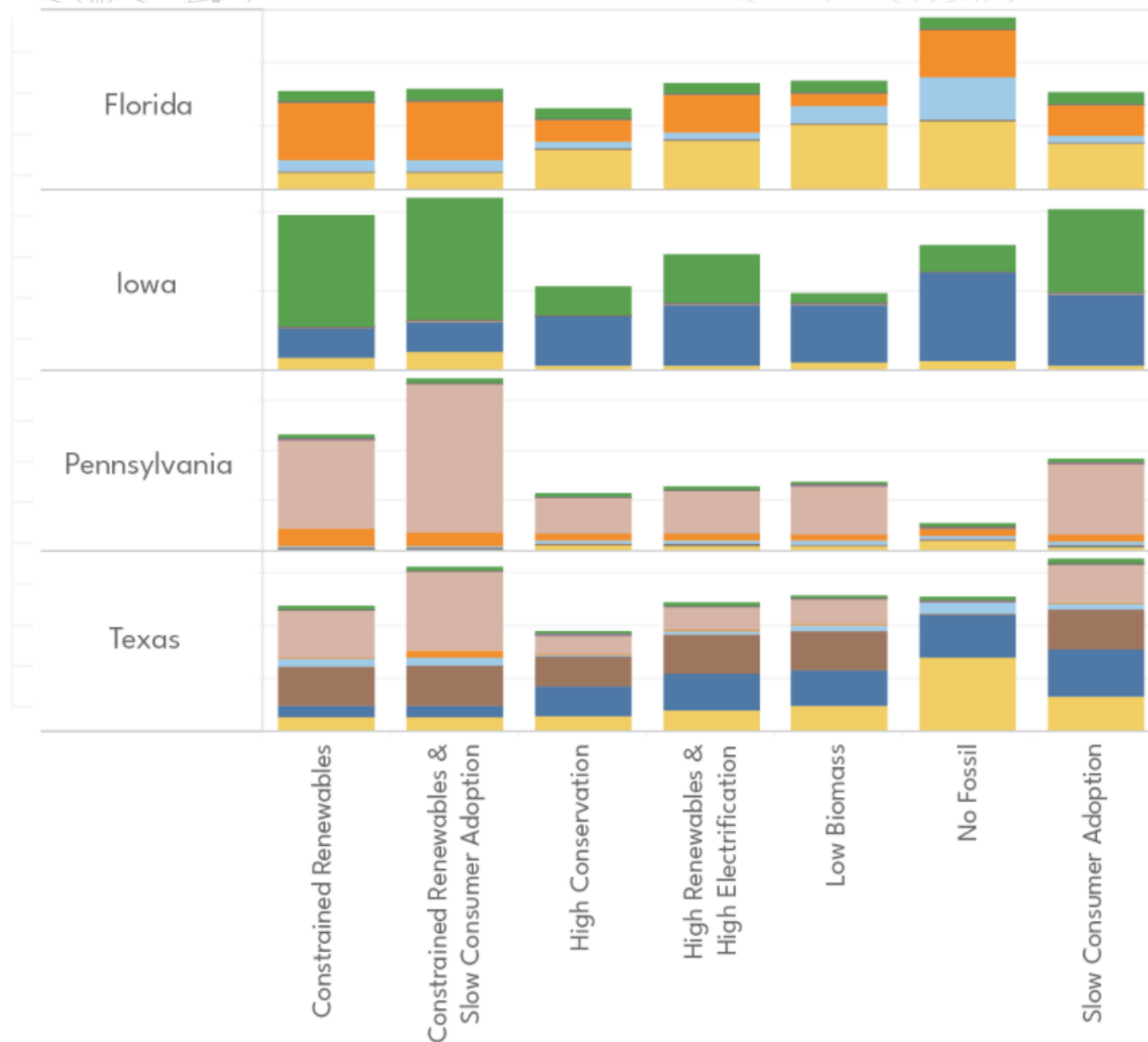
**With our current licenses, nuclear fleet would be fully retired by 2050.
Extension to 80-years allows at least 74 plants (~74 GW) to operate until 2050.**

Primary Energy in 2050 – US and 4 States



Scenario Planning

- Unintended Consequences
- Balancing pros of one technology against the cons of another



Inclusive policies for technology innovation and deployment will allow all regions of the U.S. to leverage their different resource endowments and develop new clean energy industries.

Advanced Fission

- Categorized in terms of capacity
 - Microreactors: <20 MWe (megawatt electric)
 - Small reactors: 20 MWe – <300MWe
 - Small Modular Reactors: use modular construction
 - Medium reactors: 300MWe - 700 MWe
 - Large reactors: > 700 MWe
- Variety of coolants (gas, sodium, salt, lead, water)
- Clean, high availability
- Diverse markets
- Improved safety, waste, security, and target economics
- 60+ private sector projects

Small Town: 1 Megawatt (MW)

Mid-size City: 1 Gigawatt (GW)

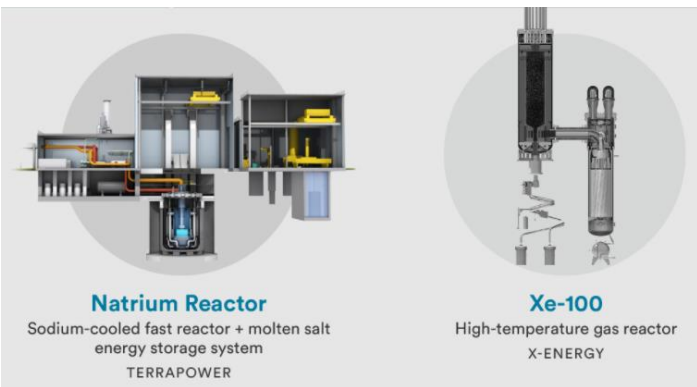
The US: 1,000 Gigawatts

Image courtesy of GAIN and Third Way, inspired by the *Nuclear Energy Reimagined* concept led by INL. Learn more about these and other energy park concepts at thirdway.org/blog/nuclear-reimagined



DOE-NE Advanced Reactor Demonstration Projects

Demonstration

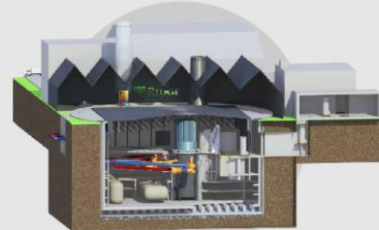


Wyoming

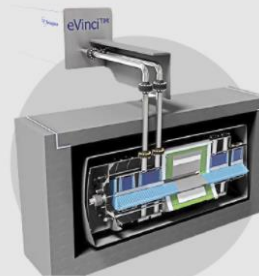
Washington

Risk Reduction

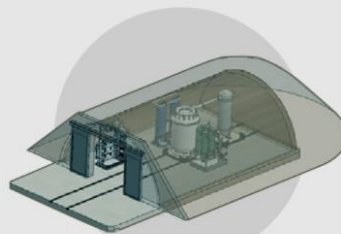
Tennessee



KP-FHR
Fluoride salt-cooled high-temperature reactor
KAIROS POWER



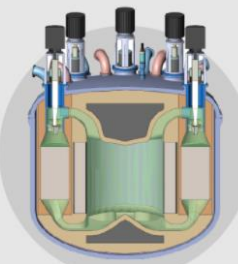
eVinci
Heat pipe-cooled microreactor
WESTINGHOUSE NUCLEAR



BWXT Advanced Nuclear Reactor (BANR)
High-temperature gas-cooled microreactor
BWXT TECHNOLOGIES

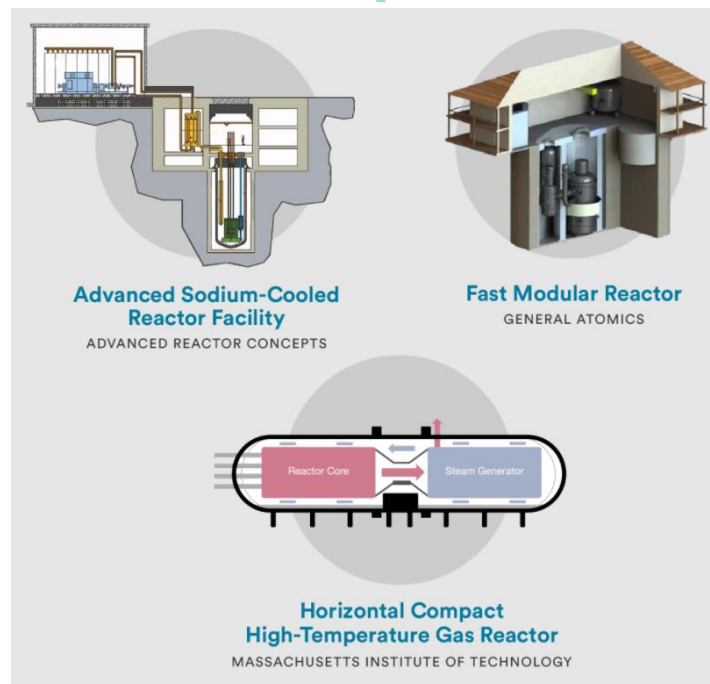


SMR-160
Advanced light-water small modular reactor
HOLTEC INTERNATIONAL

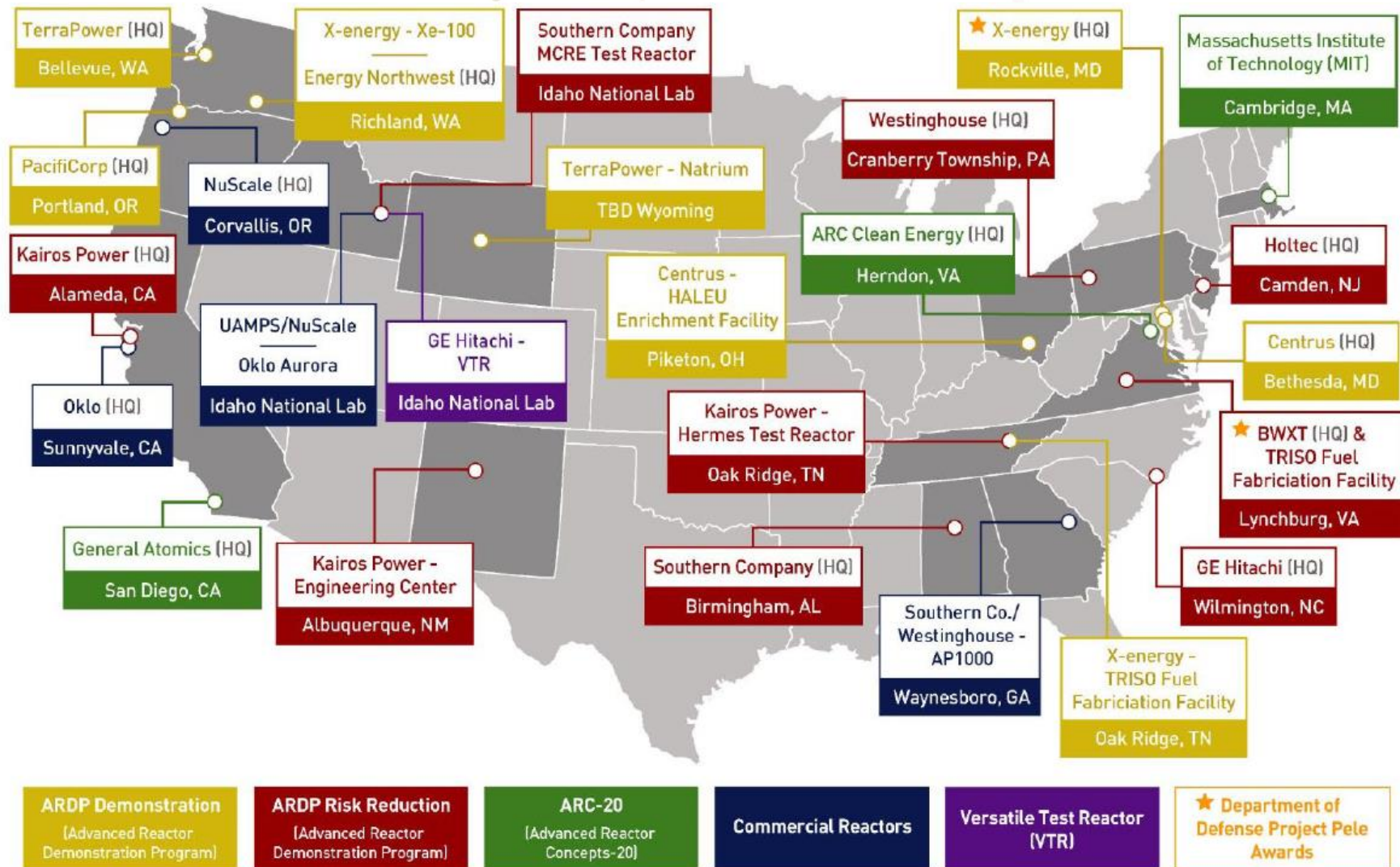


Molten Chloride Fast Reactor
SOUTHERN COMPANY

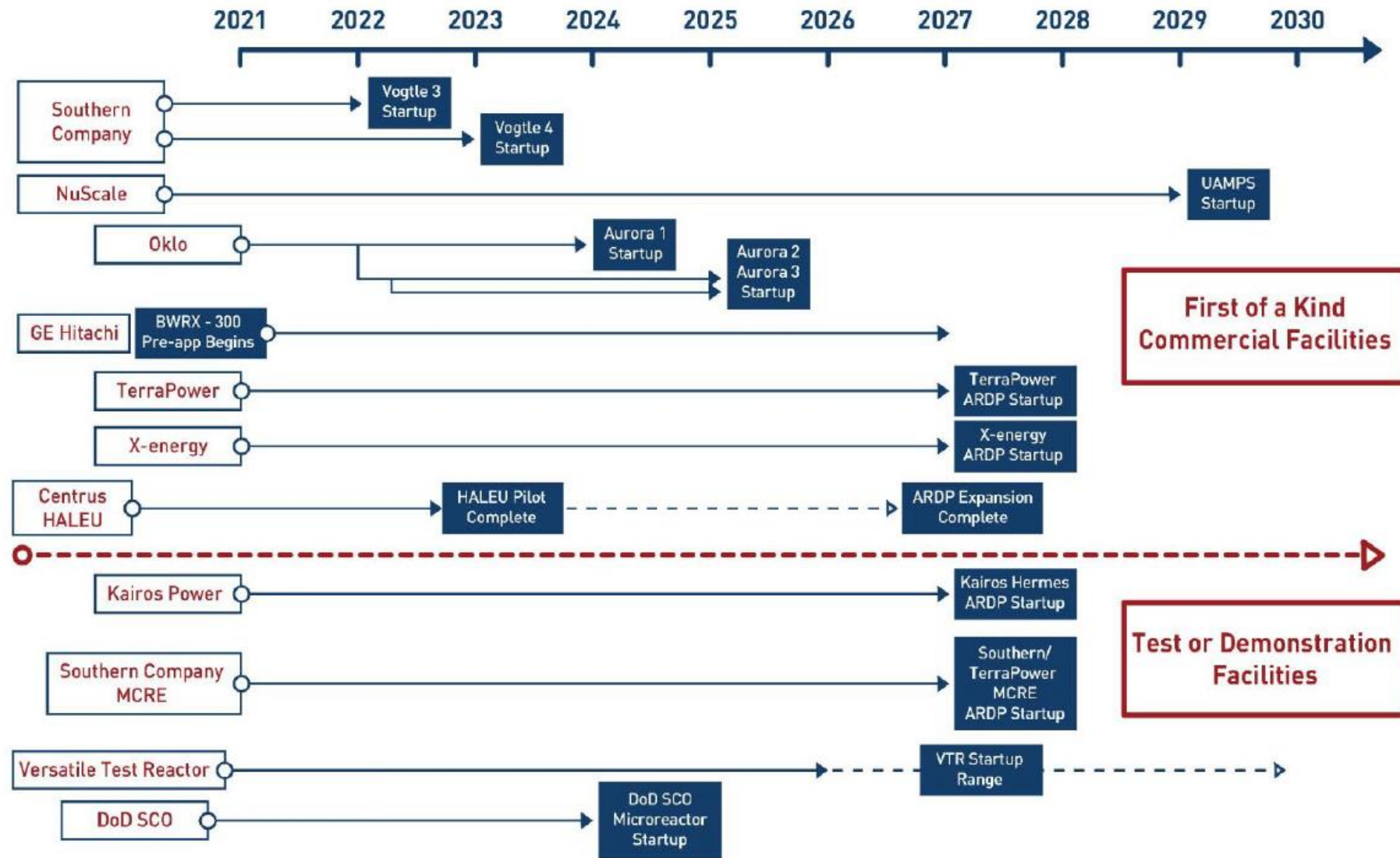
Concept Development



Slide content courtesy of U.S. DOE-NE



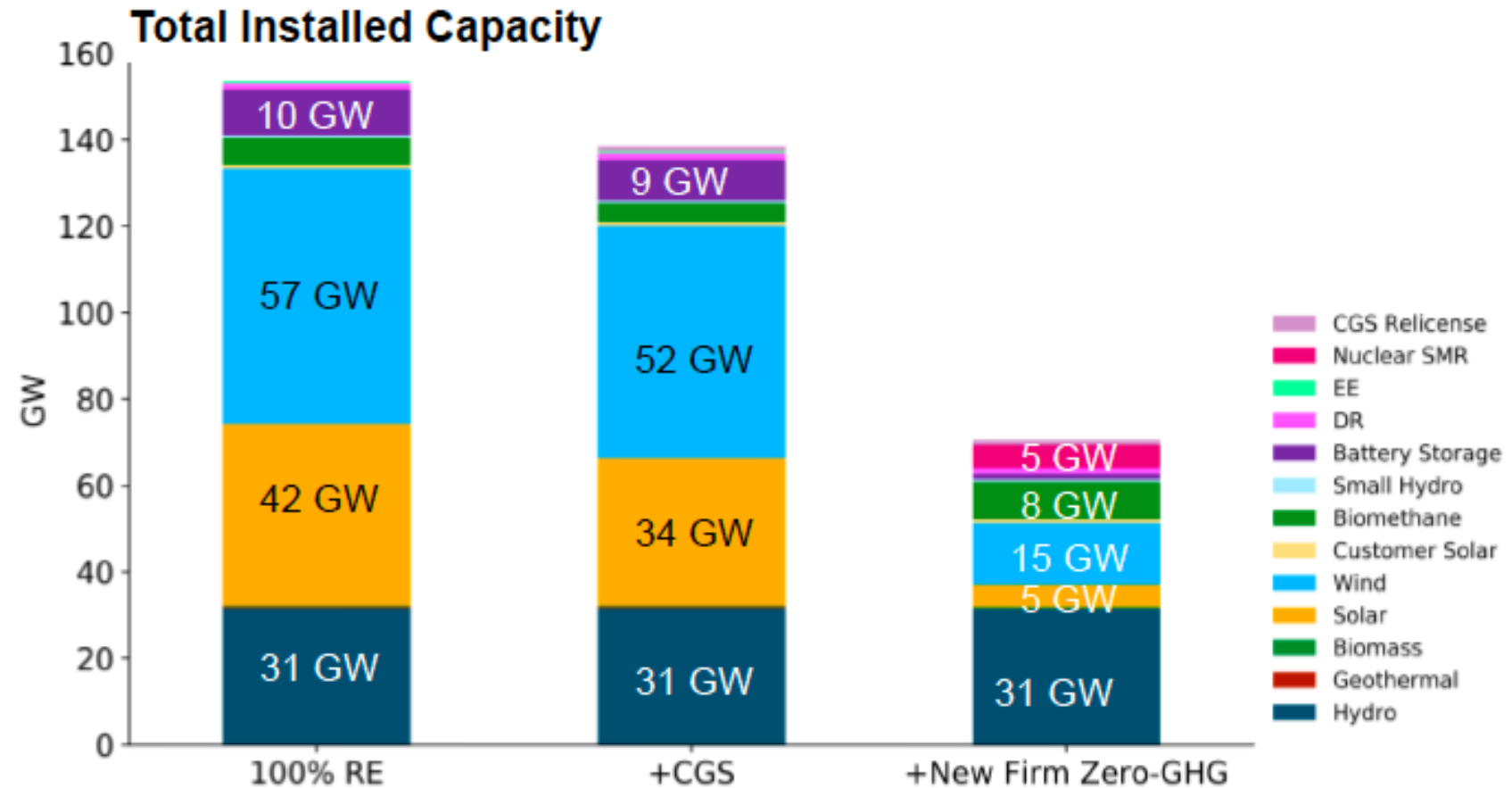
CLEARPATH



CLEARPATH

Meeting Emissions Goals with Nuclear: Example Case

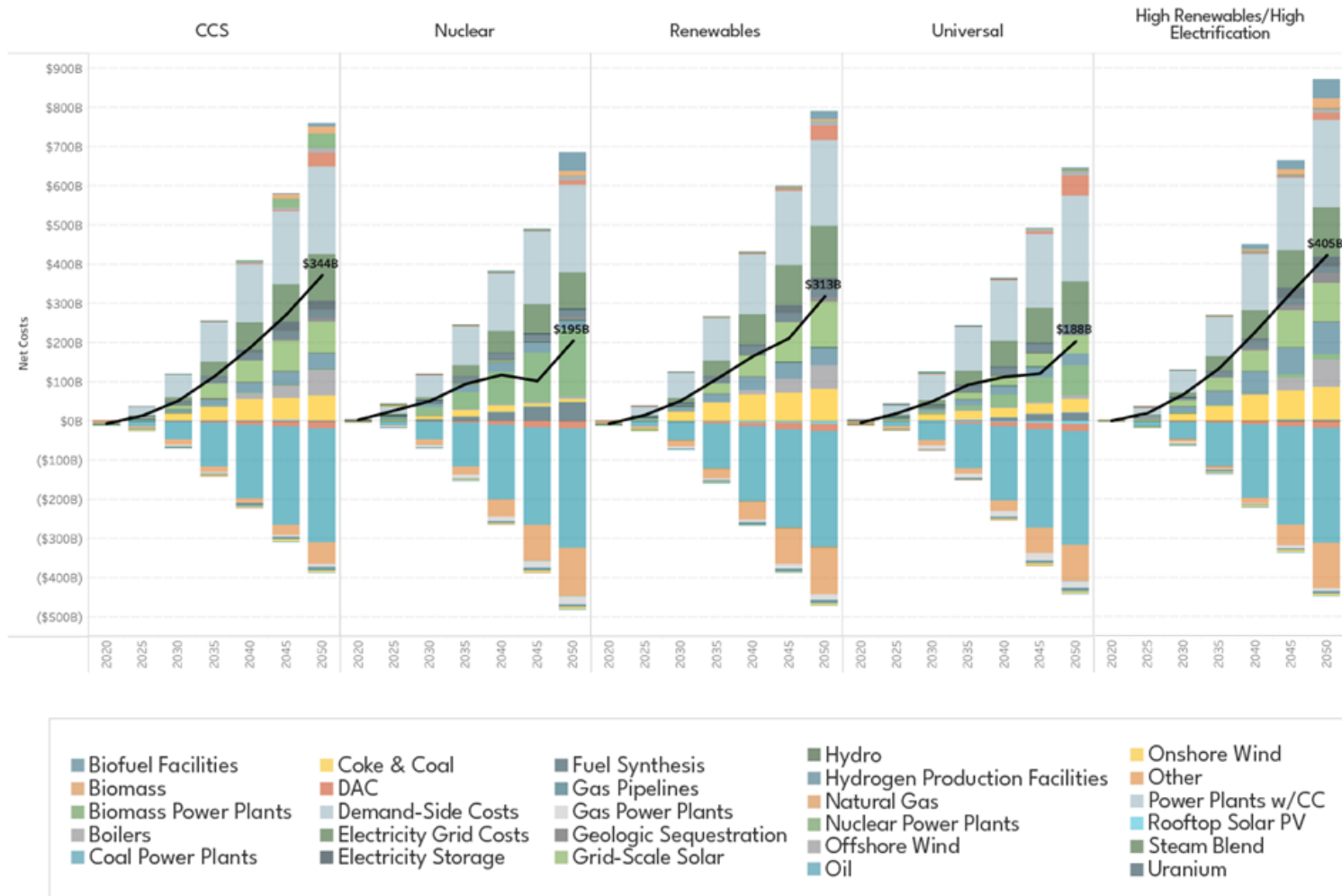
- E3 study for Energy Northwest on achieving 100% carbon free by 2045:
 - Firm zero-emitting resources like nuclear reduce costs up to \$8B per year
 - Adding 6.5GW firm avoids 91GW non-firm
- Other studies have been shared publicly



Pacific Northwest Zero-Emitting Resources Study, Energy and Environmental Economics, Inc.

<https://www.ethree.com/wp-content/uploads/2020/02/E3-Pacific-Northwest-Zero-Emitting-Resources-Study-Jan-2020.pdf>

Importance of Innovation – Decarb America Analysis



Scenario	Cost Above Reference Scenario in 2050 (billions)
High Renewables/High Electrification	\$405
CCS Innovation	\$344
Nuclear Innovation	\$195
Renewables Innovation	\$313
Universal Innovation	\$188



@GAINnuclear

gain.inl.gov



Advanced Nuclear Industry Milestones in New Website

 <p>TerraPower announces SMR proj...</p> <p>DATE 6/2/2021</p> <p>DESCRIPTION Wyoming Governor Mark Gordon announced that TerraPower and PacifiCorp will be working together to demonstrate TerraPower's Natrium small modular react...</p> <p>WEB RESOURCES TerraPower, Wyoming Governor and PacifiCo</p>	 <p>Montana relaxes nuclear constru...</p> <p>DATE 4/30/2021</p> <p>DESCRIPTION Signed by Governor Greg Gianforte in Spring of 2021, HB 273 grants the Montana State Legislature with the authority to approve the construction of new nuclear ...</p> <p>WEB RESOURCES HB 273: Eliminate Restrictions on Nuclear Fa</p>	 <p>NJBPU extends nuclear ZECs for t...</p> <p>DATE 4/27/2021</p> <p>DESCRIPTION In a unanimous vote, the New Jersey Board of Public Utilities (NJBPU) extended the ZEC credits for PSEG and Exelon's nuclear plants for an additional three years. PSEG owns t...</p> <p>WEB RESOURCES New Jersey Regulators Extend Nuclear Subs</p>	 <p>MARVEL is approved</p> <p>DATE 4/13/2021</p> <p>DESCRIPTION As part of the Department of Energy's (DOE) Microreactor Program, the Microreactor Applications and Research Validation and EvaLuation (MARVEL) Project will be house...</p> <p>WEB RESOURCES INL's MARVEL could demonstrate remote op</p>
---	---	---	--

The new website captures key industry achievements in technology, development, policy, regulation, finance, integrated systems.

<https://www.airtable.com/universe/expnrIMohdf6dlvZI/milestones-in-advanced-nuclear?explore=true>

GAIN Energy Calculator

The GAIN Energy Calculator is available at <https://gain.ornl.gov/#/>.

