Future Role of Nuclear Energy

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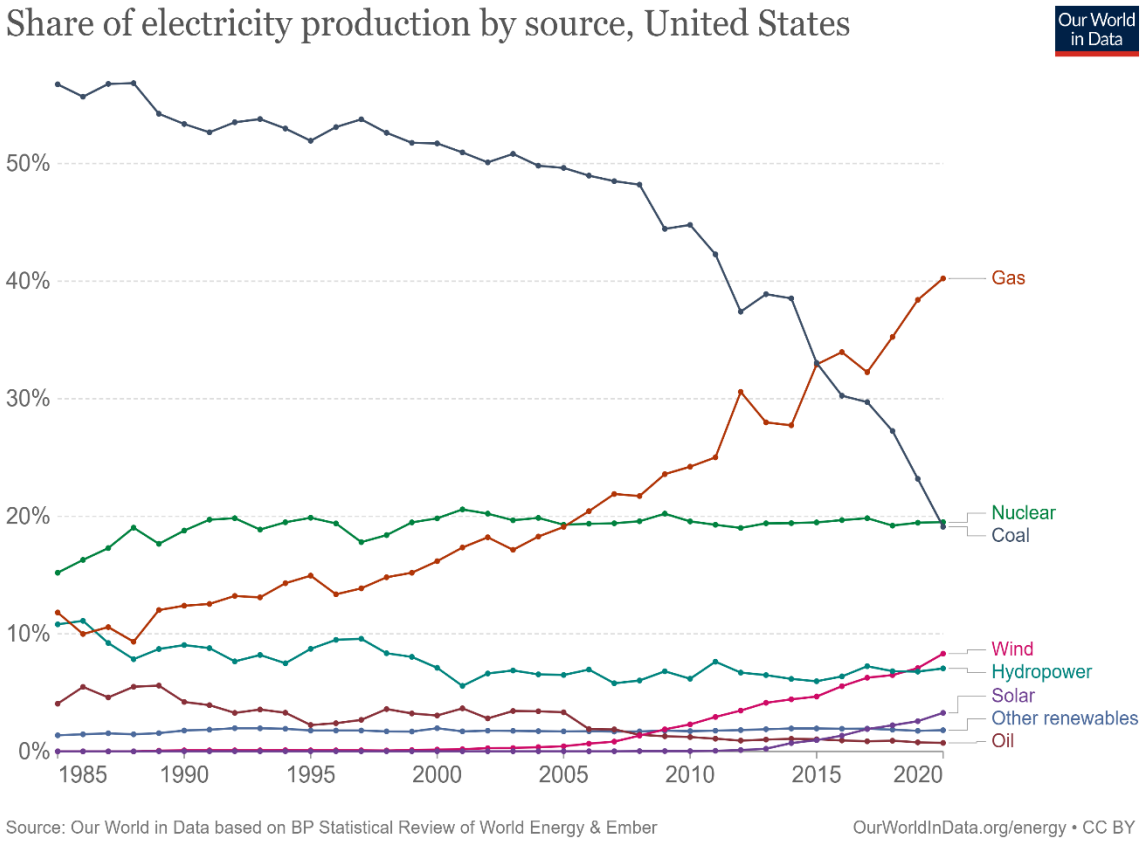
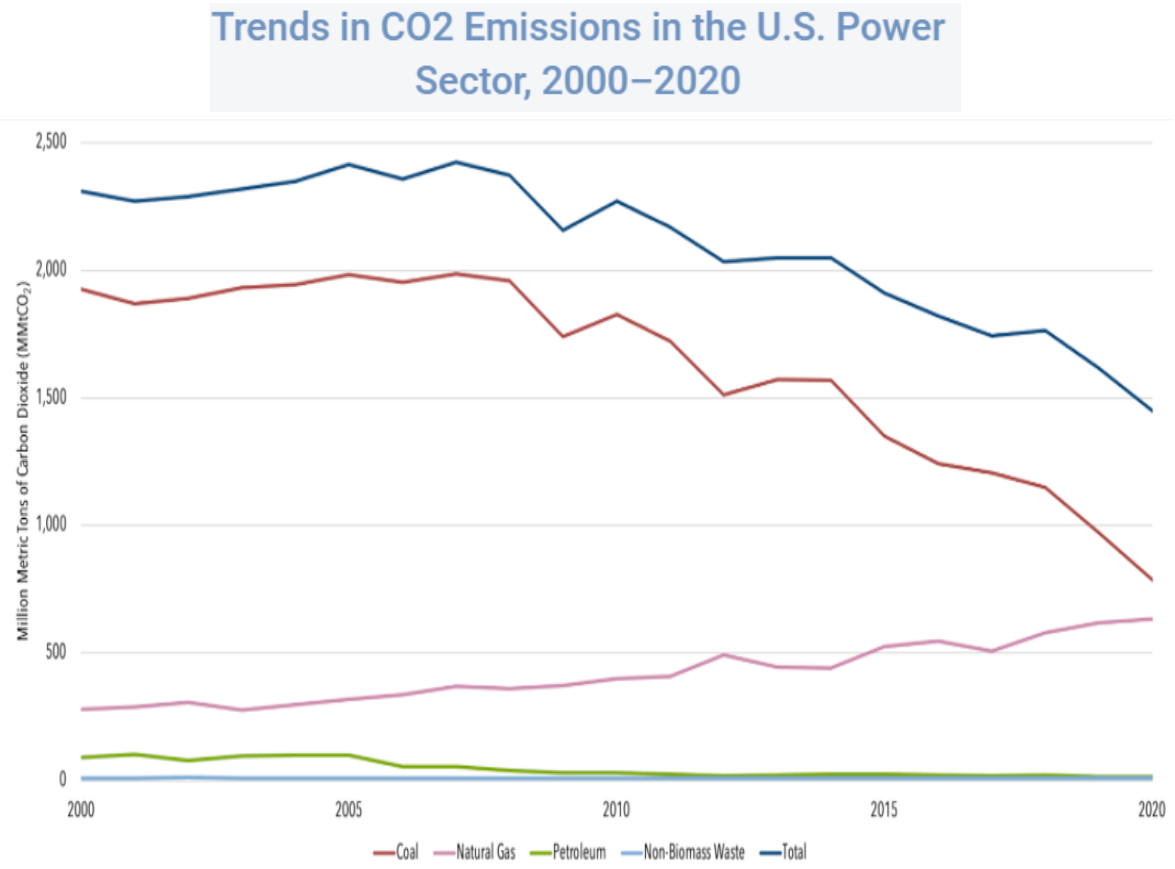
GAIN
Gateway for Accelerated Innovation in Nuclear

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.

What has really changed for electricity?





Source: Monthly Energy Review EIA 2021

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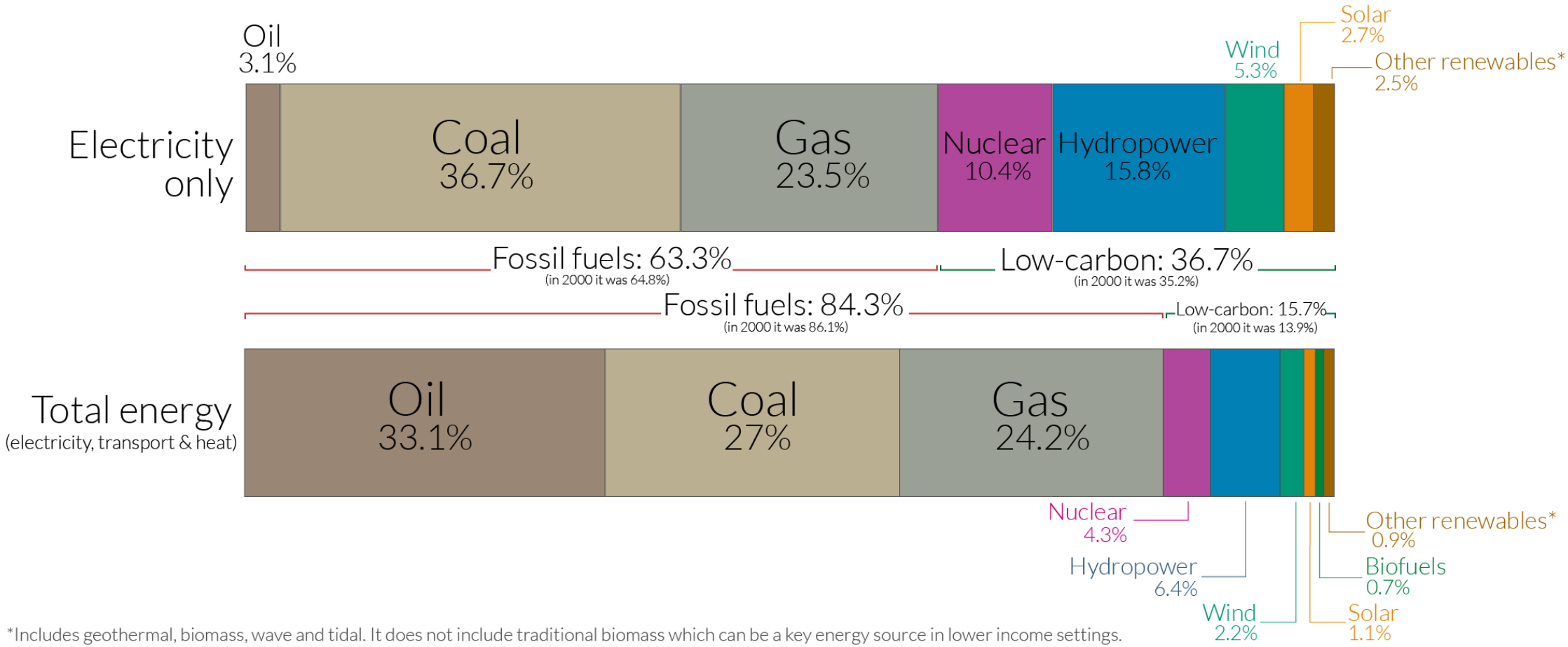
More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does

Our World in Data

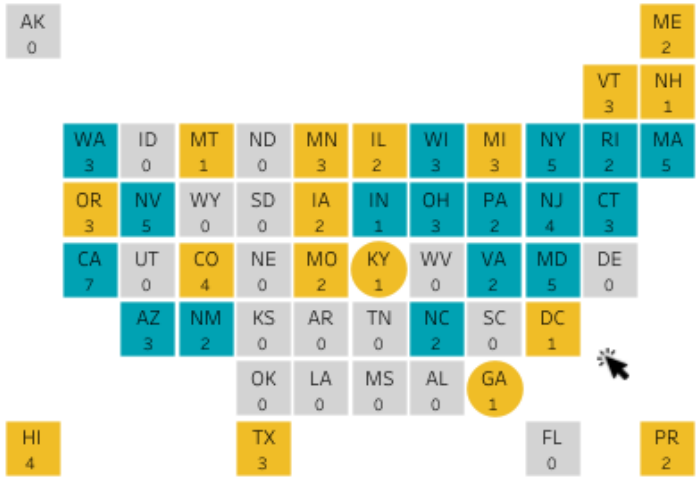


*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

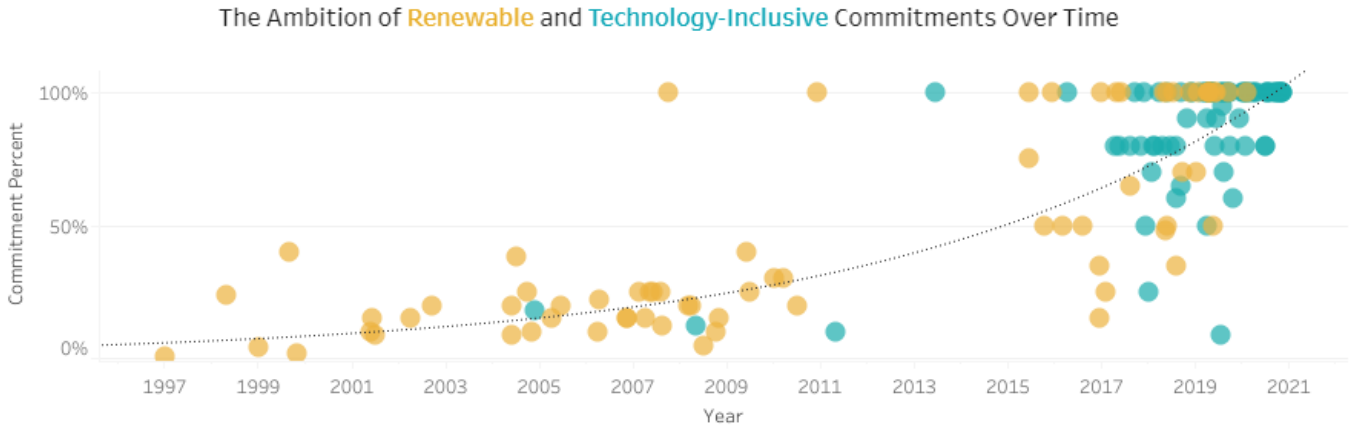
OurWorldinData.org – Research and data to make progress against the world's largest problems.

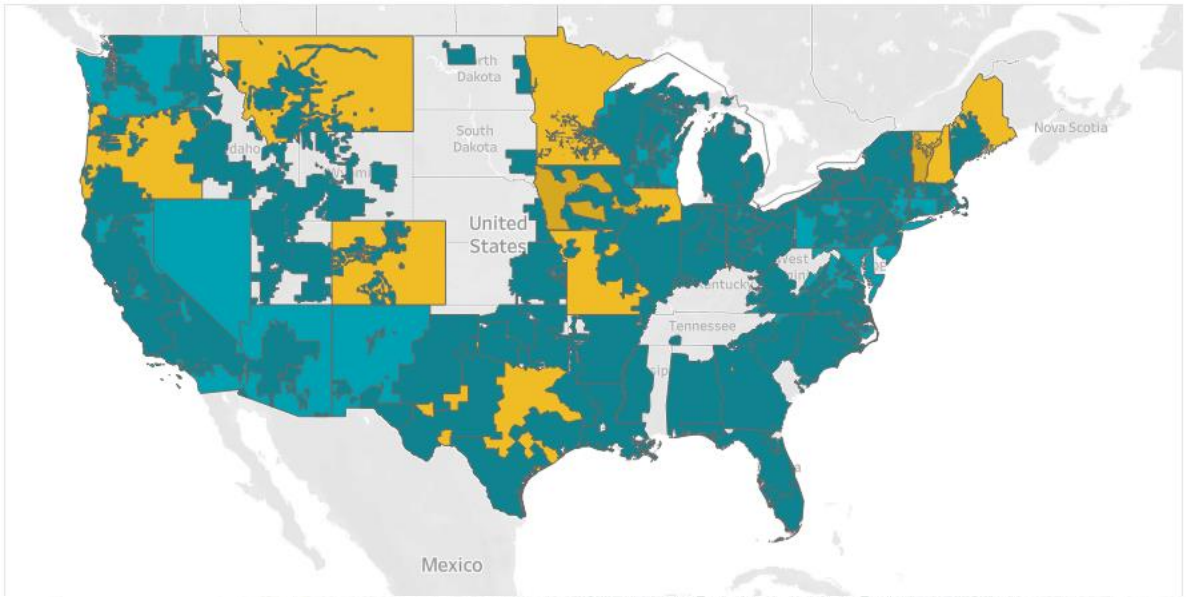
Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.

Commitments by State: Renewable and Tech Inclusive



* GA only has a city commitment



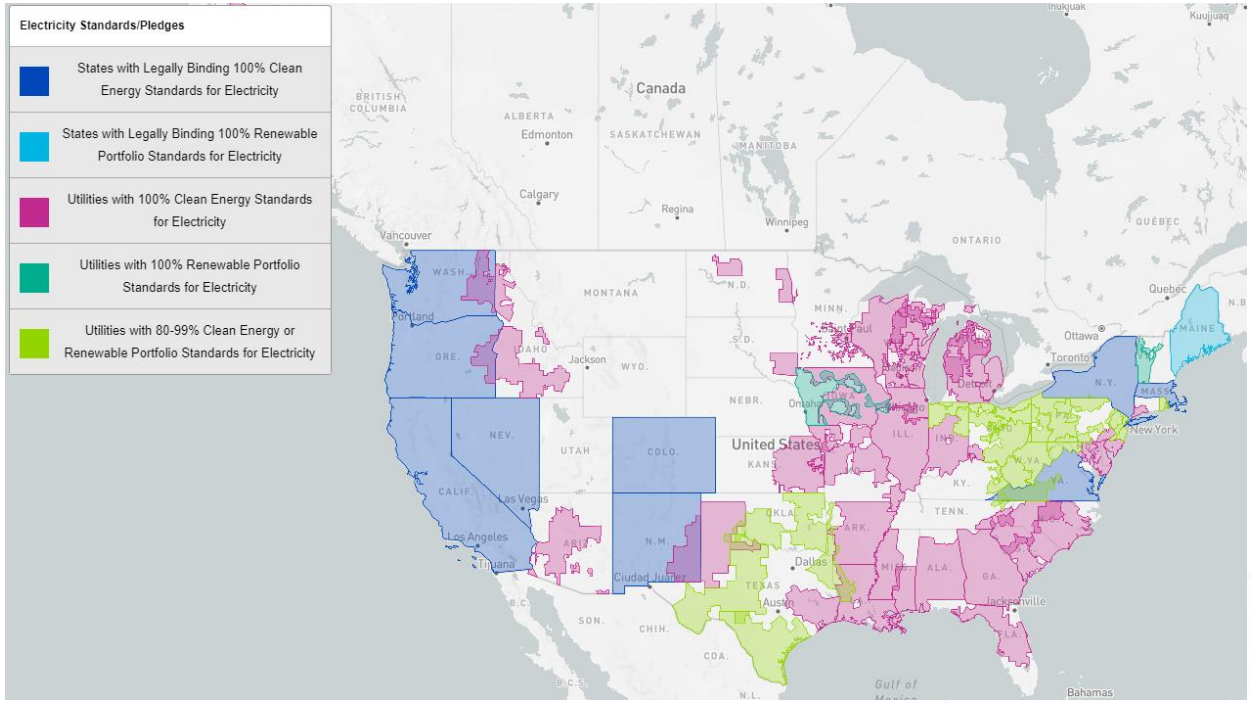


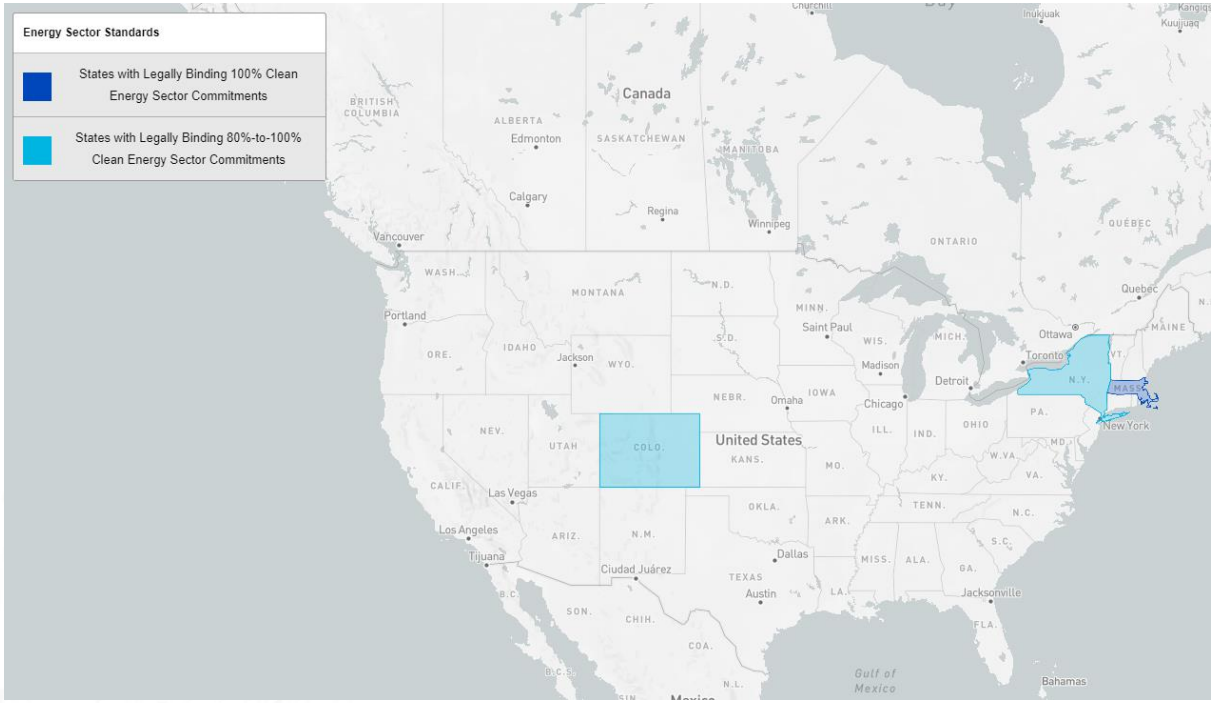
THIRD WAY

GRAPHIC *Published December 11, 2019 · Updated December 1, 2020 · 15 minute read*

Clean Energy Targets Are Trending

US Decarbonization Targets – Electricity vs Energy; Utilities vs States

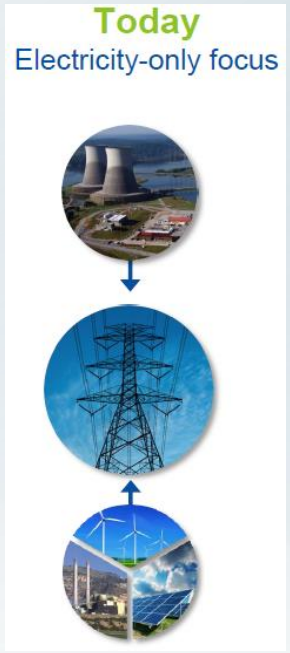


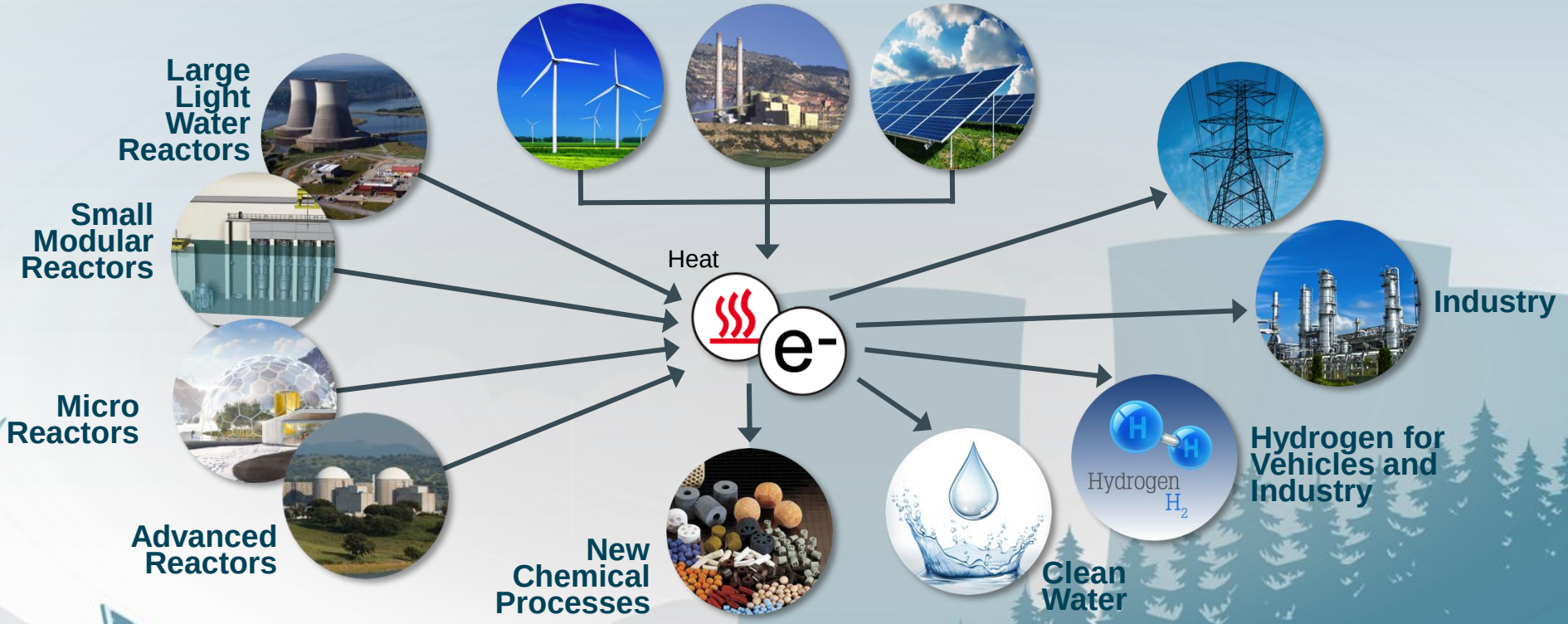


U.S. Decarbonization Commitments | Clean Air Task Force

IES
Integrated Energy Systems

Future clean energy systems would leverage contributions from low emission energy generation for electricity, industry, and transportation





A net zero future will take decades to achieve, will make us rethink energy across all sectors and gives us the opportunity to make the most of our resources!

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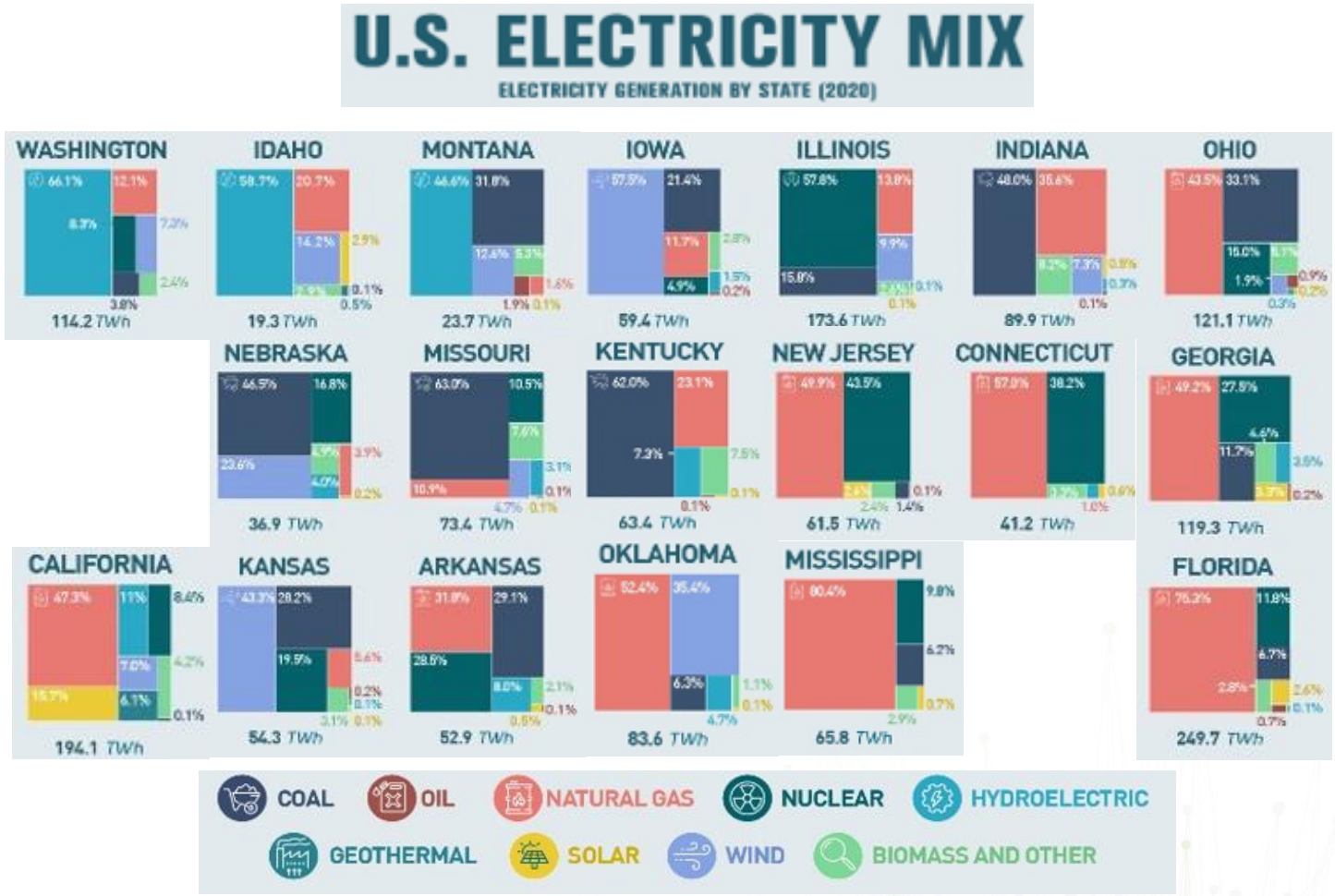

Emerging Technologies

- Carbon Capture
- Zero-Carbon Electricity Generation
- Energy Storage
- Zero-Carbon Fuels
- Vehicles
  - Electric vehicles
  - Zero-emission trucks
  - Engines capable of running on ammonia and for other transportation modes that are difficult to electrify
- Aviation
  - Advanced (more efficient) aviation technology
- Industrial Materials
  - Hydrogen-direct reduced Iron

Rapid decarbonization of the U.S. economy will require a diverse set of existing and new clean energy technologies.

PATHWAYS TO NET-ZERO EMISSIONS

Decarb America Research Initiative
Key Takeaways

FEBRUARY 4, 2021

GAIN Gateway for Accelerated Innovation in Nuclear

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

PATHWAYS TO NET-ZERO EMISSIONS

Decarb America Research Initiative
Key Takeaways

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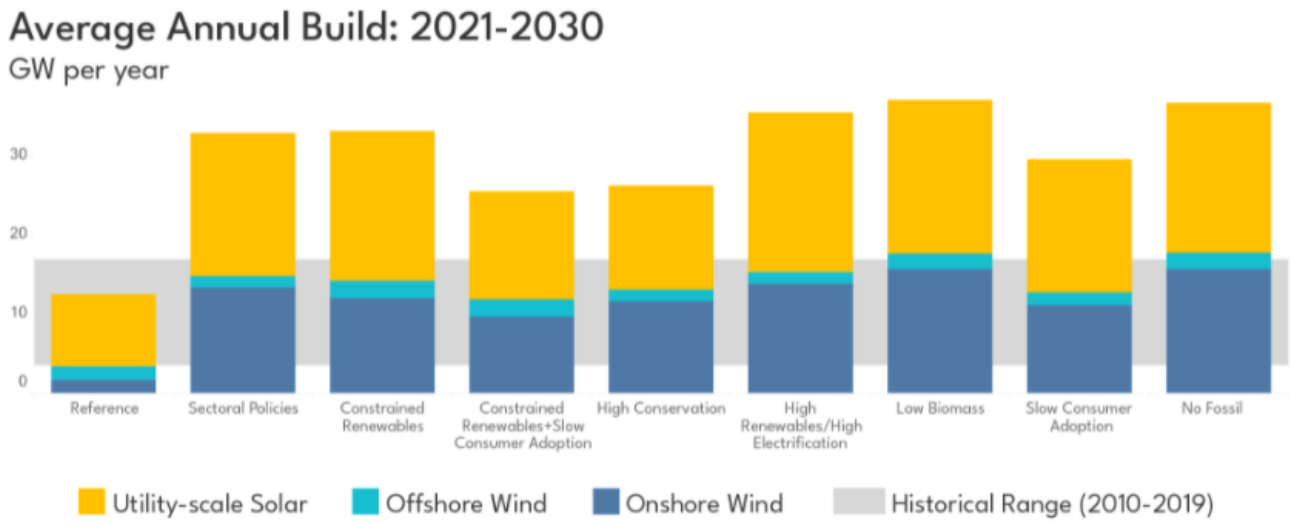
Infrastructure Needs for 2050

Continue cost reductions for low carbon technologies

Preserve infrastructure where we can

Double	• Build at least 102 gigawatts (GW) of wind
Double	• Build at least 174 GW of solar
10X- 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



PATHWAYS TO NET-ZERO EMISSIONS

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Primary Energy in 2050 – US and 4 States

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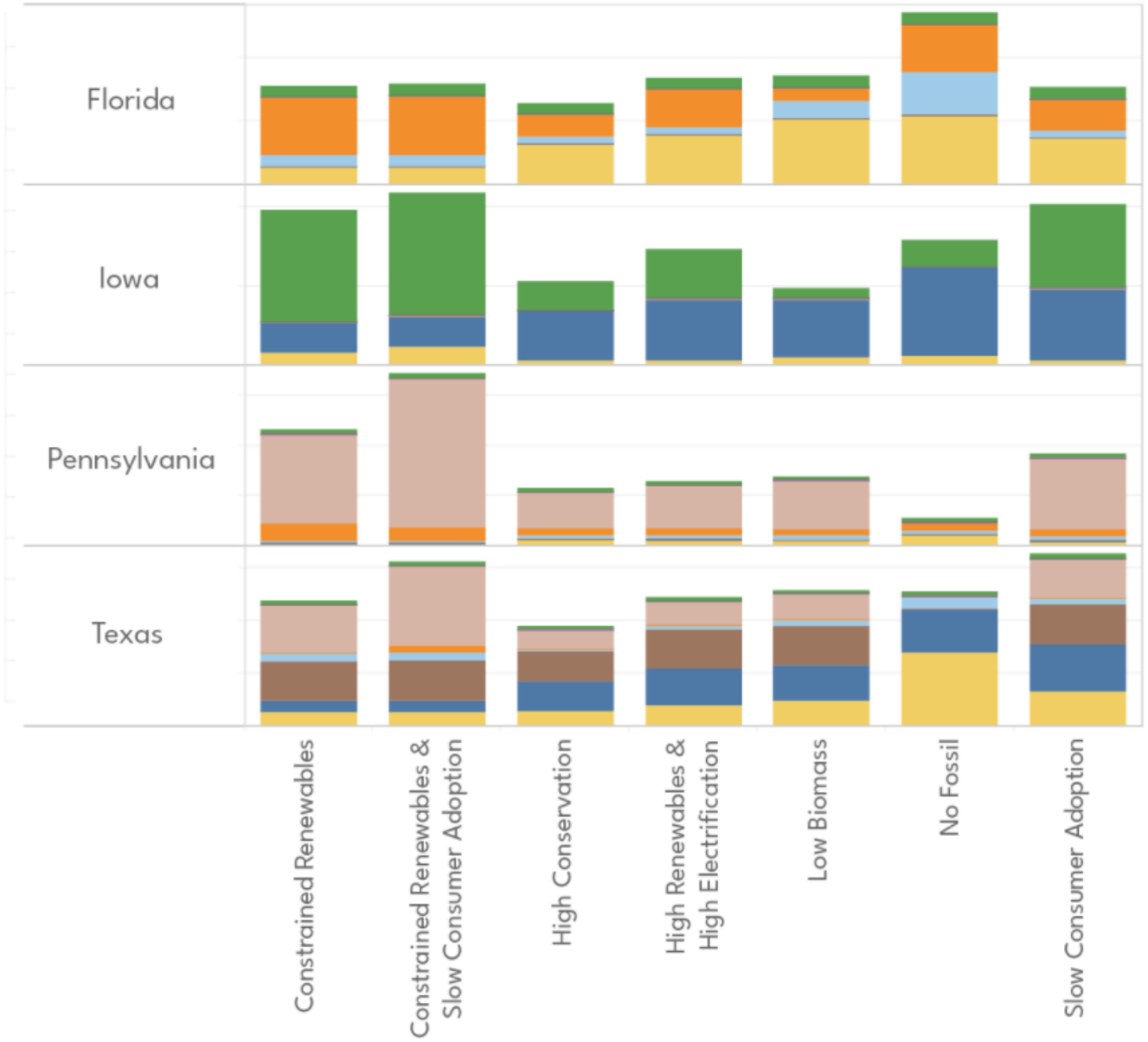


Inclusive policies for technology innovation and deployment will allow all regions of the U.S. to leverage their different resource endowments and develop new clean energy industries.

PATHWAYS TO NET-ZERO EMISSIONS

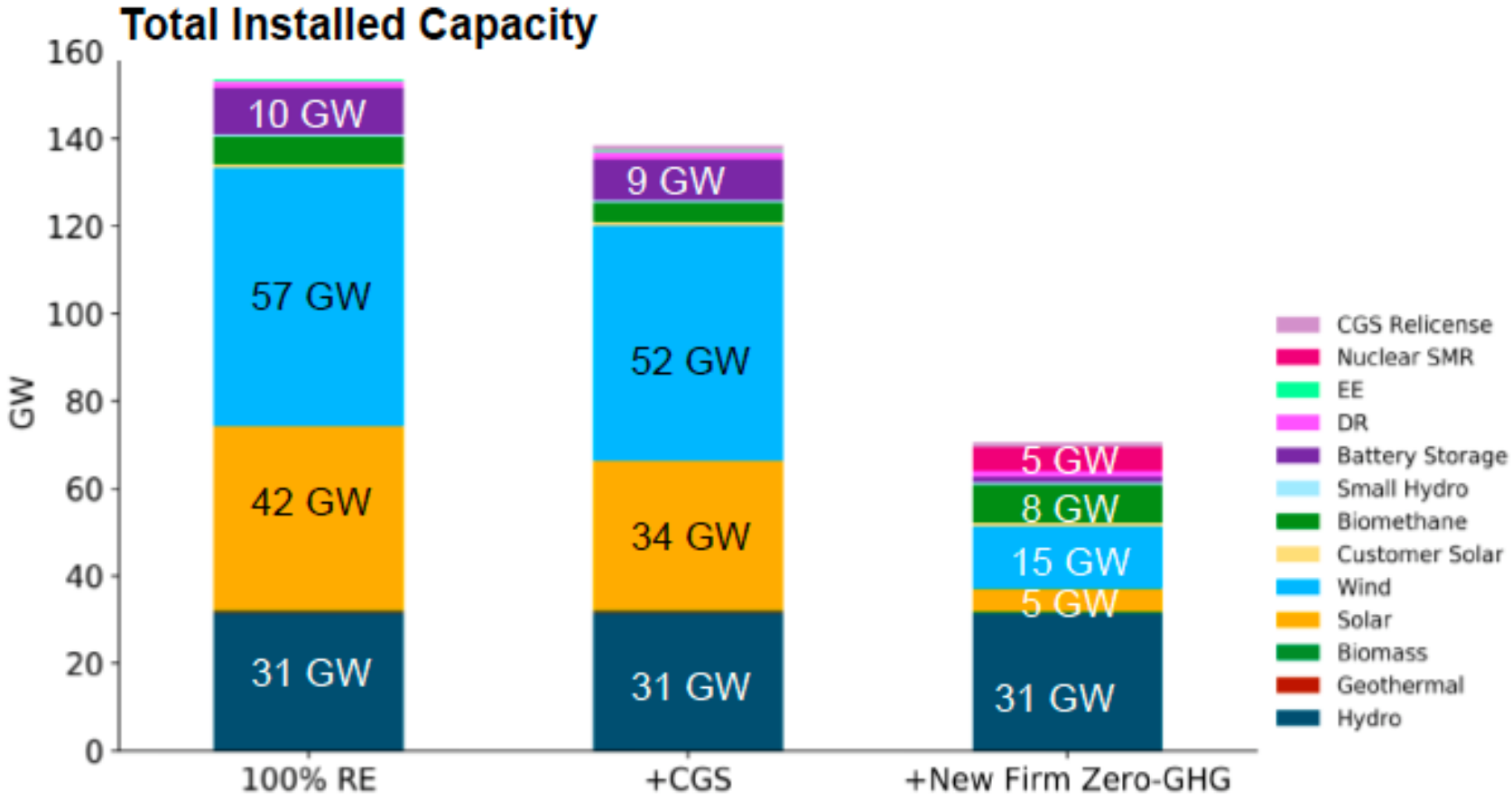
Decarb America Research Initiative
Key Takeaways

FEBRUARY 4, 2021

Meeting Emissions Goals with Nuclear Leads to Local Resource Optimization

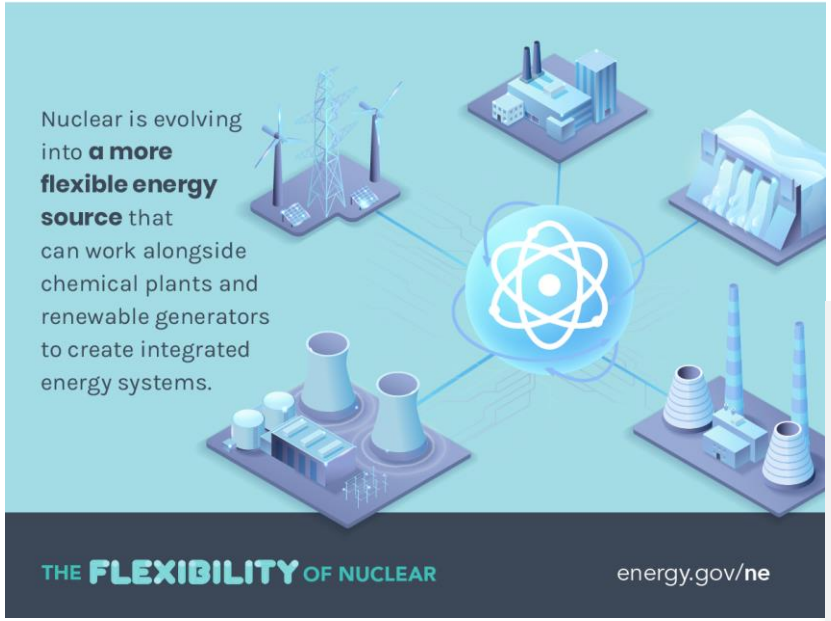
- E3 study for Energy Northwest on achieving 100% carbon free by 2045:
  - Firm zero-emitting resources like nuclear reduce costs up to $8B per year
  - Adding 6.5GW firm avoids 91GW non-firm
- Other studies have been shared publicly

NOTE: CGS – Columbia Generating Station

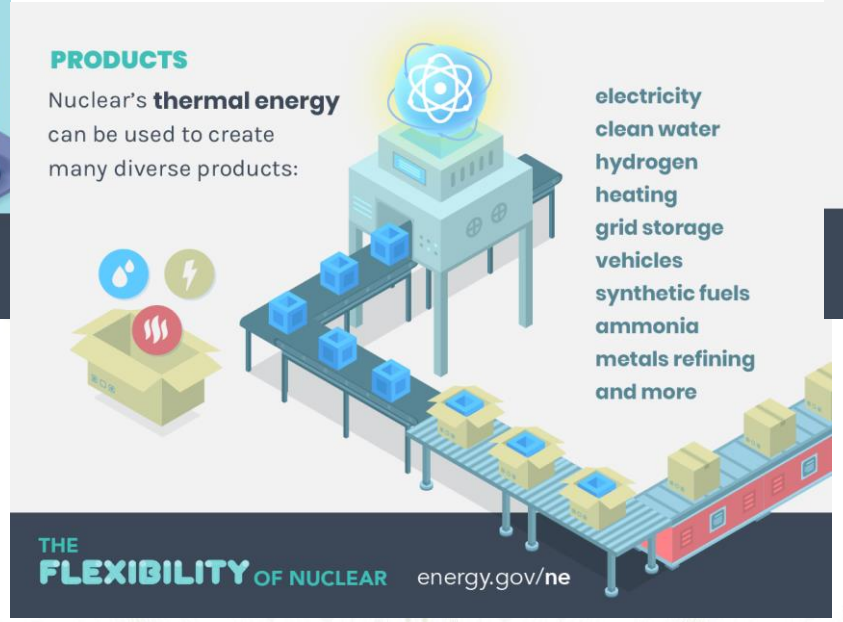


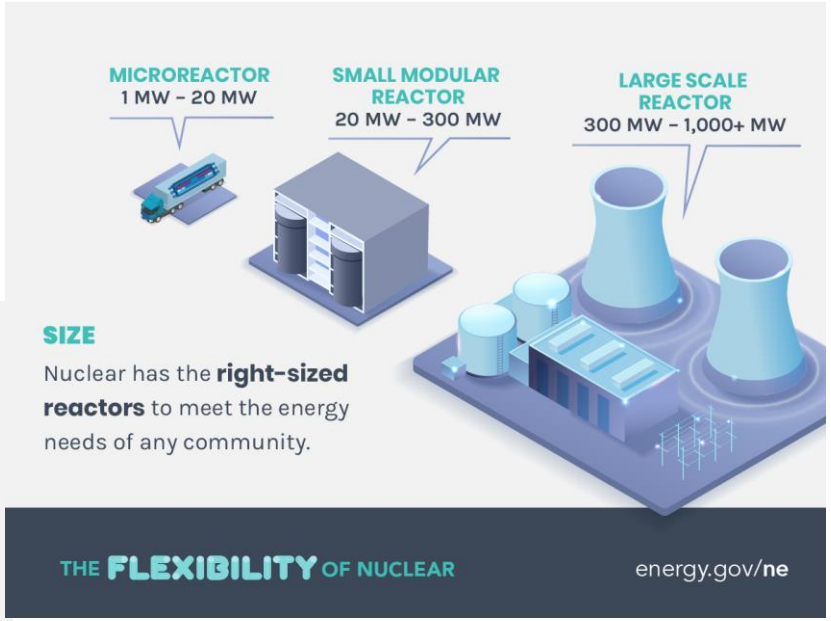
Pacific Northwest Zero-Emitting Resources Study, Energy and Environmental Economics, Inc. https://www.ethree.com/wp-content/uploads/2020/02/E3-Pacific-Northwest-Zero-Emitting-Resources-Study-Jan-2020.pdf

New operational paradigms—nuclear energy flexibility



Nuclear flexibility can be key in enabling other clean energy generators.





- ***Operational* flexibility**
  - ***Product* flexibility**
    - ***Deployment* flexibility**

Flexible Nuclear Energy for Clean Energy Systems, September 2020
https://www.nice-future.org/flexible-nuclear-energy-clean-energy-systems

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

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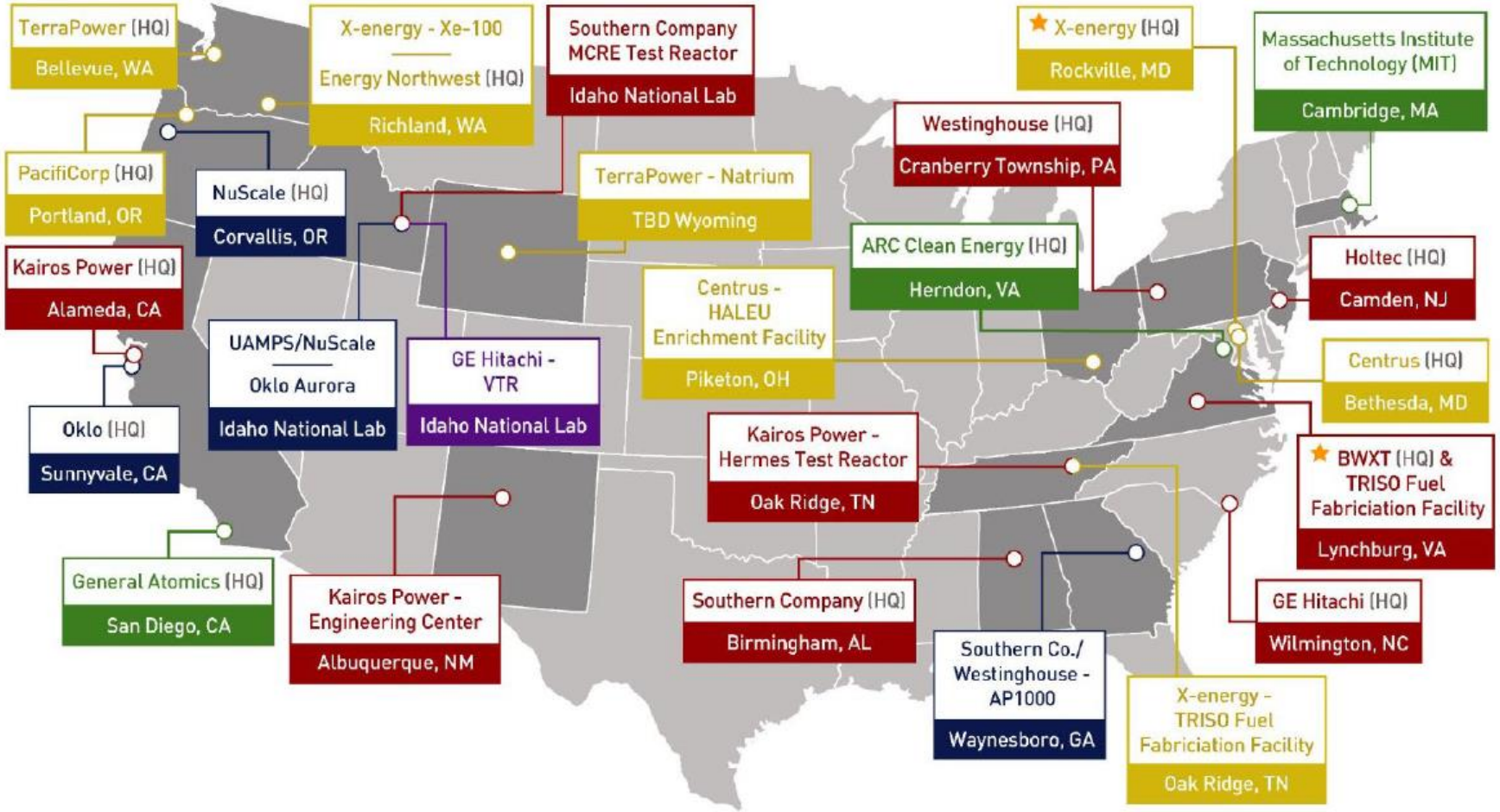

CLEARPATH

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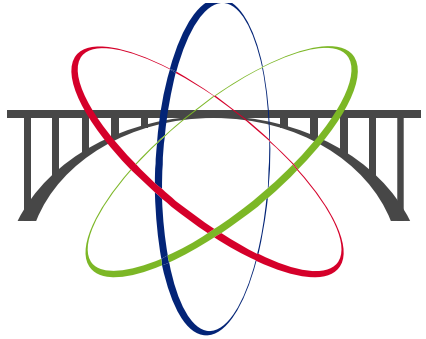
Public-Private Partnerships *(Related to Advanced Nuclear over past 5 years)*

Name	#	Size, Length	Cost Share	Federal ($M)	Private ($M)	Total ($M)
NE Voucher (GAIN)	60	<$500K, 1 year	80/20	19	5	24
Industry Funding Opportunity Announcement (FOA) -1817						
First of a Kind	6	$10-40M, 3 year	50/50	70	72	142
Adv Rx Dev	23	$500K – 20M, 2 year	80/20	89	38	127
Reg Assist	9	$50 – 500K, 1 year	80/20	4.2	1.5	5.7
Advanced Reactor Demonstration Program						
Demo	2	$160M, within 5-7 years	50/50	2,620	2,620	5,240
Risk Reduction	5	$30M, within 10-14 years	80/20	602	403	1,005
Adv Rx Con	3	$20M, demo in mid 2030s	80/20	56	14	70
				3,460	3,153	6,614

2016 $2M 2017 $4M 2018 $157M 2019 $87M 2020+ $6.4B

Advanced Nuclear Industry Milestones in New Website

The new website captures key industry achievements in technology, development, policy, regulation, finance, integrated systems.
https://www.airtable.com/universe/expnrIMohdf6dIvZl/milestones-in-advanced-nuclear?explore=true



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GAIN Energy Calculator

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