NEW MEXICO

emnrd

Energy, Minerals and Natural Resources Department

Consortium for Energy Sustainability and Advancement Management

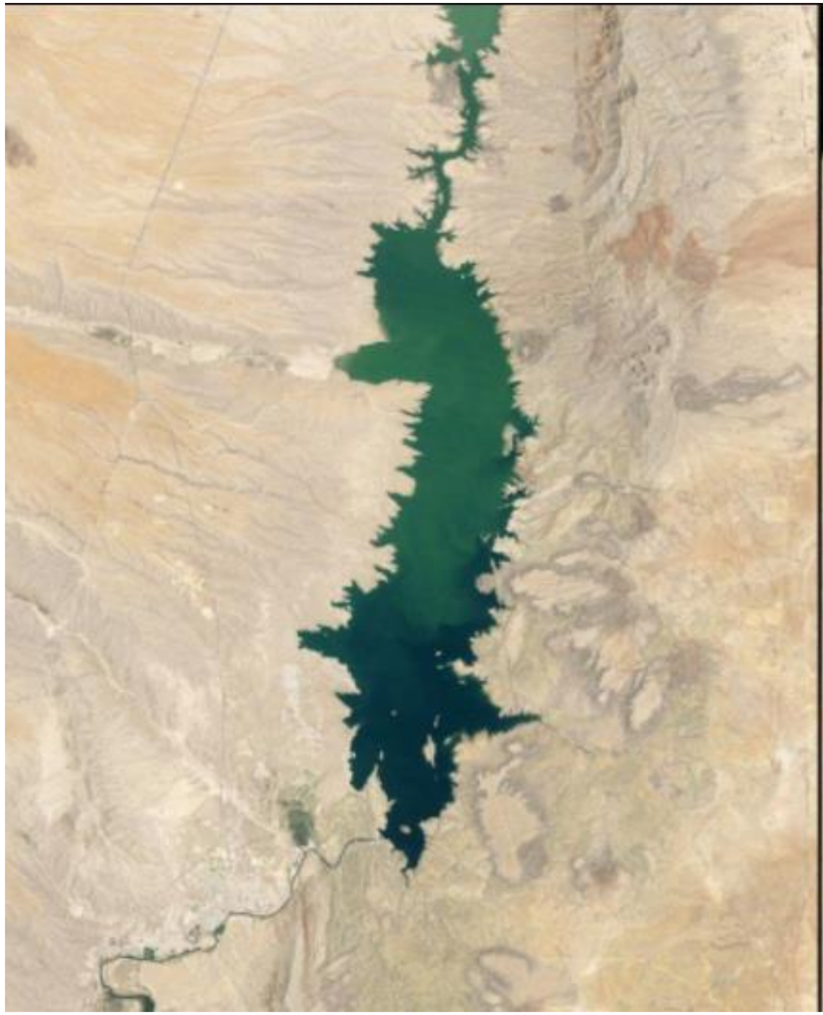
Melanie Kenderdine

November 8, 2024

Socorro, New Mexico

NASA Satellite Photos, Elephant Butte Reservoir, New Mexico, My Home State

1994



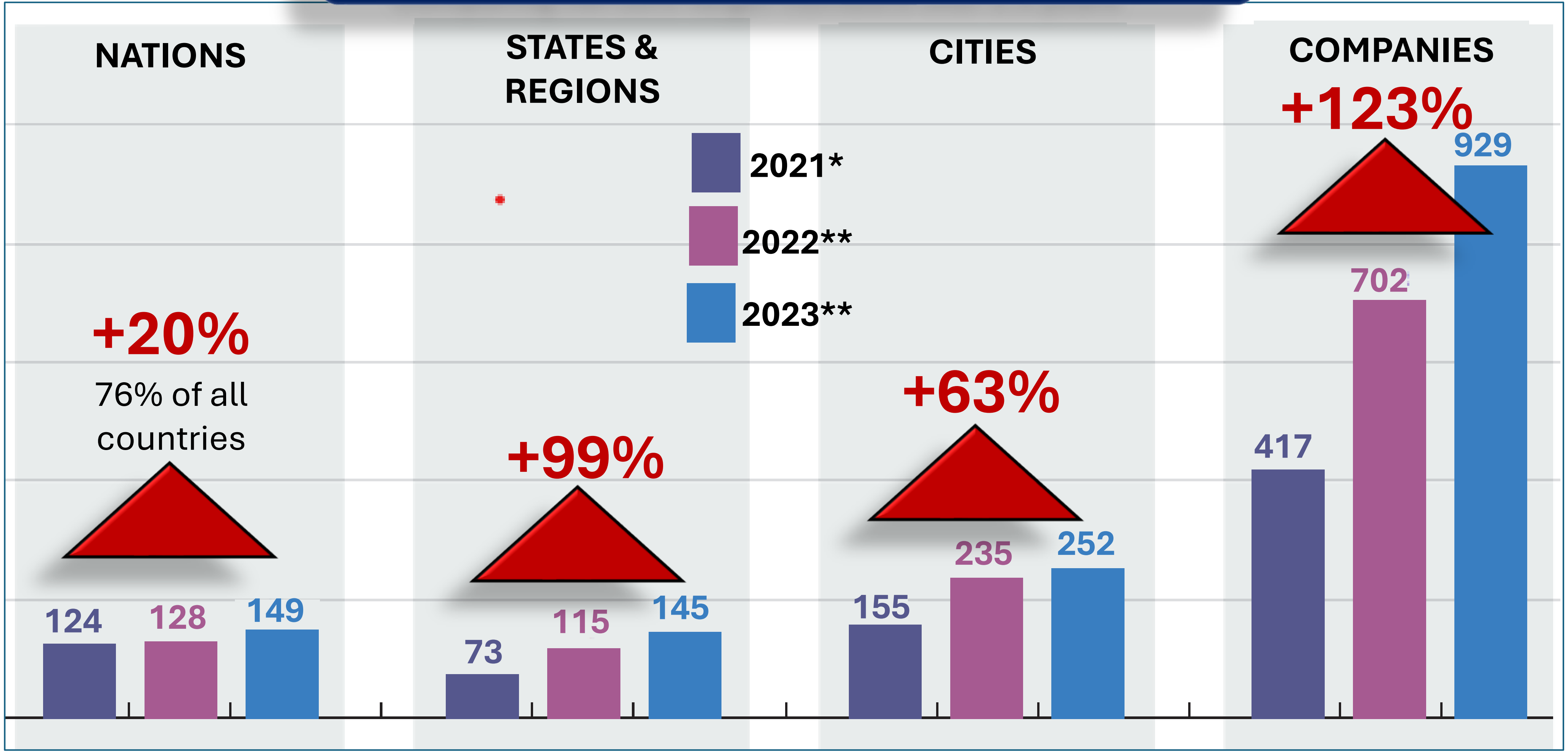
2013

NASA Satellite Photos, Elephant Butte Reservoir, New Mexico, My Home State

Net Zero Target Coverage, June 2023

Net Zero Target Setting

Comparing net zero target numbers over 2.5 years



*Black et al. 2021, Data: Dec. 2020

**Net Zero Stocktake 2022, Data: June 2022

**Net Zero Stocktake 2023, Data: June 2023

https://zerotracker.net/analysis/net-zero-stocktake-2022

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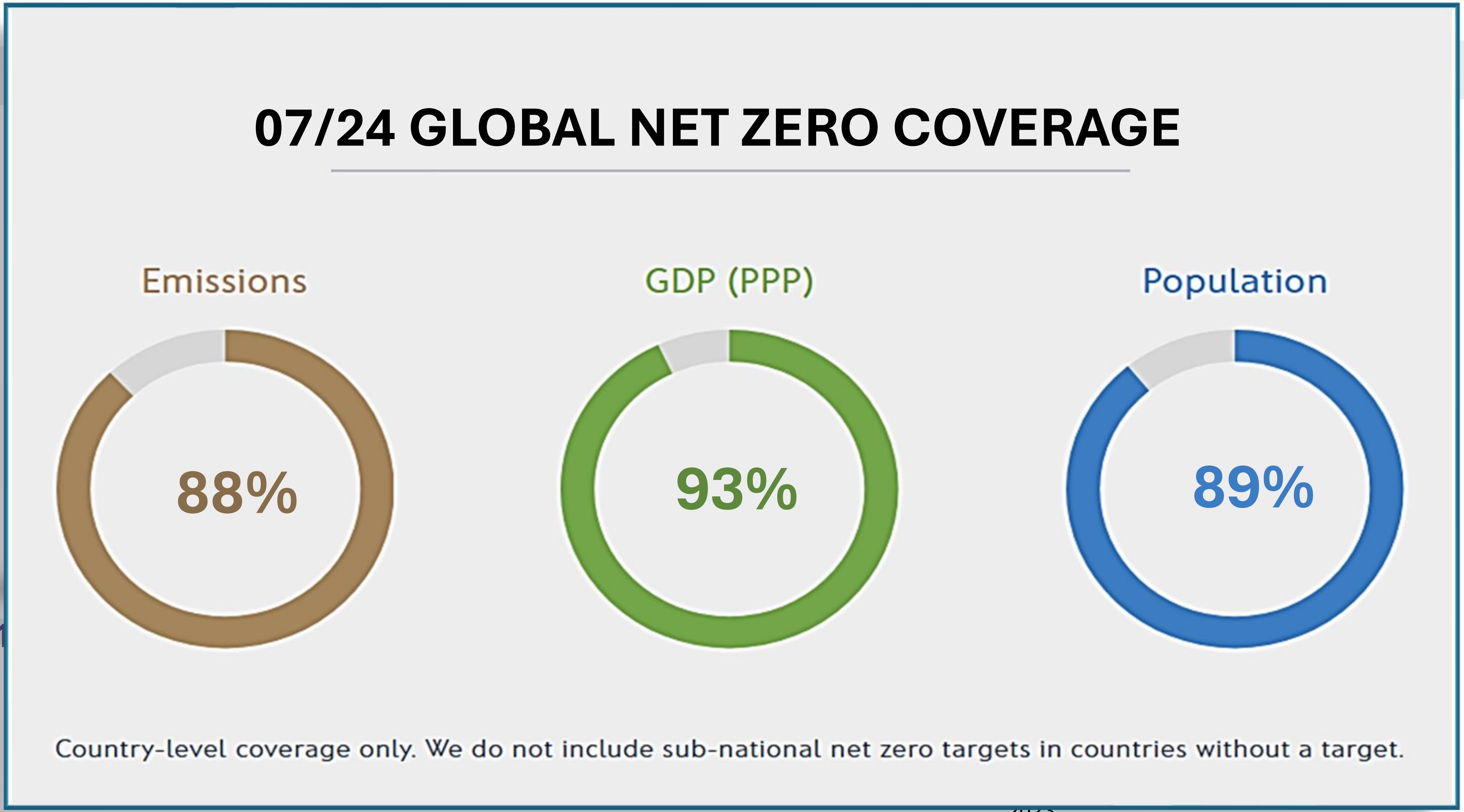
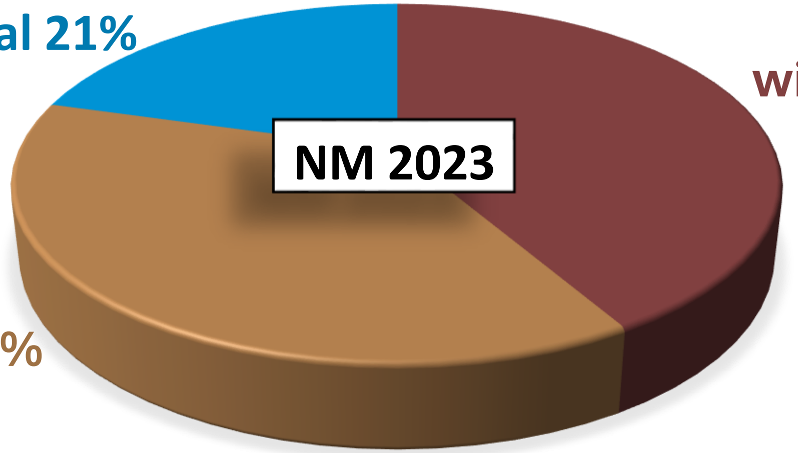
Net Zero Target Coverage, June 2023



https://zerotracker.net/analysis/net-zero-stocktake

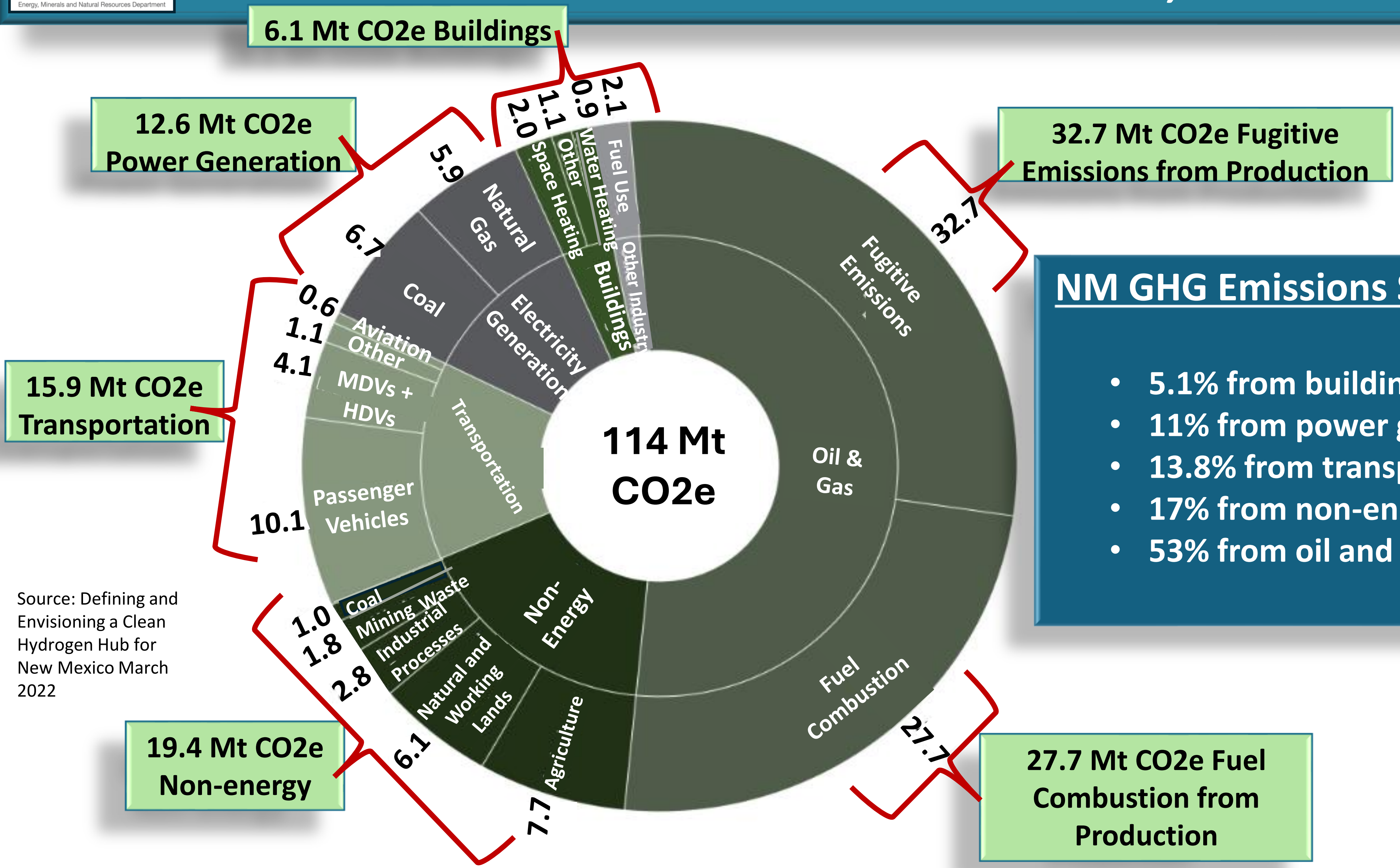
New Mexico Energy Rankings/Generation Sources

59% fossil generation
41% renewable generation



https://www.eia.gov/state/?sid=NM#tabs-5

New Mexico GHG Emissions Sources, 2020 (Mt CO2e)



Source: Defining and Envisioning a Clean Hydrogen Hub for New Mexico March 2022

NM GHG Emissions Sources, 2020

- 5.1% from buildings/industry
- 11% from power generation
- 13.8% from transportation
- 17% from non-energy sources
- 53% from oil and gas production

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Levelized Cost of Electricity (LCOE) & Storage (LCOS) for Plants Entering Service in 2027

USC Coal → **$82.61**

$52.11

85%

Combined Cycle → **$39.94**

$9.36

87%

Advanced Nuclear → **$88.24**

$60.71

90%

Battery Storage → **$128.55**

$64.03

10%

Combustion Turbine → **$117.86**

$53.78

10%

Capacity Resource Technologies

Geothermal → **$39.82**

$22.04

90%

Dispatchable

Total system LCOE or LCOS (2020 $/MWhr)
Levelized capital cost
Capacity factor

Onshore Wind → **$40.23**

$29.90

41%

Solar Standalone → **$36.49**

$26.60

29%

Offshore Wind → **$136.51**

$103.77

44%

Hydroelectric → **$64.27**

$46.58

54%

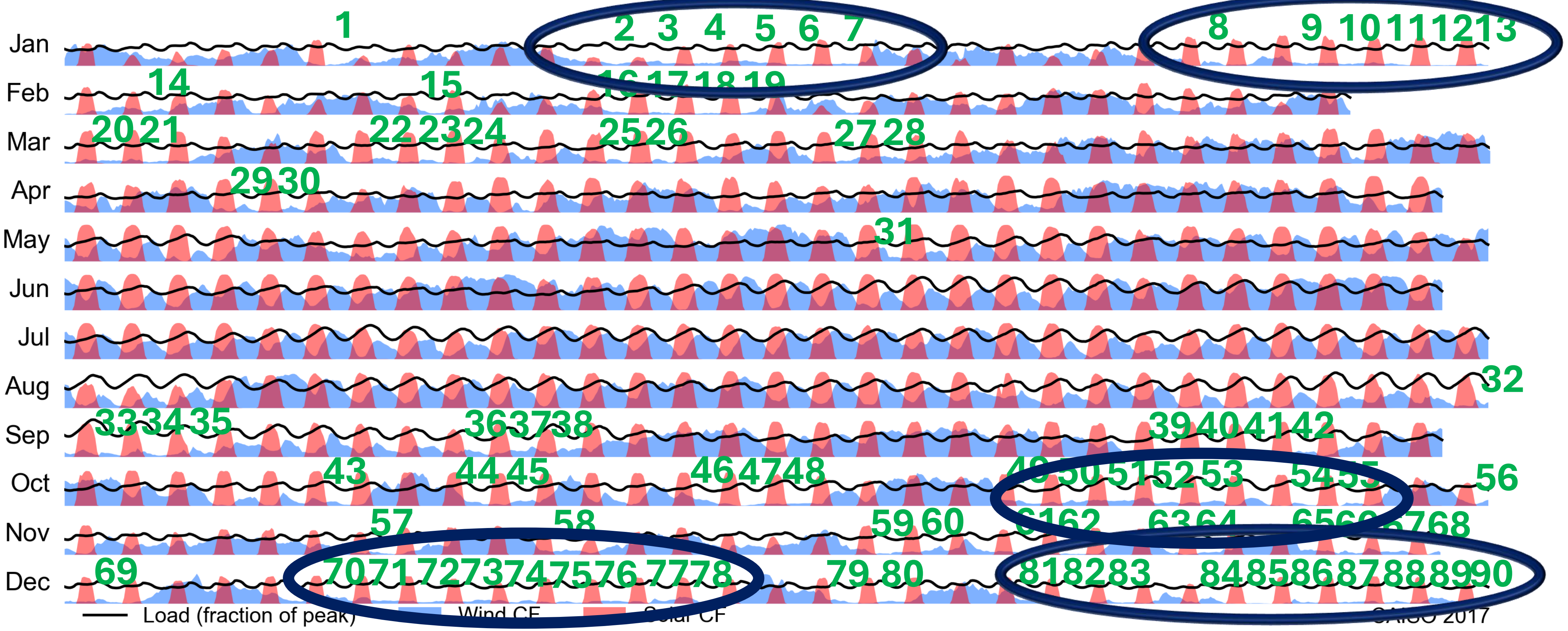
Resource Constrained Technologies

"Energy "too cheap to meter" has long been a sci-fi dream. But as the cost of solar power plummets toward zero, it might just become a reality."
NYT Magazine, 09/01/24

https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

The Challenges of Integrating Intermittent Renewables

Over the course of a year large-scale dependence on both wind and solar will result in significant periods requiring very large-scale back-up options

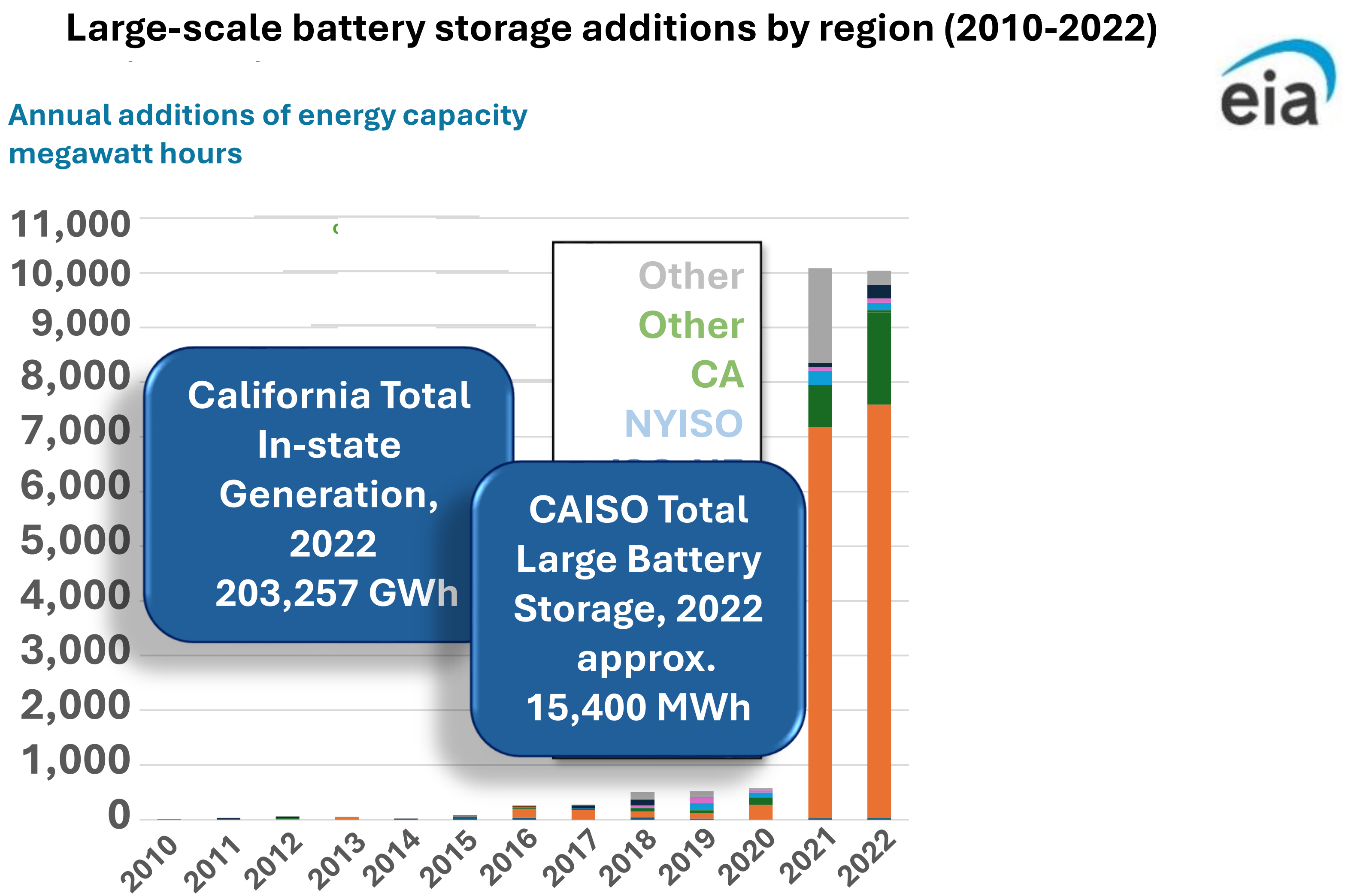


Hourly trends in solar and wind capacity factors in CA for 2017 aligned to normalized variation in hourly load relative to peak daily load

Source: CAISO data, EFI analysis

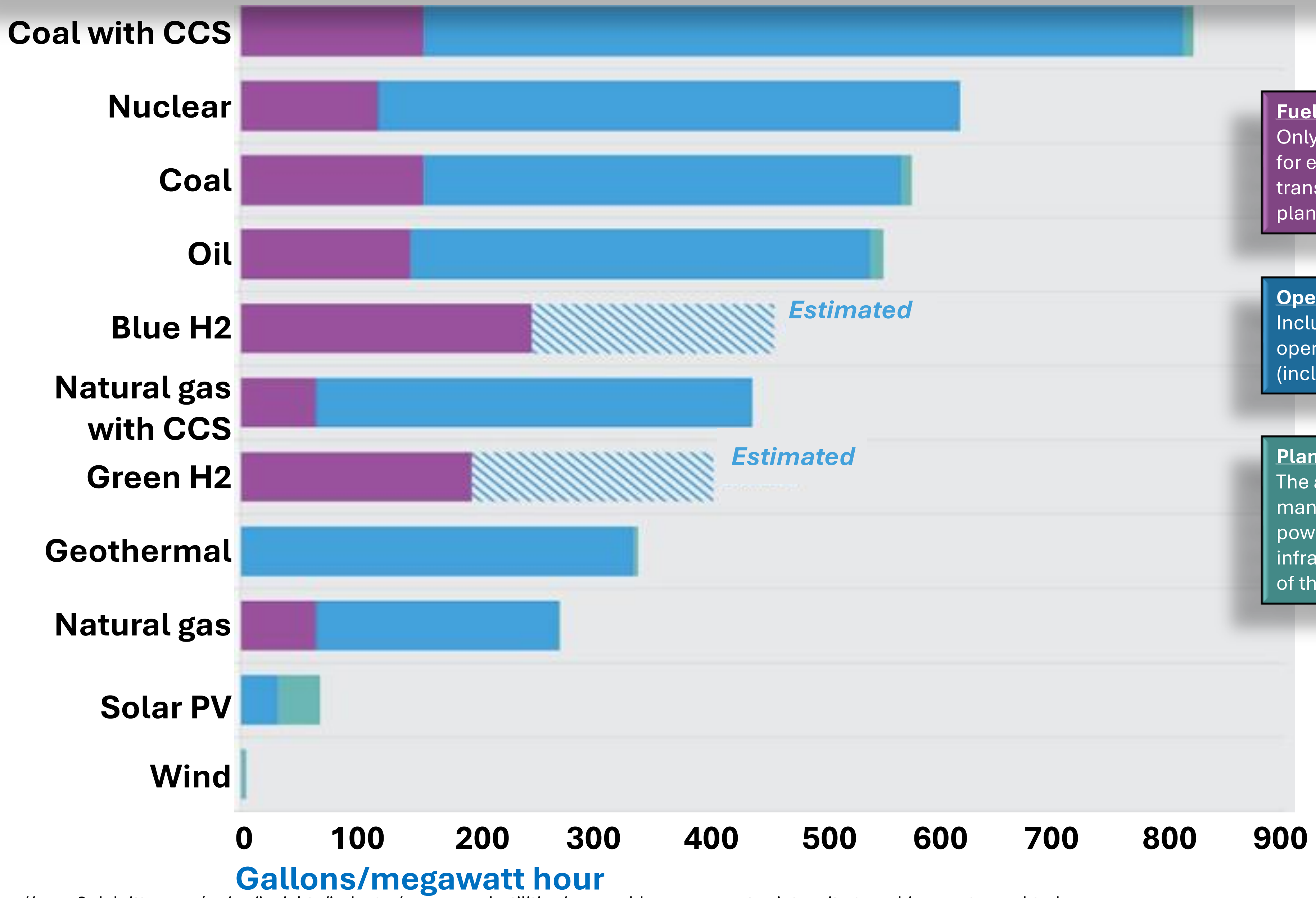
Source: EIA, 2020

The Challenges of Integrating Intermittent Renewables



Data source: U.S. Energy Information Administration, *2022 Form EIA-860 Early Release, Annual Electric Generator Report*

Average Lifecycle Water Consumption by Generation Type/Use, North America



Fuel production use
Only applies to the blue water used for extraction, processing, and transport of fuels upstream of power plant

Operational use
Includes blue water used in the operational process of power plants (including combustion and cooling)

Plant infrastructure use
The amount of water use to manufacture the material inputs of power plants or renewable infrastructure calculated of the life of the infrastructure

https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/renewable-energy-water-intensity-to-achieve-net-zero.html

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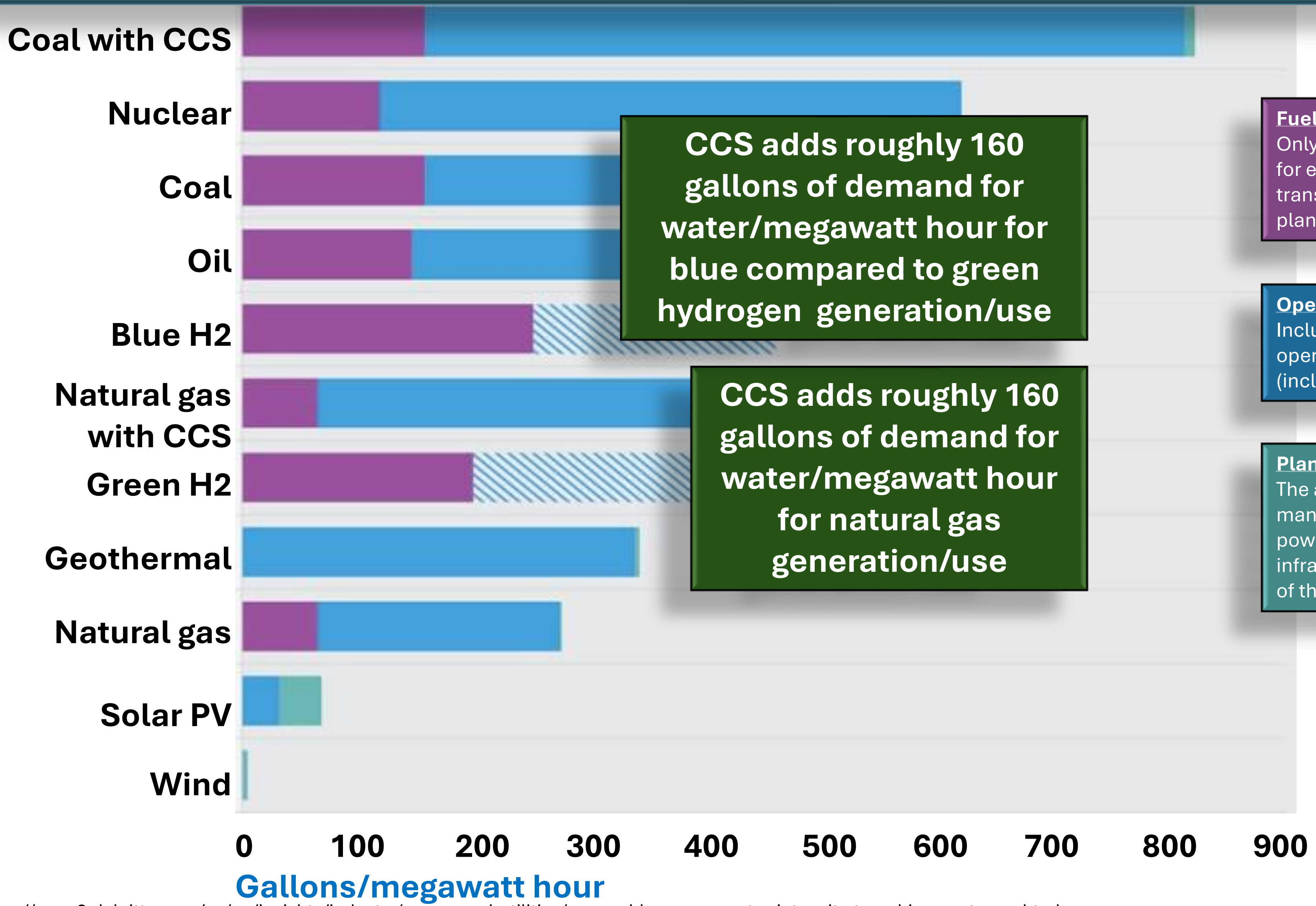

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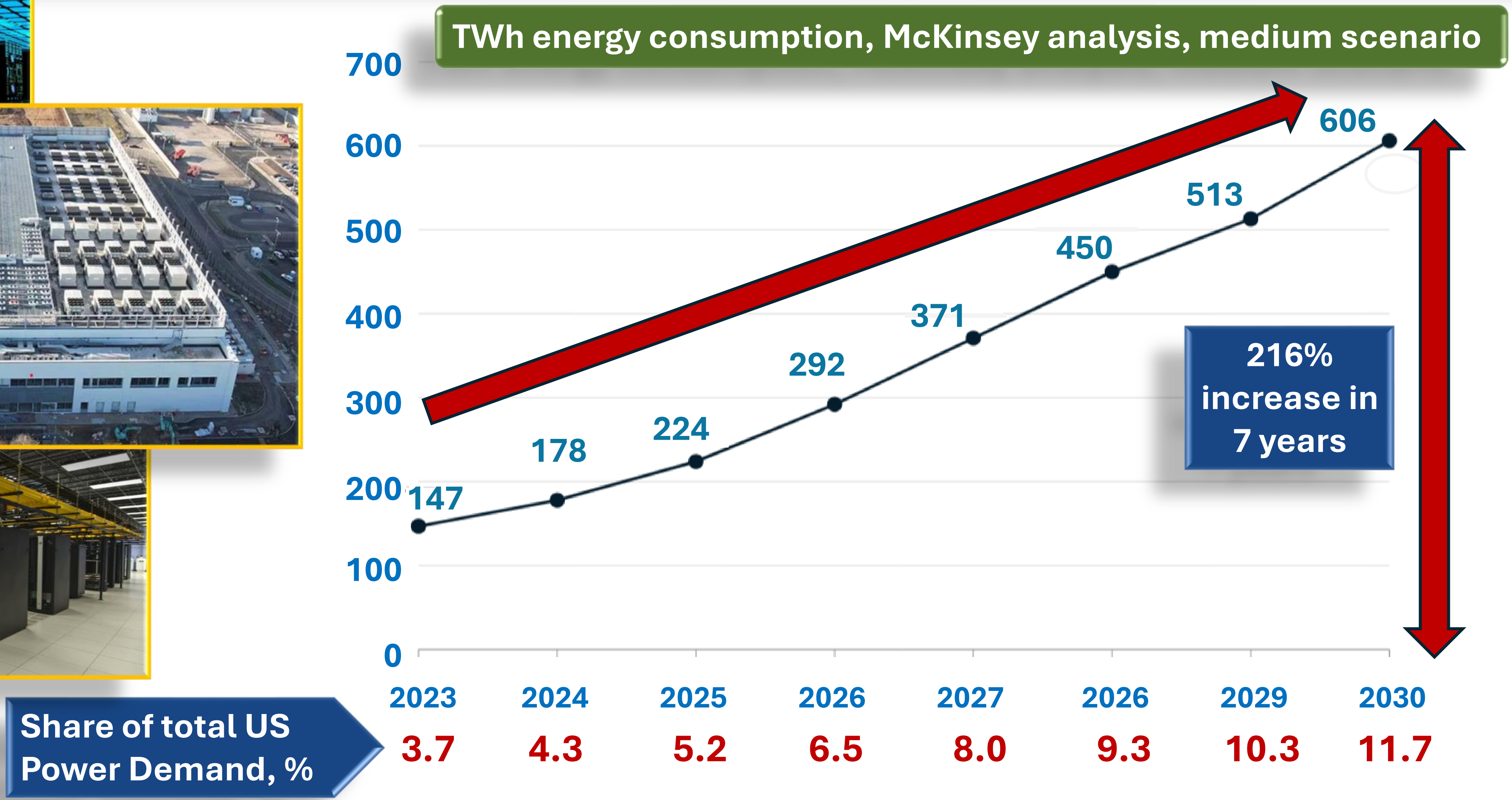
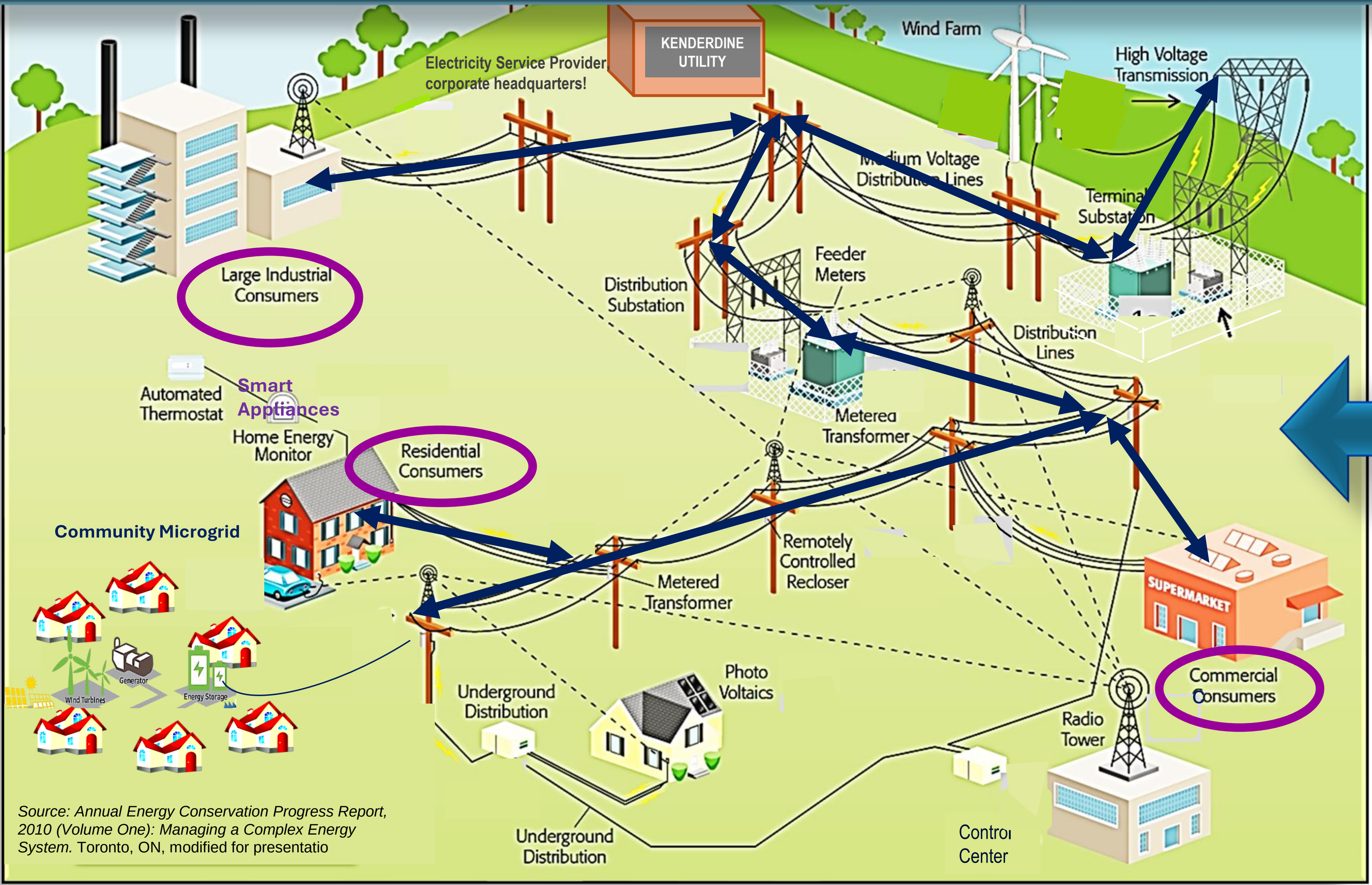
Forecast US Data Center Power Consumption, 2023-2030



https://www.noypigeeks.com/business/st-telemedia-data-center-philippines/
https://www.mckinsey.com/industries/private-capital/our-insights/how-data-centers-and-the-energy-sector-can-sate-ais-hunger-for-power

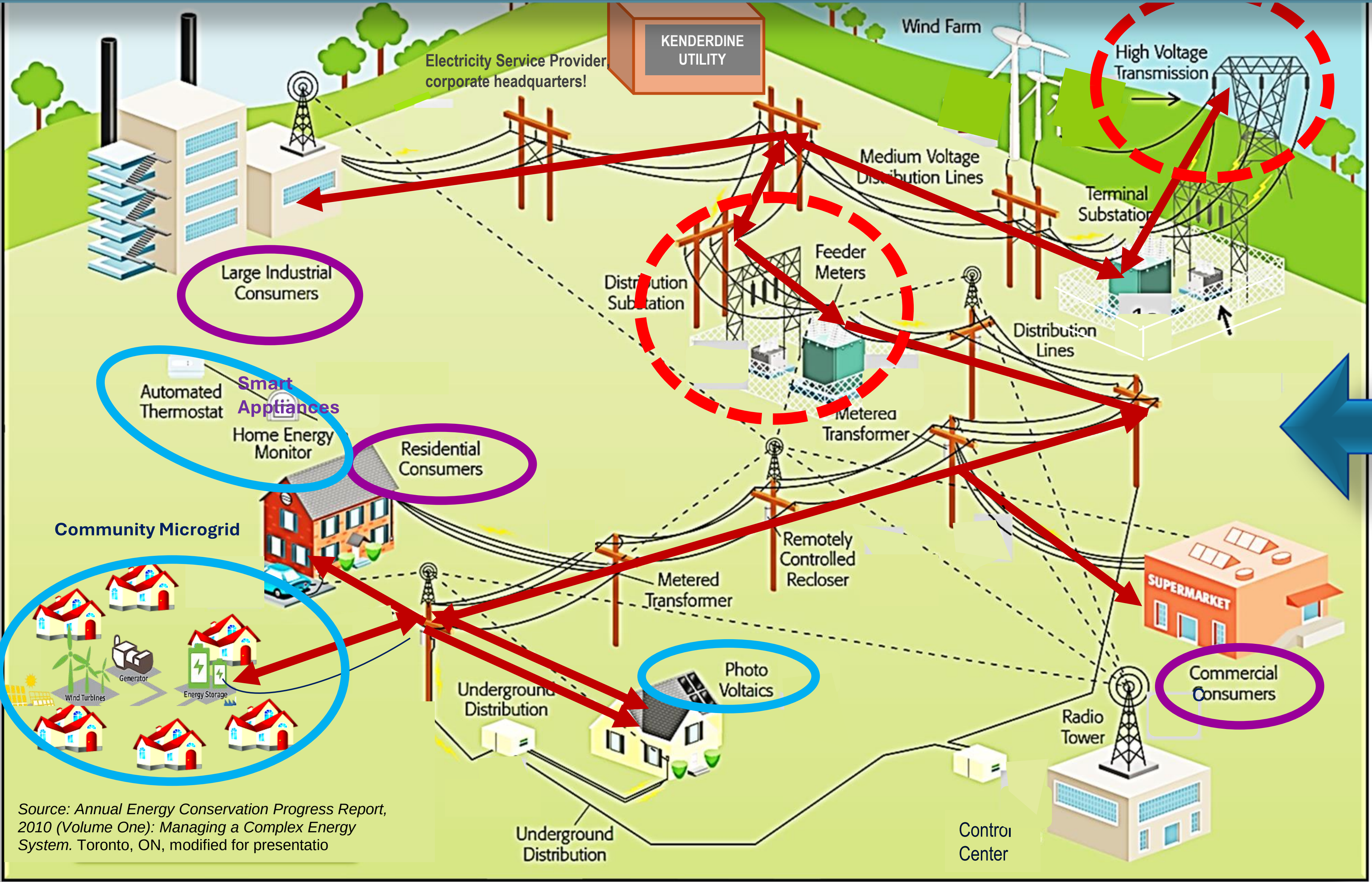
Two Way Electricity Flows and Grid Security



Source: Annual Energy Conservation Progress Report, 2010 (Volume One): Managing a Complex Energy System. Toronto, ON, modified for presentatio

"…emerging advancements in … smart grid technologies, cloud computing services, grid-cyber vulnerability & assessments, and distributed energy resources represent significant cybersecurity threats to the continuity of delivered power. " (Sandia National Laboratory)

Two Way Electricity Flows and Grid Security



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"…emerging advancements in … smart grid technologies, cloud computing services, grid-cyber vulnerability & assessments, and distributed energy resources represent significant cybersecurity threats to the continuity of delivered power. " (Sandia National Laboratory)

Connected West Reference Case, Generation Additions, Transmission Lines in 2045

Generator Additions by Technology

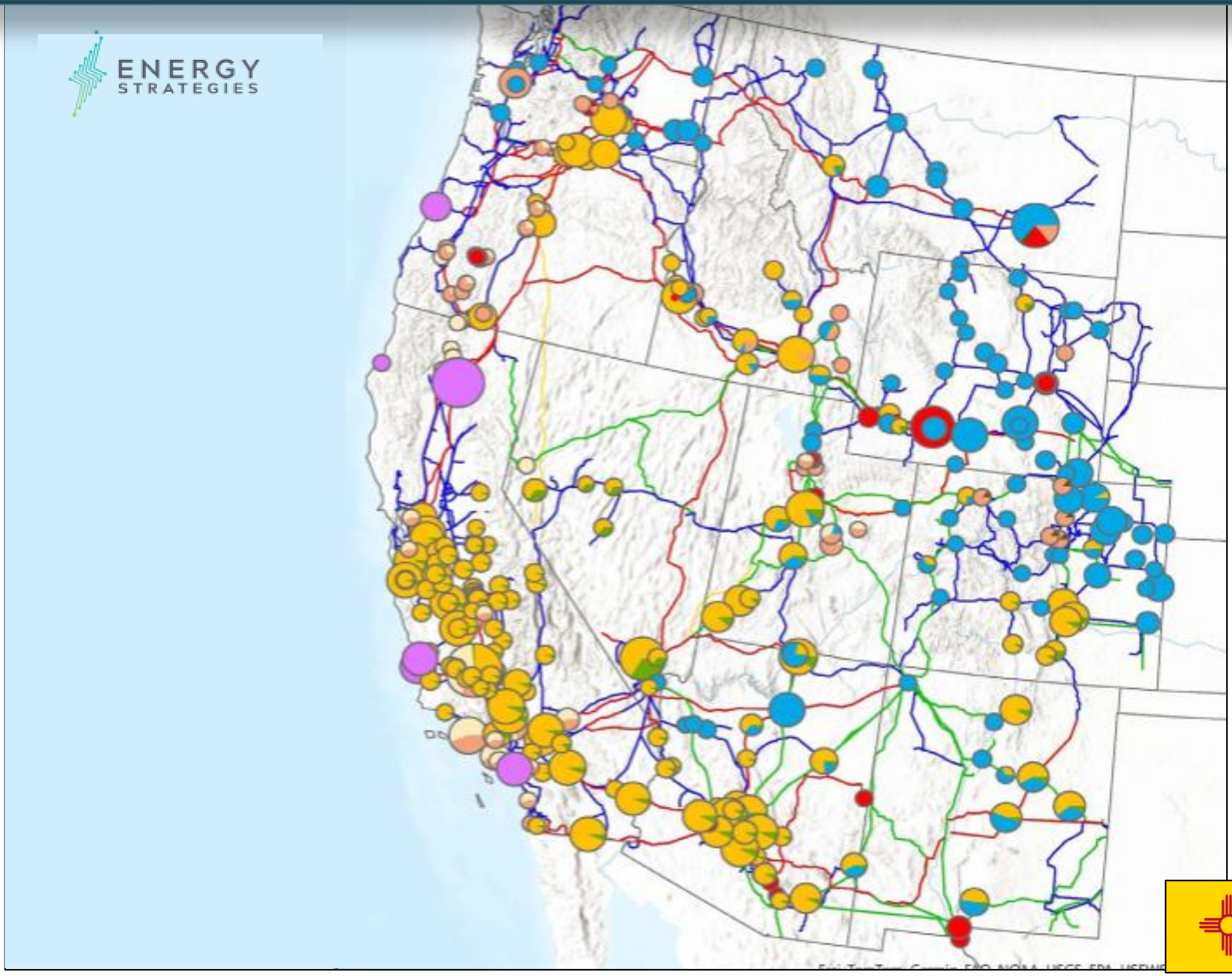
- Solar PV
- Onshore wind
- Offshore wind
- Battery storage
- Biomass
- Geothermal
- Natural gas CC
- Natural gas CT

Sum of Selected Fields

7.300
3.700
0.73

WECC Transmission Lines

- 230-300 kV
- 345 kV
- 500 kV
- DC Line



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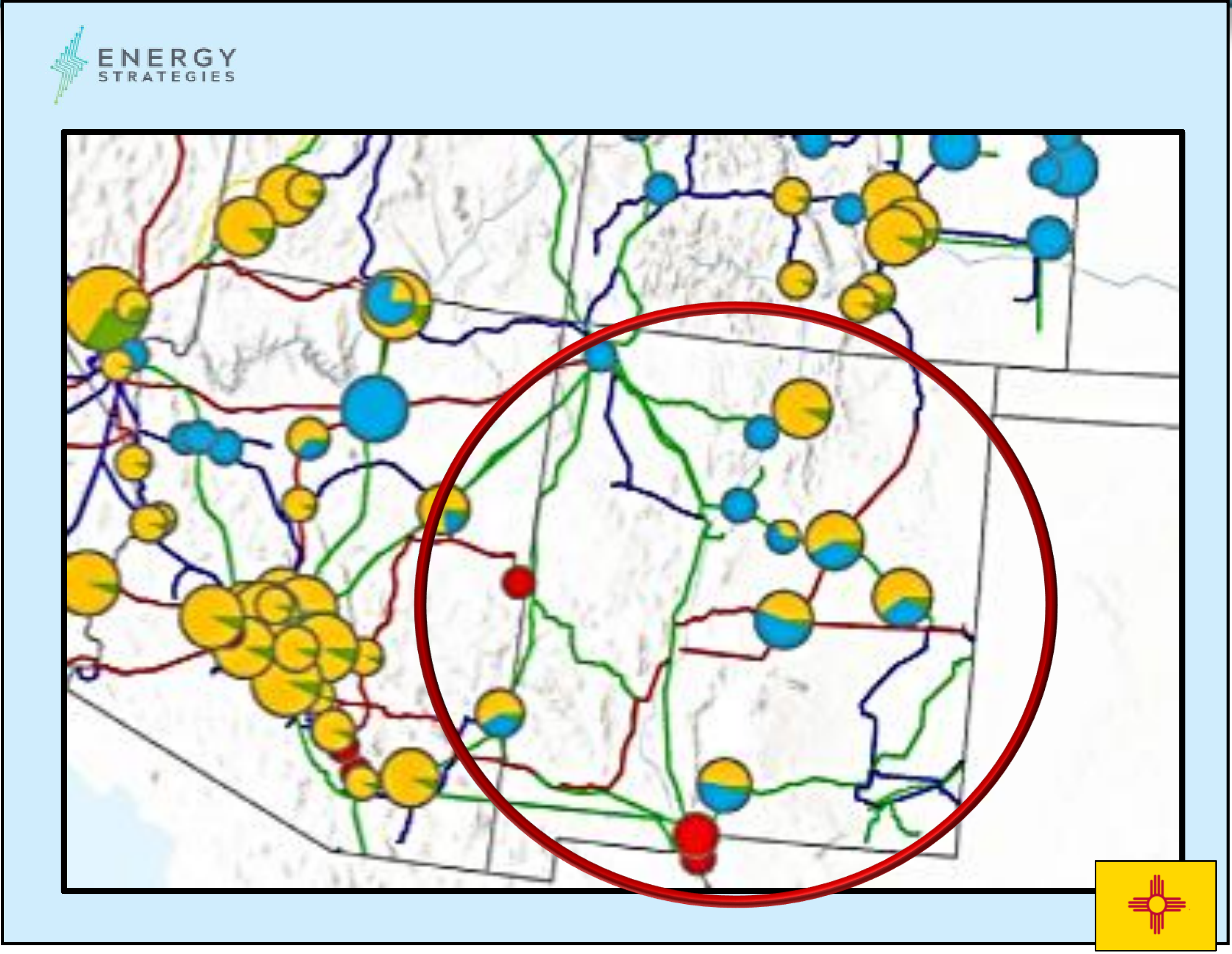
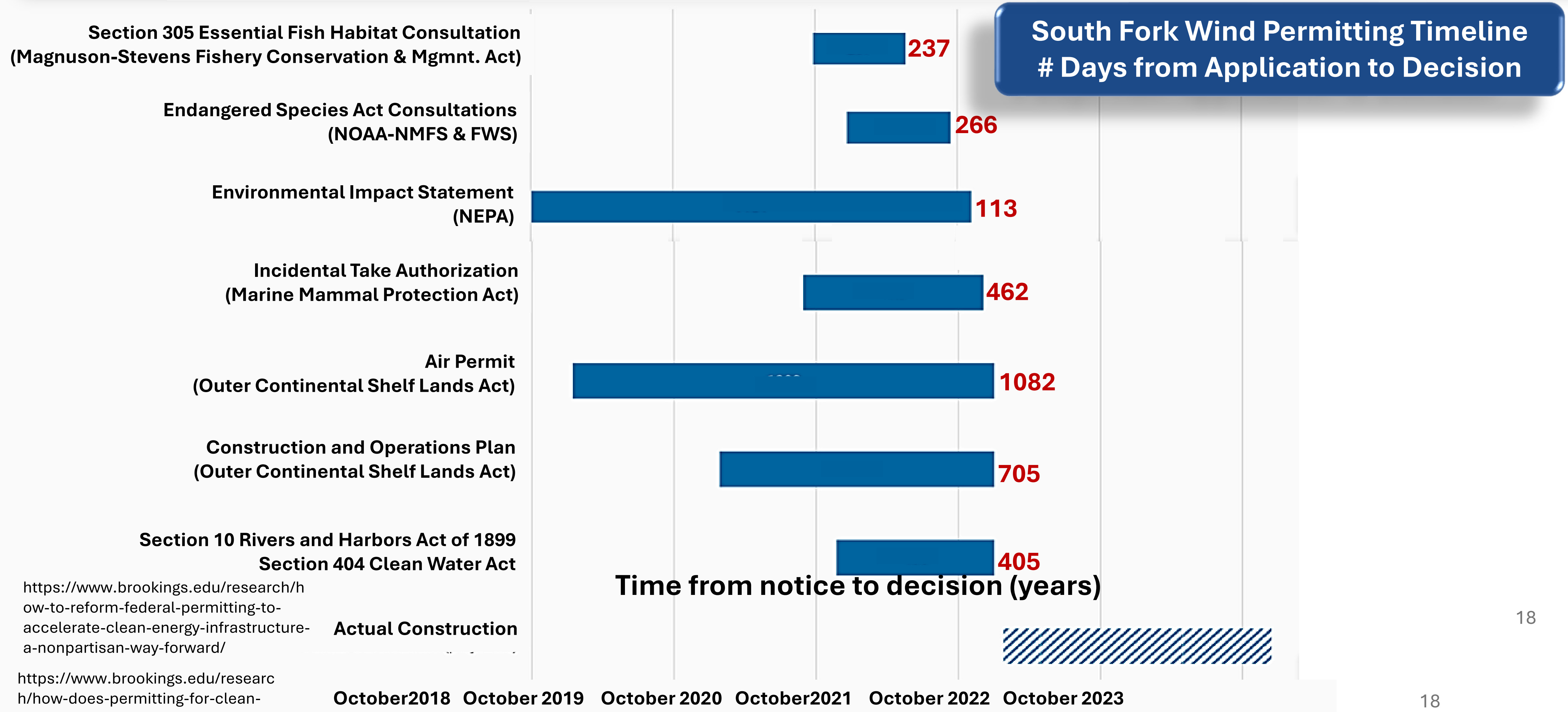


Permitting Times: Issue for Both Clean and Conventional Energy



https://www.brookings.edu/research/how-to-reform-federal-permitting-to-accelerate-clean-energy-infrastructure-a-nonpartisan-way-forward/

https://www.brookings.edu/research/how-does-permitting-for-clean-energy-infrastructure-work/

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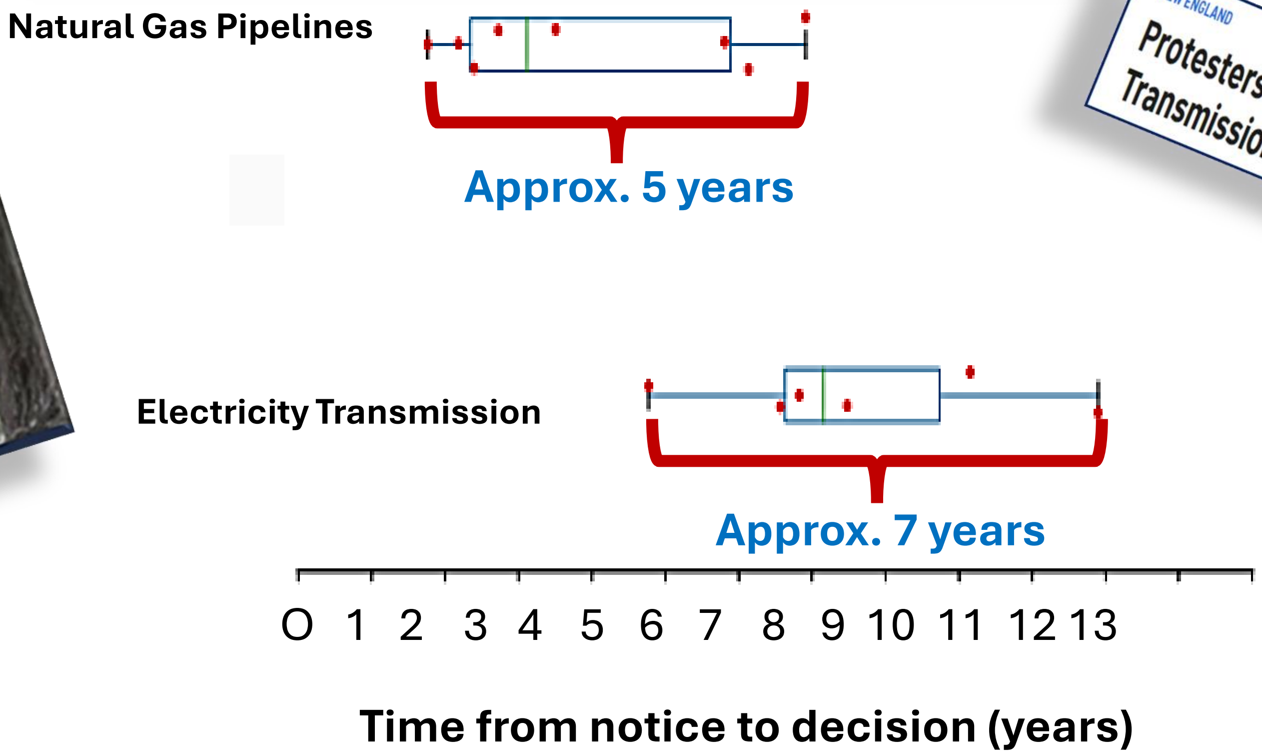
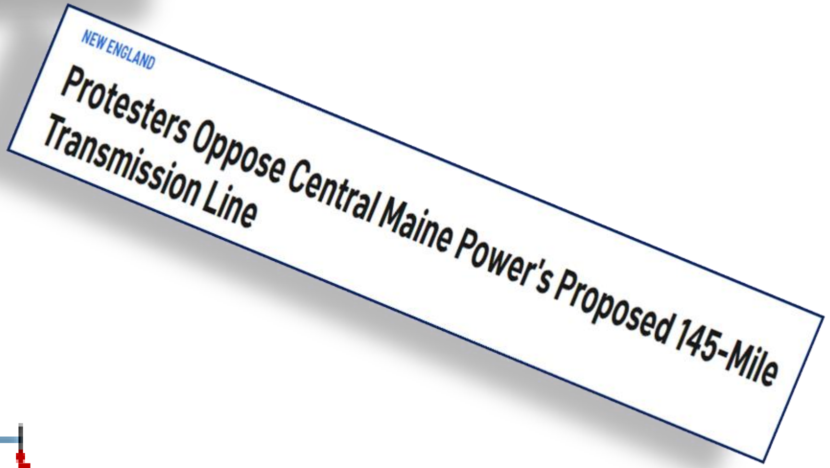
Permitting Times: Issue for Both Clean and Conventional Energy

Time Taken for Federal Permit Review as of 9/23/22
For Completed Gas Pipeline and Transmission Projects




NEW ENGLAND
Protesters Oppose Central Maine Power's Proposed 145-Mile Transmission Line

https://www.brookings.edu/research/how-to-reform-federal-permitting-to-accelerate-clean-energy-infrastructure-a-nonpartisan-way-forward/

https://www.brookings.edu/research/how-does-permitting-for-clean-energy-infrastructure-work/

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Reference Frame: High Voltage Transmission Line Materials Needed by 2030

EIA: In 2016, there were 160,000 miles of high voltage transmissions lines

↓

Princeton NZA (E+RE pathway with base land availability)**: The US will need a 75% increase in transmission capacity by 2030 to meet net zero targets**

↓

Assume 60% of that capacity is achieved by adding new miles (the other 40% is met with technology improvements)

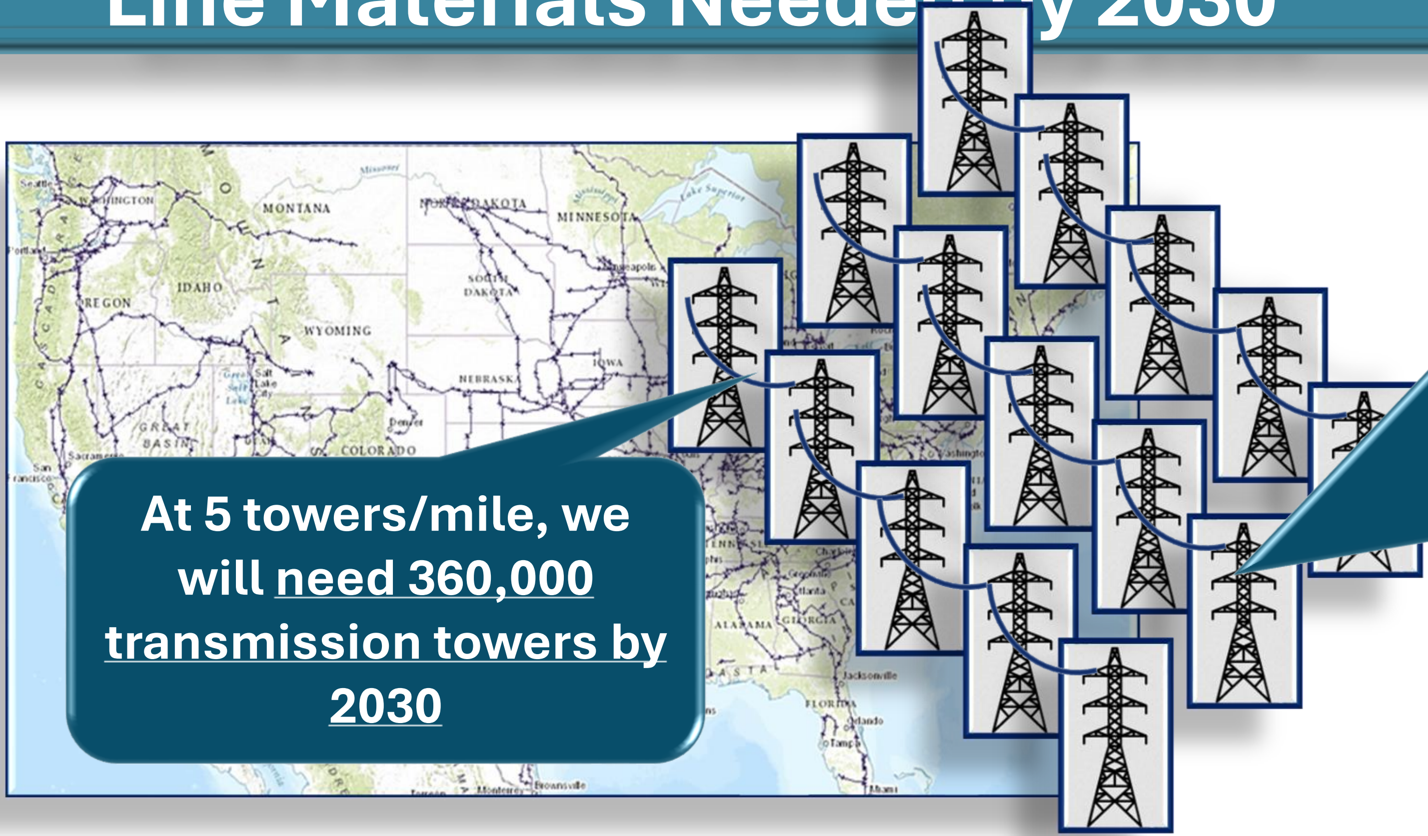
→

60% of 96,000 translates to 72,000 miles of new high voltage transmission lines by 2030

→

There are between 5 and 5.6 towers per mile on a high voltage transmission line
(credible numbers range from 5 to 5.6)

→



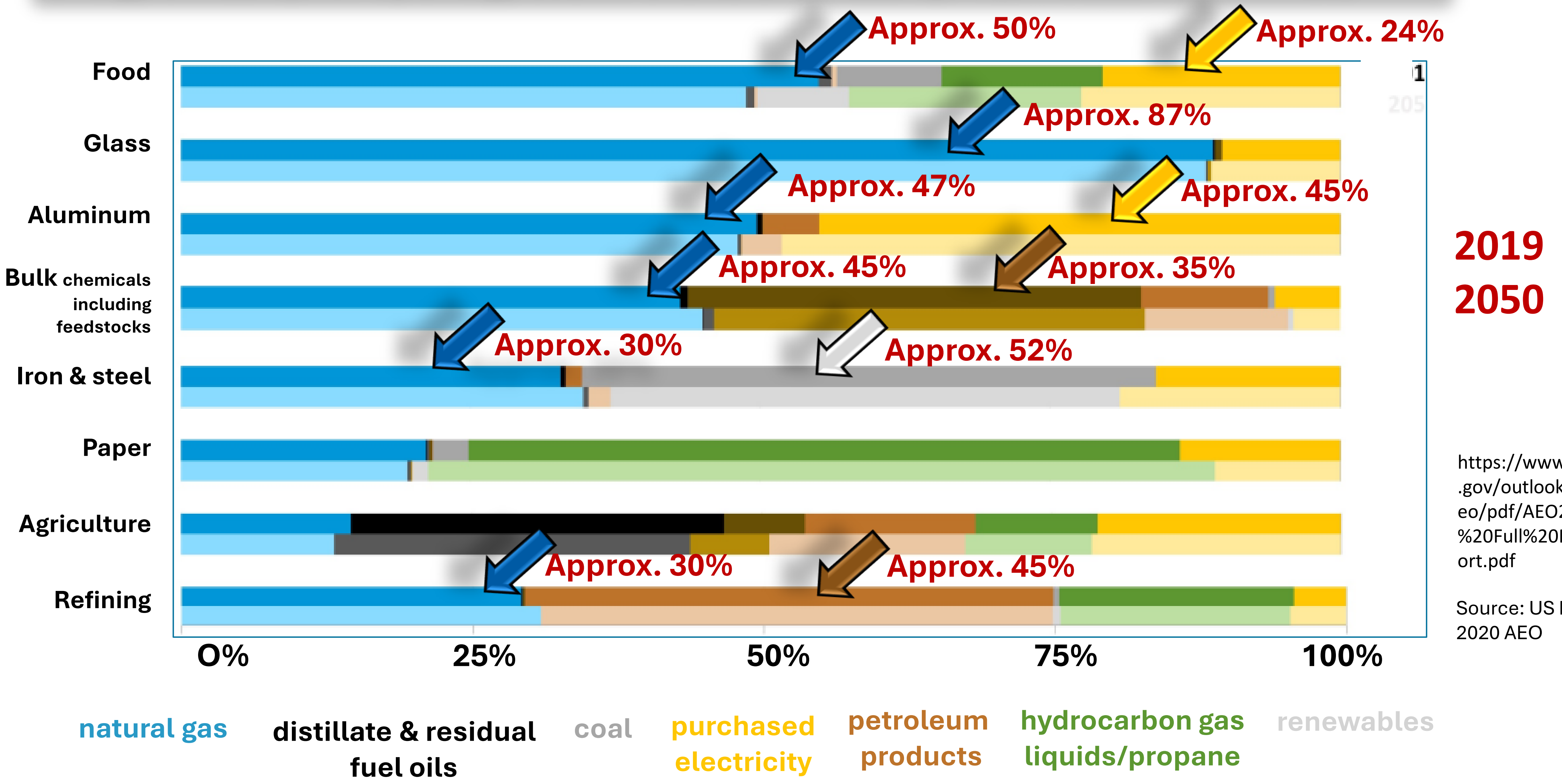
At 5 towers/mile, we will need 360,000 transmission towers by 2030

Transmission towers are made of steel, aluminum and copper, among other materials. So are transmission lines. So are wind turbines. So are cell towers. So are EVs. So are EV charging stations

https://www.eia.gov/todayinenergy/detail.php?id=27152

US Industrial Uses of Energy

Energy Consumption by Energy Source Shares and Industry, % (EIA AEO2020 Reference Case)

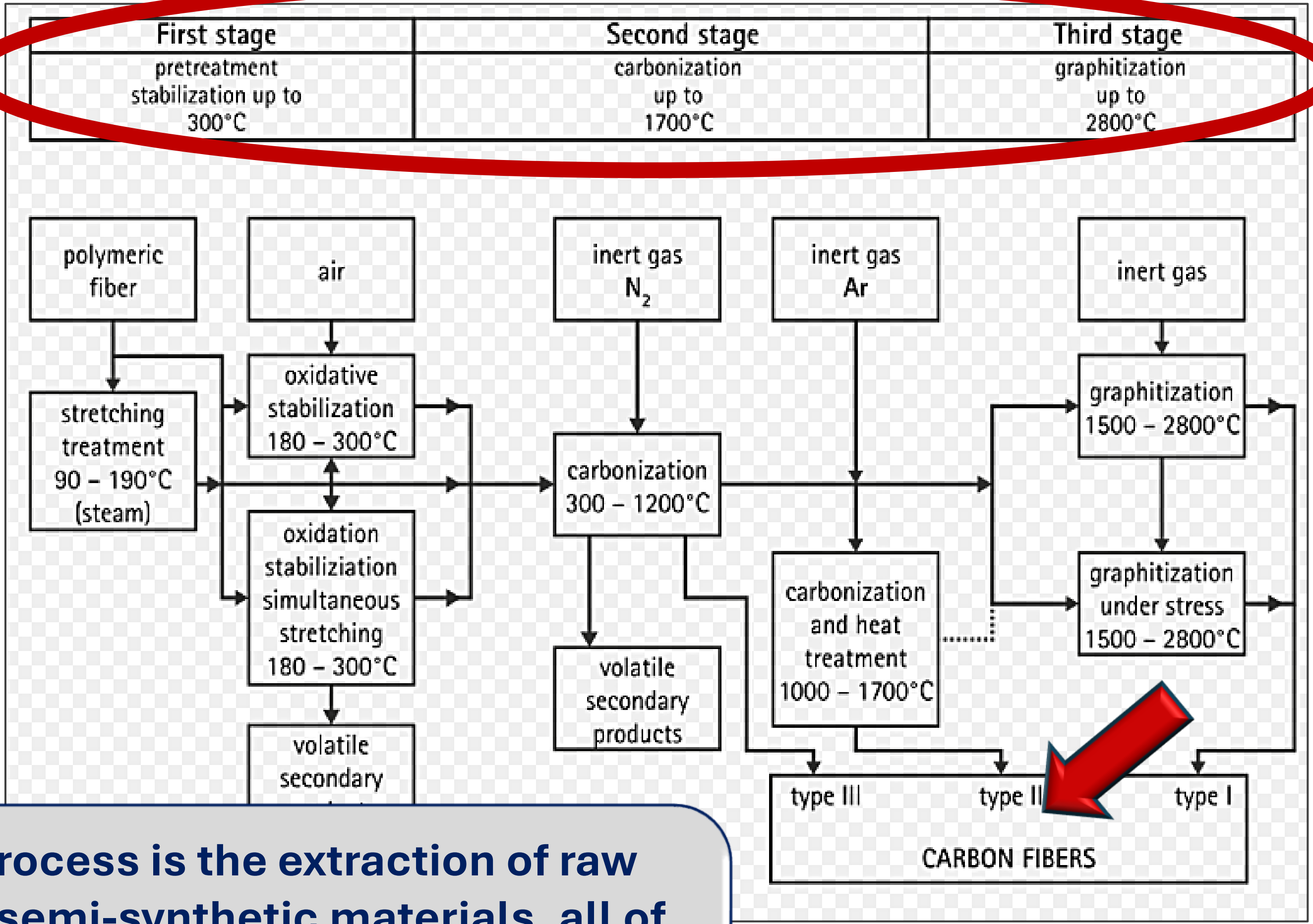


https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Full%20Report.pdf

Source: US EIA, 2020 AEO

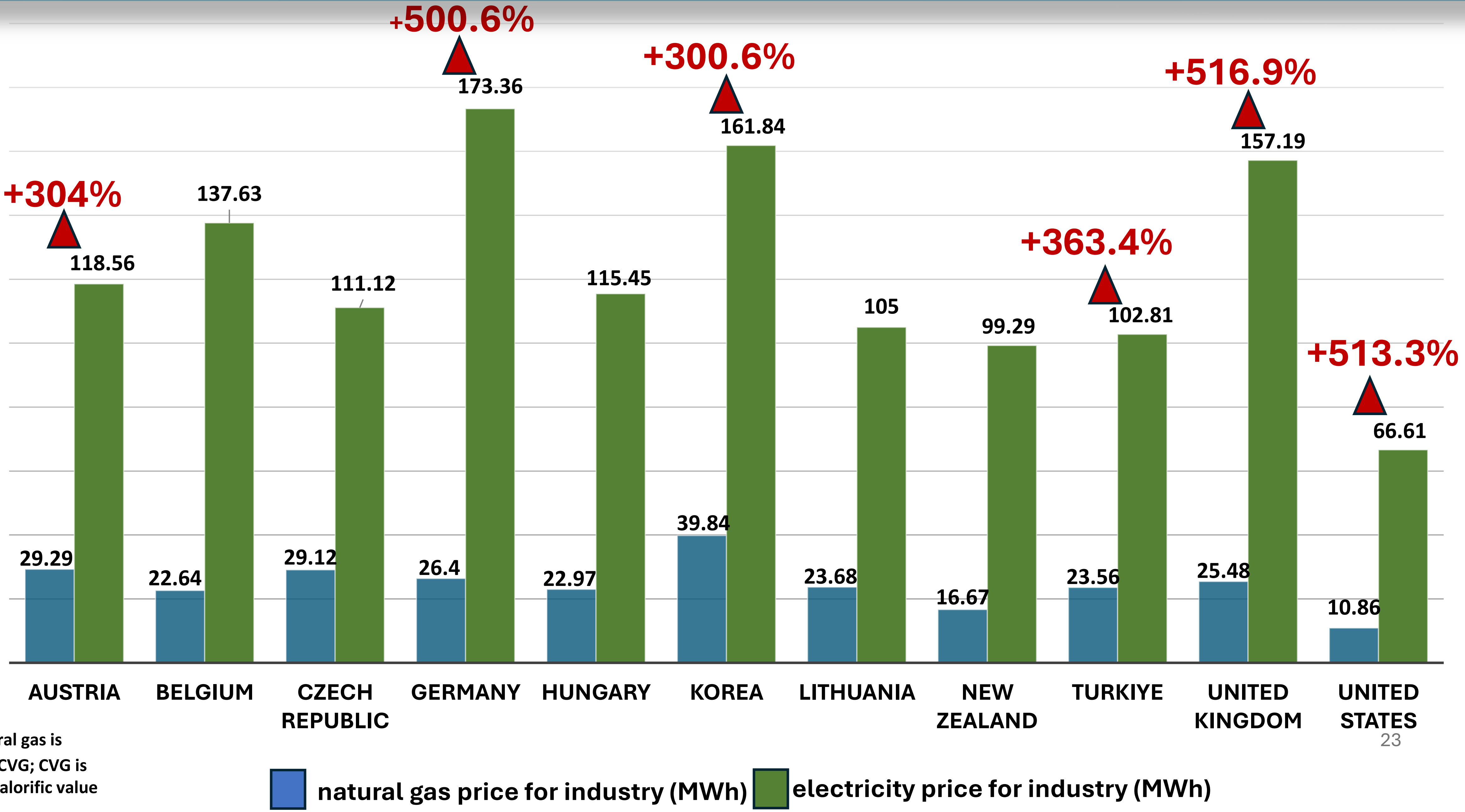
Key Technology Needs Both Heat and Oil

Wind turbine blades are manufactured using a composite mix of glass, carbon fiber, and plastic. It's a unique material that gives the blades the strength and durability to do its job.



The first step in the plastic manufacturing process is the extraction of raw materials…plastic is made from synthetic or semi-synthetic materials, all of which are derived from fossil fuels. The most common ones include natural gas, crude oil, and coal. These fossil fuels are extracted from the ground and then refined to create hydrocarbon-based feedstocks used to make plastic.

Natural Gas and Electricity Prices, Select OECD countries, 2021 (MWhr*)



*natural gas is MWhrCVG; CVG is gross calorific value

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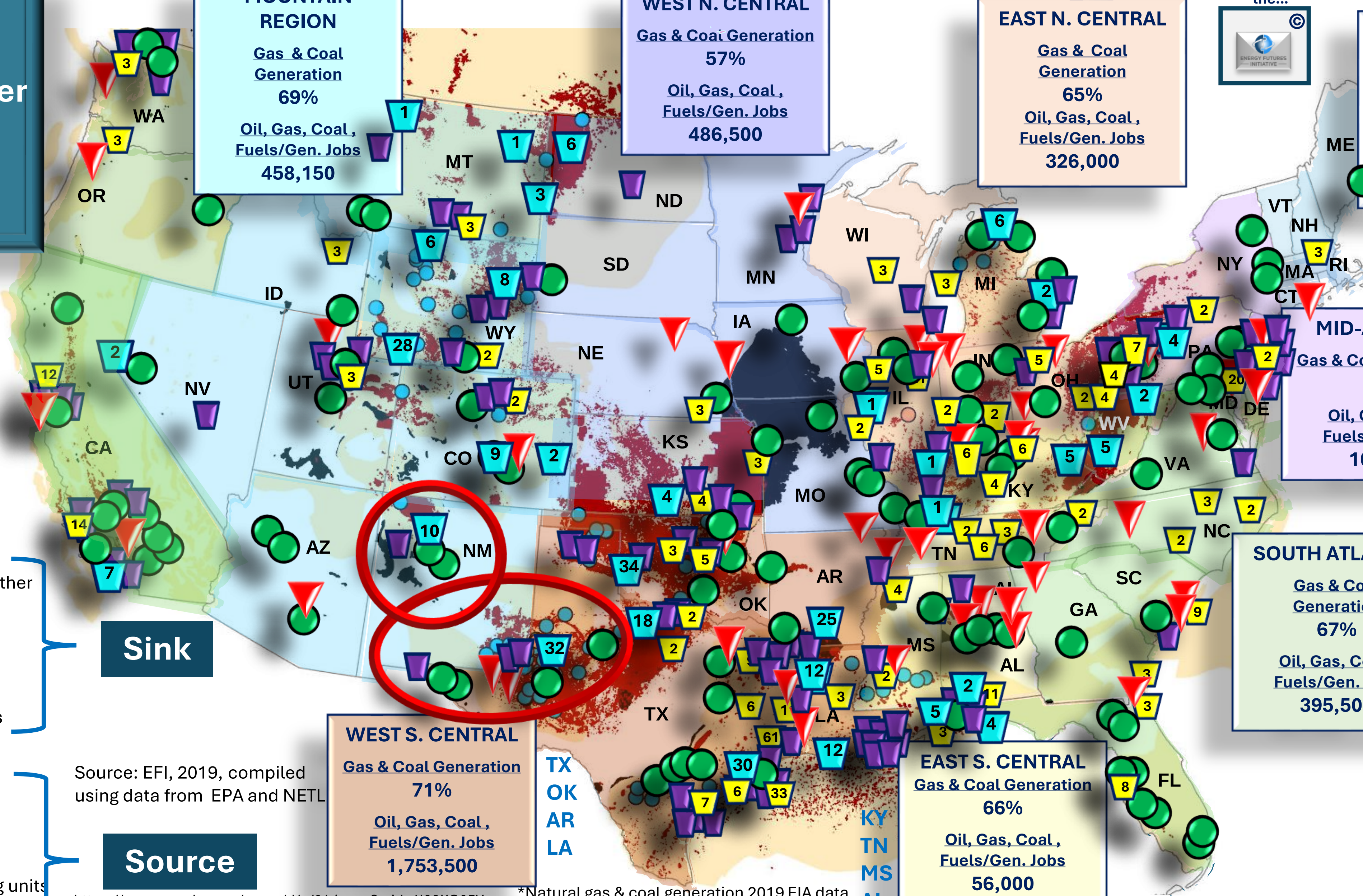
Industrial/Power Emissions, Carbon Sinks

Work product of the... ENERGY FUTURES INITIATIVE ©



MT WY ID NV UT AZ NM CO

MOUNTAIN REGION

Gas & Coal Generation
69%
Oil, Gas, Coal , Fuels/Gen. Jobs
458,150

ND SD NE KS MO IA MN

WEST N. CENTRAL

Gas & Coal Generation
57%
Oil, Gas, Coal , Fuels/Gen. Jobs
486,500

WI IL IN MI OH

EAST N. CENTRAL

Gas & Coal Generation
65%
Oil, Gas, Coal , Fuels/Gen. Jobs
326,000

ME NH VT MA RI CT

NEW ENGLAND

Gas & Coal Generation
50%
Oil, Gas, Coal , Fuels/Gen. Jobs
116,500

CA OR WA

PAC. CONTIGUOUS

Gas & Coal Generation
36%
Oil, Gas, Coal , Fuels/Gen. Jobs
384,300

NY NJ PA

MID-ATLANTIC

Gas & Coal Generation
51%
Oil, Gas, Coal , Fuels/Gen. Jobs
102,400

DE MD WV VA NC SC GA FL

SOUTH ATLANTIC

Gas & Coal Generation
67%
Oil, Gas, Coal , Fuels/Gen. Jobs
395,500

TX OK AR LA

WEST S. CENTRAL

Gas & Coal Generation
71%
Oil, Gas, Coal , Fuels/Gen. Jobs
1,753,500

KY TN MS AL

EAST S. CENTRAL

Gas & Coal Generation
66%
Oil, Gas, Coal , Fuels/Gen. Jobs
56,000

Sink

- Enhanced Recovery & Other
- Geologic Sequestration
- Oil and Gas Reservoirs
- Saline Formations
- Unmineable Coal Seams

Source

- Cement plant
- Steel plant
- Refinery
- Approx.# gas processing units
- # Chemical processing Facilities, 2019****

Source: EFI, 2019, compiled using data from EPA and NETL

https://www.google.com/maps/d/u/0/viewer?mid=1l83KG05Yxac2ZL9CaqwJO1oahUk&ll=35.78235042370692%2C-88.7570173125&z=6

https://earthjustice.org/sites/default/files/map-refineries2_800.png

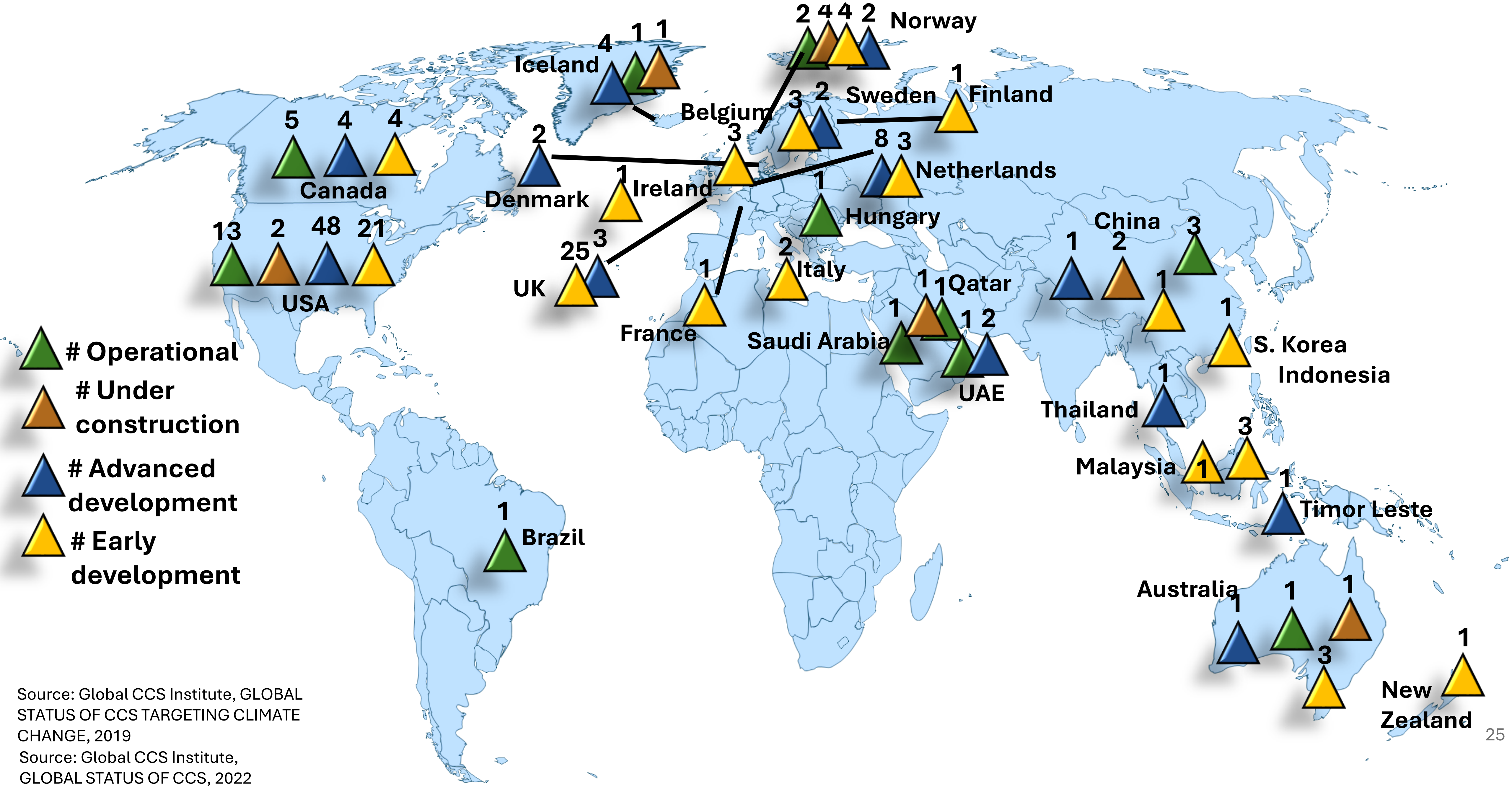
*Natural gas & coal generation 2019 EIA data

** Natural gas, coal generation, fuels jobs, assumes induced jobs of 3.5X, rounded to nearest 100

*** Locations of facilities are proximate

EPA website accessed 02/04/21

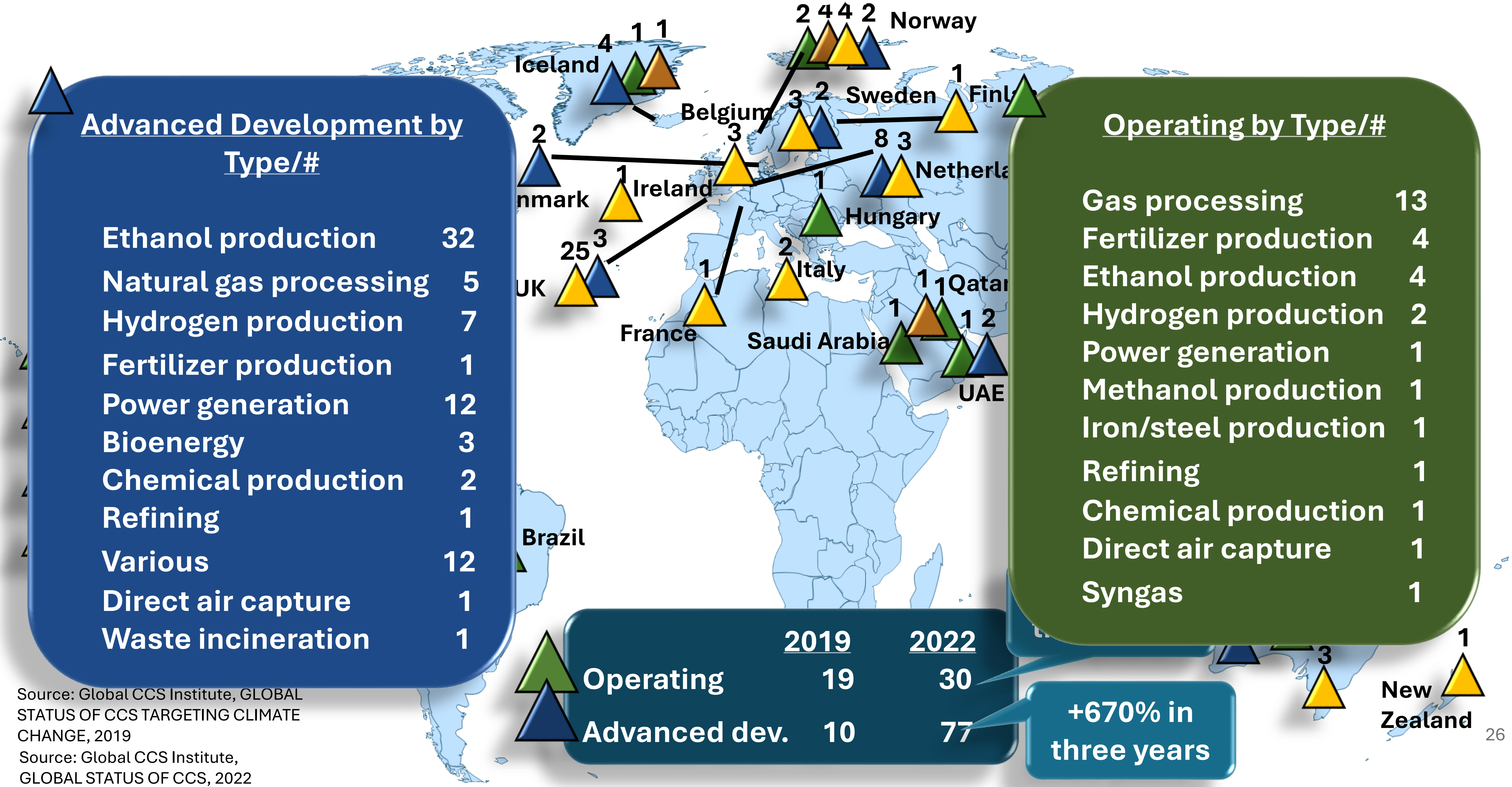
CCS Projects 2022, Operational, Under Construction, Advanced/Early Development



Source: Global CCS Institute, GLOBAL STATUS OF CCS TARGETING CLIMATE CHANGE, 2019

Source: Global CCS Institute, GLOBAL STATUS OF CCS, 2022

CCS Projects 2022, Operational, Under Construction, Advanced/Early Development



Advanced Development by Type/#

Ethanol production	32
Natural gas processing	5
Hydrogen production	7
Fertilizer production	1
Power generation	12
Bioenergy	3
Chemical production	2
Refining	1
Various	12
Direct air capture	1
Waste incineration	1

Operating by Type/#

Gas processing	13
Fertilizer production	4
Ethanol production	4
Hydrogen production	2
Power generation	1
Methanol production	1
Iron/steel production	1
Refining	1
Chemical production	1
Direct air capture	1
Syngas	1

	2019	2022
Operating	19	30
Advanced dev.	10	77

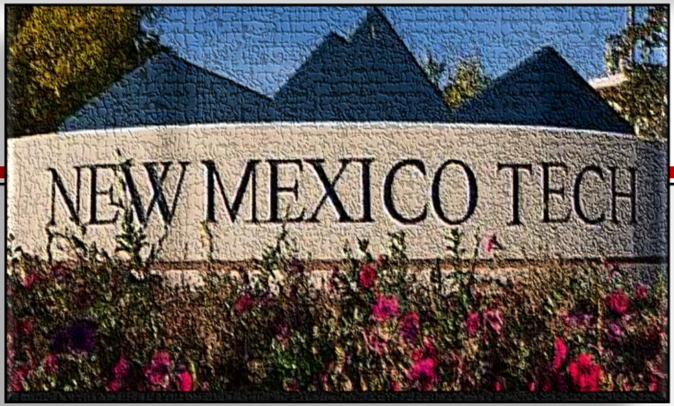
+670% in three years

Source: Global CCS Institute, GLOBAL STATUS OF CCS TARGETING CLIMATE CHANGE, 2019

Source: Global CCS Institute, GLOBAL STATUS OF CCS, 2022

Class VI Primacy: Nine Key Tasks for NM Tech + (Duration)

NM Tech will initially focus on tasks 1,2,3,4,8 and $976,464 has been approved to support the initial tranche of work.



1. Class VI Research and Planning (3 MOS.)
2. Class VI Rule Development (6 MOS)
3. Stakeholder Education and Engagement (9 MOS)
4. Continued Proposed Rule Development based on Feedback from Task 3 (9 MOS)
5. EPA Preapplication Review Package (9 MOS)
6. Undertake State Level Class VI Rulemaking (12 MOS)
7. Formal Class VI Application for Submittal (9 MOS)
8. Identify Potential State-Level Legislative Changes Necessary to Support a Successful Class VI Program (6 MOS)
9. General Legal Support (18 MOS)

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The Value of NM's Produced and Brackish Water

According to Mike Hightower with the New Mexico Produced Water Research Consortium at NMSU --

- NM is estimated to generate of 4 million barrels of produced water per day. Much of this is disposed of through deep well injections
- Up to 150,000 acre feet of produced water is available on an annual basis (3X the water used by ABQ)
- Treatment and reuse is an avoided cost for oil and gas companies. This could lower costs to consumers
- NM also has two billion acre feet of brackish water that could utilized for green hydrogen production

According to a Dec. 2023 press release announcing Governor Lujan Grisham's strategic water supply initiative, "Diverting just 3% of the produced water disposed of in injection wells to make hydrogen could result in enough energy to fully power over 2 million homes annually."

https://nmbizcoalition.org/nm-oil-and-gas-producers-making-progress-on-produced-water/
https://nmpwrc.nmsu.edu/_assets/public_information/Water-Needs-for-Hydrogen-Development.pdf

NM Metals, Minerals on Which the US is 75-100% Import Dependent, Country Suppliers of US Market/% Total Imports from Country

All are on the 2022 USGS Critical List

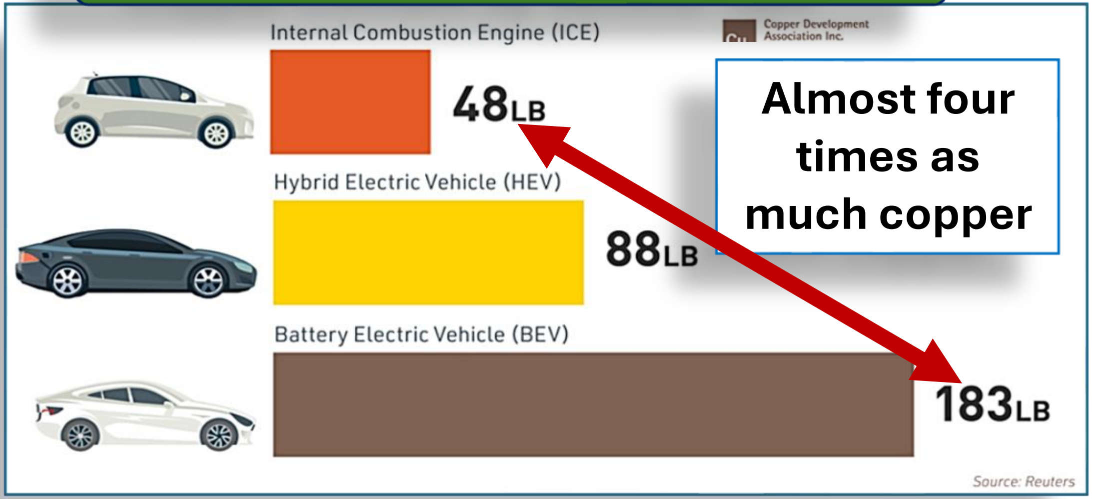
Found and/or Produced in NM

Mineral	% Import Dependent	% Suppliers	Key Uses
Antimony	81	63% China	Ceramics, glass
Arsenic	100	58% China	Lumber preservatives
Bismuth	94	69% China	Medical, atomic research
Gallium	100	55% China	LEDs
Graphite	100	9% India 33% China 23% Mexico 7% Canada	Batteries, fuel cells
Indium	100	34% China 22% Canada 15% S. Korea	Electrical components
Manganese	100	69% Gabon	Steel production
Niobium	100	22% Canada	Steel alloys
Rare earths	100	80% China	Metallurgy, glass, wind turbines
Scandium	100	China, Japan Europe (% NA)	Aluminum, fuel cells electronics
Tellurium	95	57% Canada	Solar cells, cooling
Titanium	75	39% South Africa 20% Australia 11% Canada	Steel alloys
Vanadium	95	37% South Africa 14% Russia 11% China	Steel
Zinc	83	64% Canada 14% Mexico	Metal galvanizing

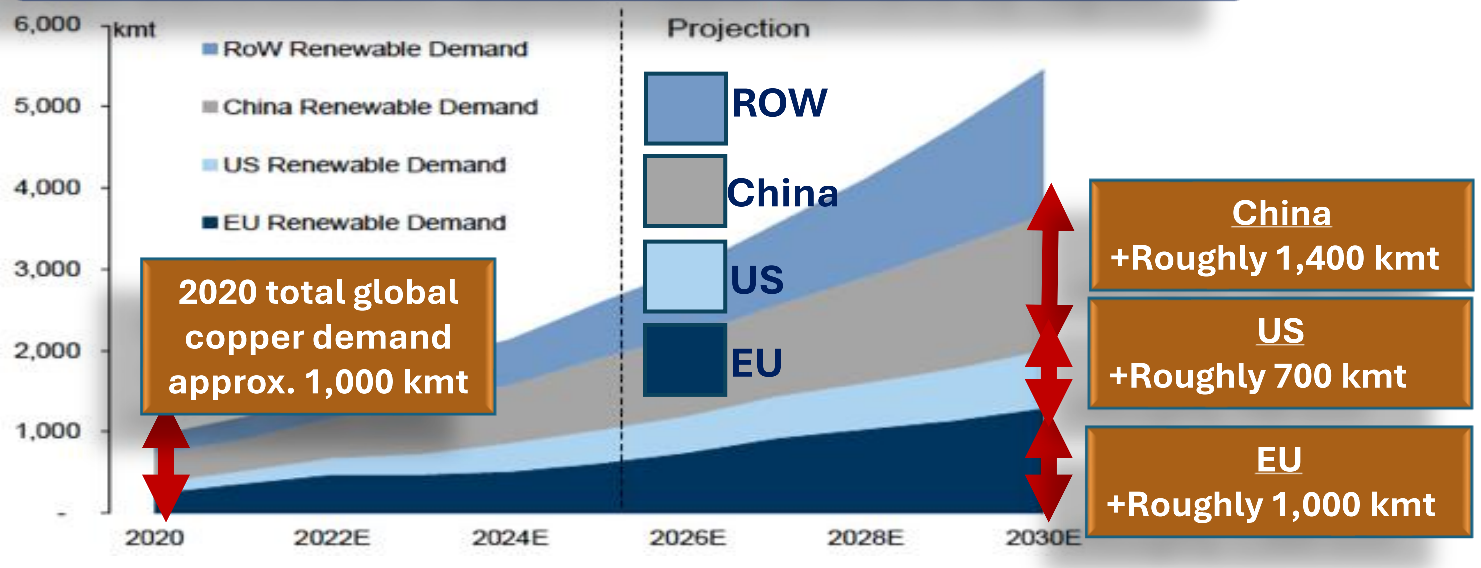
Demand for Electrification/Transportation = $10,000 per ton Copper

Copper, 5 Year Price Chart

Copper Content by Vehicle Type



Green electrification related copper demand by region



140 M EVs by 2030 in IEA's SDS X 183 lbs. of copper/EV = 11.6 million Mt of copper for EVs

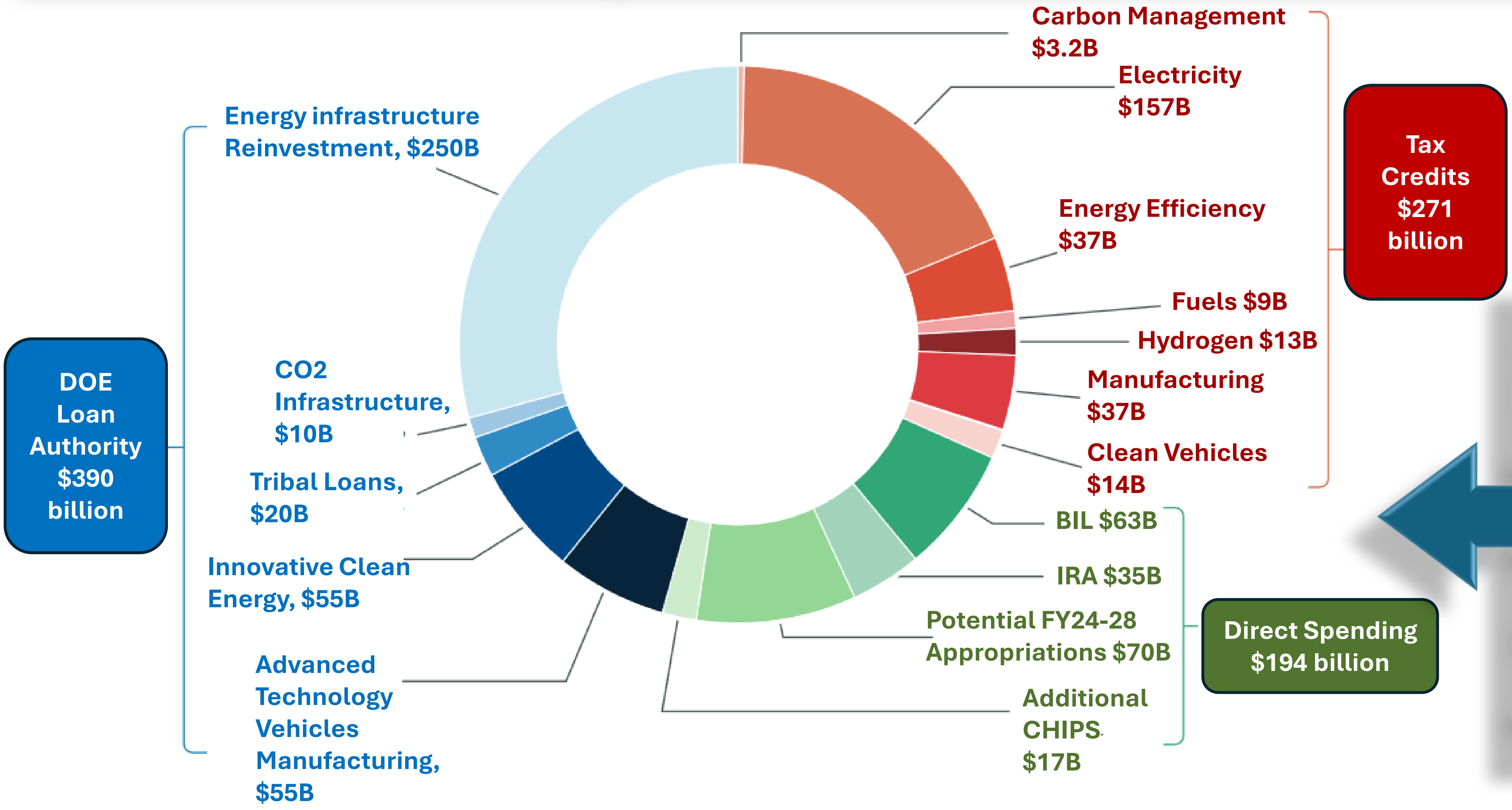
Global production, 2020: approx. 20 million Mt

US uses (%): building construction, 43%; electrical and electronic products, 21%; transportation equipment, 19%; consumer and general products, 10%; and industrial machinery and equipment, 7%.

Frik Els | April 13, 2021 | 2:16 pm

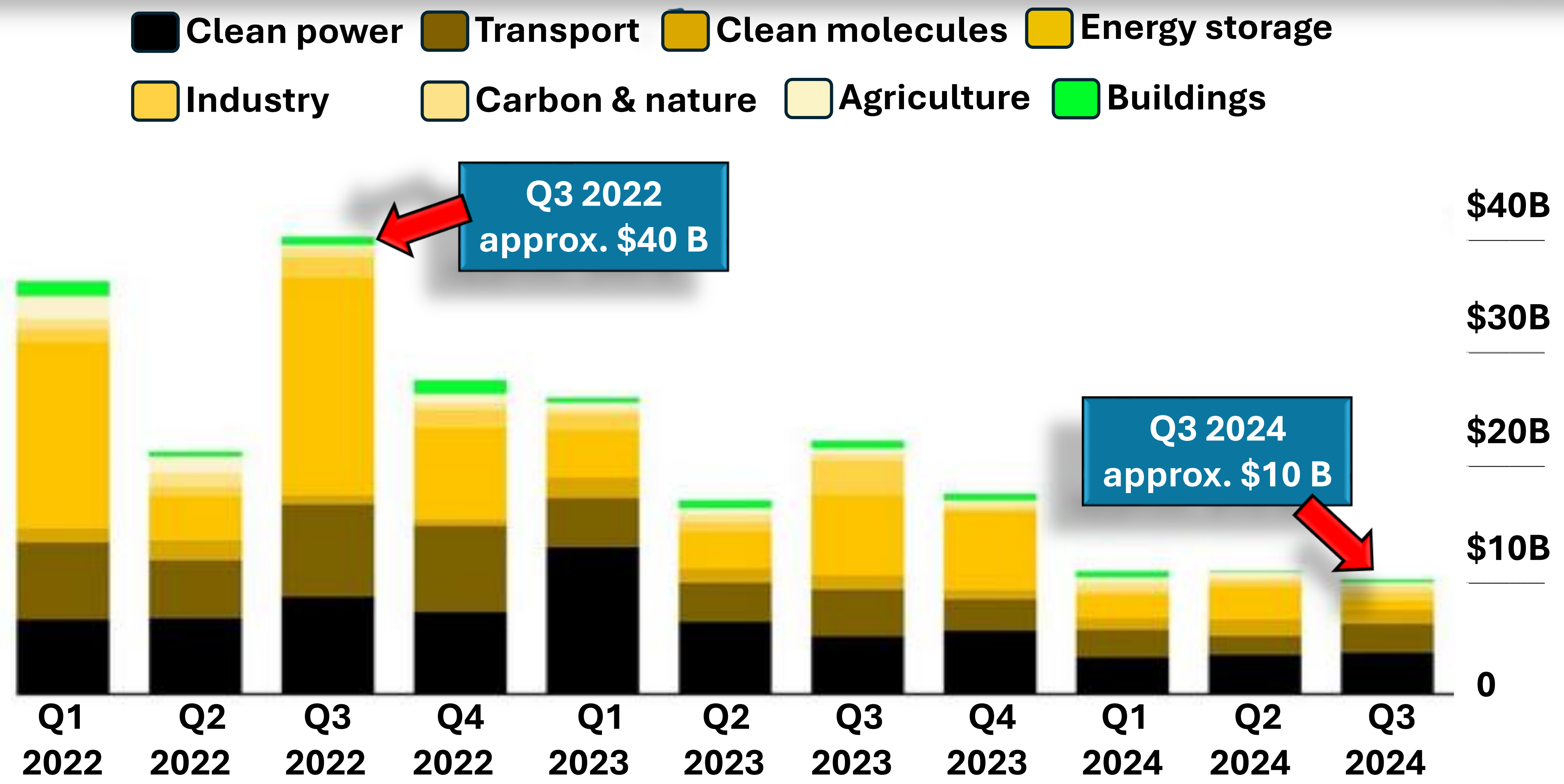
Federal Financial Resources to Accelerate the Clean Energy Transition:

Tax Incentives, Loan & Loan Guarantee Authority, Direct Spending*



New Mexico has received $5.9 billion from these and other related funds for clean energy, infrastructure and manufacturing

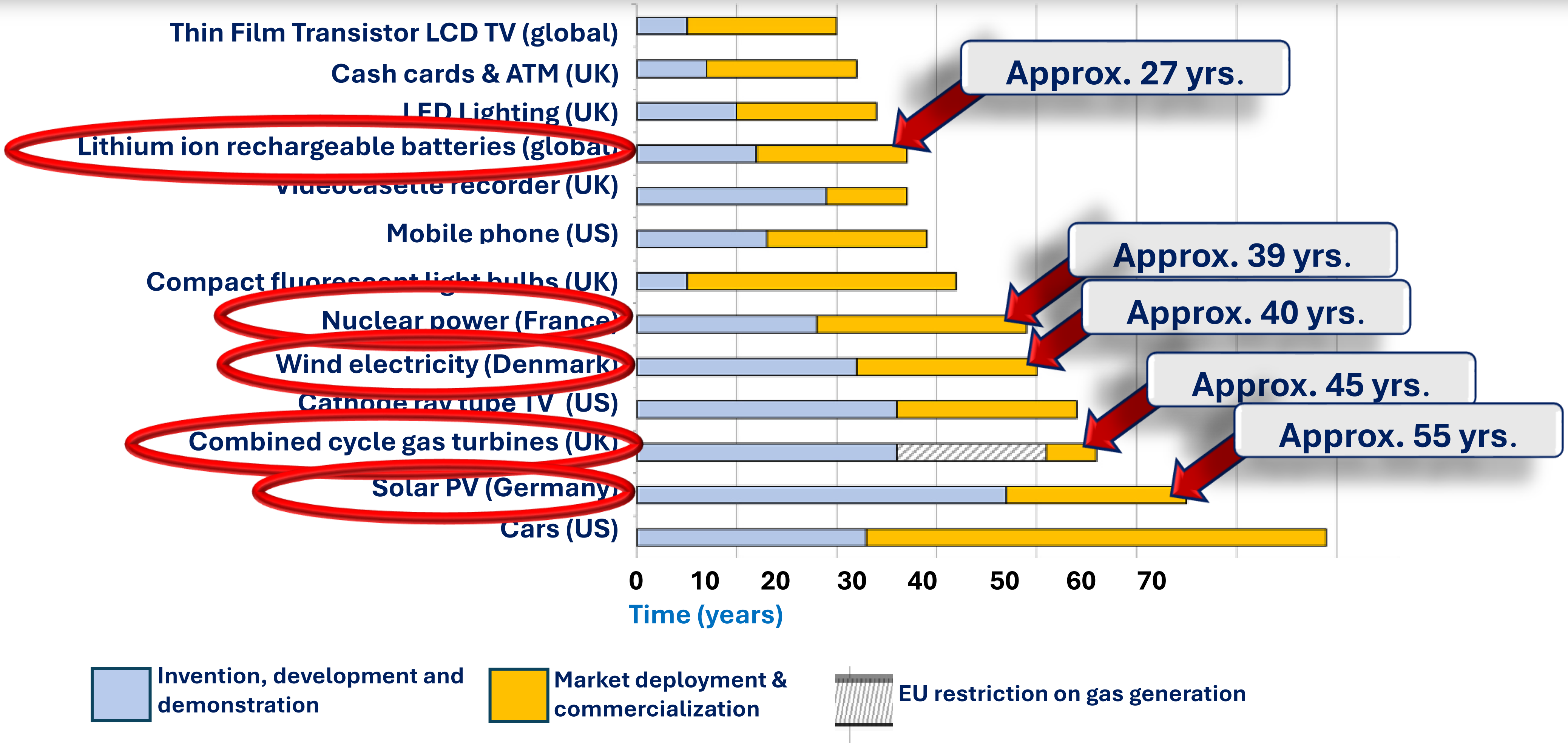
Company Climate-Tech Funding



Companies raised $10.3 billion globally in 3rd quarter 2024

Source: BloombergNEF
Note: Data excludes undisclosed values and deals under $1 million

Development/Deployment Timelines for Key Technologies



Francehttps://reader.elsevier.com/reader/sd/pii/S0301421521000240?token=875F291C875B56A06A22FF61D6E0AFD903726134EEA017D8914E90A9DB516318501601DD1CDF1A5072CFFED060D141A1&originRegion=us-east-1&originCreation=20210715180413

Focusing the Energy Innovation Portfolio on Breakthrough Potential

- Federal and private clean energy innovation are complementary
- Key platform technologies hold great potential to unlock significant clean energy innovation
- A four-step process is used to identify breakthrough technologies that have the potential to aid government, industry and thought leaders in efforts to transform the energy sector

Analyze key drivers of clean energy technology breakthroughs

Digitalization, big data & smart systems

The difficult to decarbonize sectors

Integration of platform technologies

Systems and supply chains

Develop selection criteria for breakthrough technologies

Technical merit

Market viability

Compatibility

Consumer value

Identify the universe of emerging energy technologies that have critical features across various timescales

Identify innovation areas with significant breakthrough potential

Critical innovation areas identified are:

- Storage and battery technologies
- Advanced nuclear reactors
- **Technology applications for industry and buildings as sectors that are difficult to decarbonize including hydrogen,** advanced manufacturing technologies; and building technologies
- Systems: electric grid modernization and smart cities
- **Deep decarbonization/large-scale carbon management; carbon capture, use and storage at scale;** sunlight to fuels; enhanced biological and oceans sequestration

Source: https://www.energy.gov/energy-earthshots-initiative

Source: Advancing the Landscape of Clean Energy Innovation, 2019, EFI, IHS Markit

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Focusing the Energy Innovation Portfolio on Breakthrough Potential

ENERGY earthshots U.S. DEPARTMENT OF ENERGY

- ✓ **Hydrogen Shot**
- ✓ **Long Duration Storage Shot**
- ✓ **Carbon Negative Shot**
- ✓ **Enhanced Geothermal Shot**
- ✓ **Floating Offshore Wind Shot**
- ✓ **Industrial Heat Shot**
- ✓ **Clean Fuels and Products Shot**
- ✓ **Affordable Home Energy Shot**

Critical innovation areas identified are:

- ➢ Storage and battery technologies
- ➢ Advanced nuclear reactors
- ➢ **Technology applications for industry and buildings as sectors that are difficult to decarbonize including hydrogen,** advanced manufacturing technologies; and building technologies
- ➢ Systems: electric grid modernization and smart cities
- ➢ **Deep decarbonization/large-scale carbon management; carbon capture, use and storage at scale;** sunlight to fuels; enhanced biological and oceans sequestration

Source: https://www.energy.gov/energy-earthshots-initiative

Source: Advancing the Landscape of Clean Energy Innovation, 2019, EFI, IHS Markit

New Mexico's "Energy Trilemma"