Amy Jaffe
Global Energy and Geopolitical Risk
Tufts University
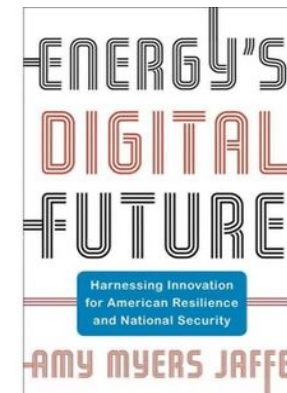
ECC

CLIMATE POLICY LAB
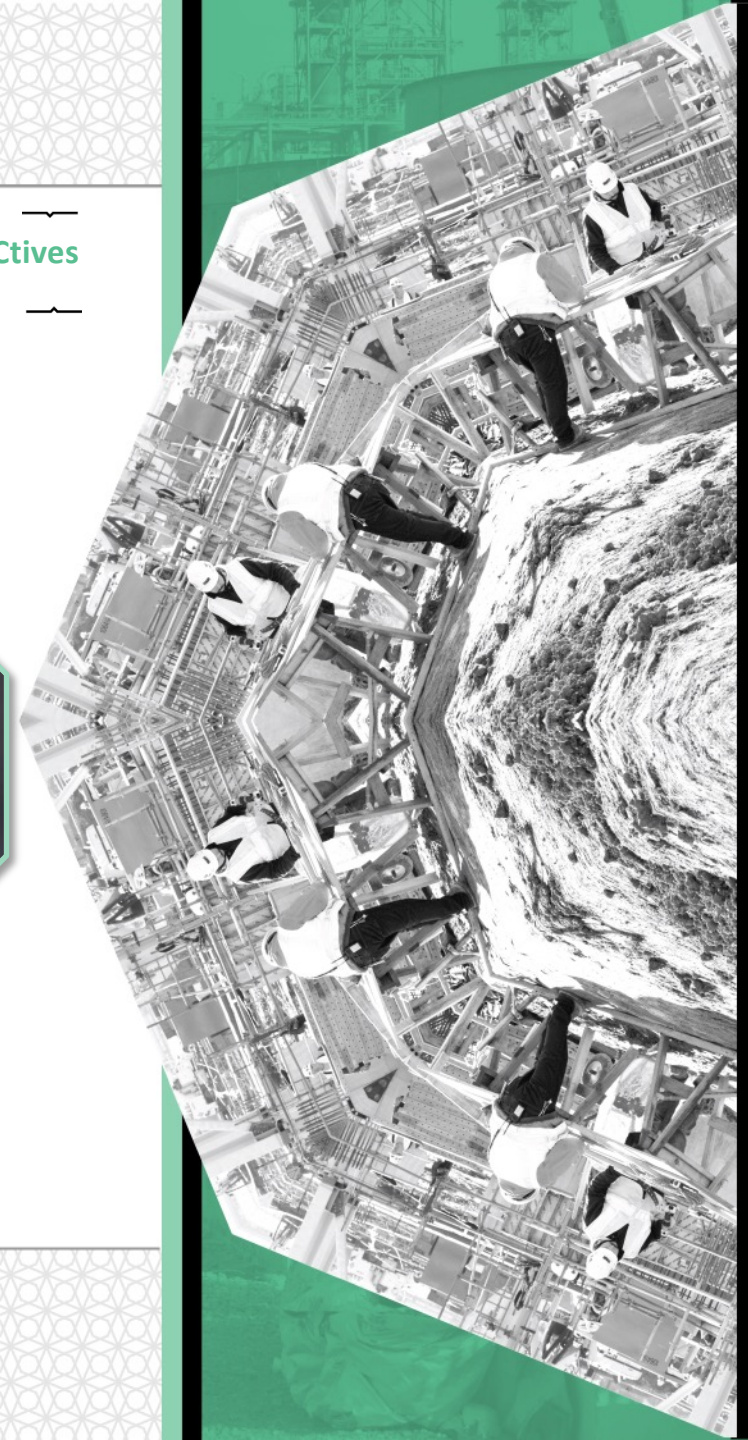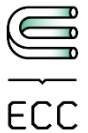
Presentation to:

Annual PerspECCtives Conference
September 8, 2022
JW Marriott Hill Country, San Antonio, TX

Amy Myers Jaffe
AMJ Energy

ENERGY'S DIGITAL FUTURE
Harnessing Innovation for American Resilience and National Security
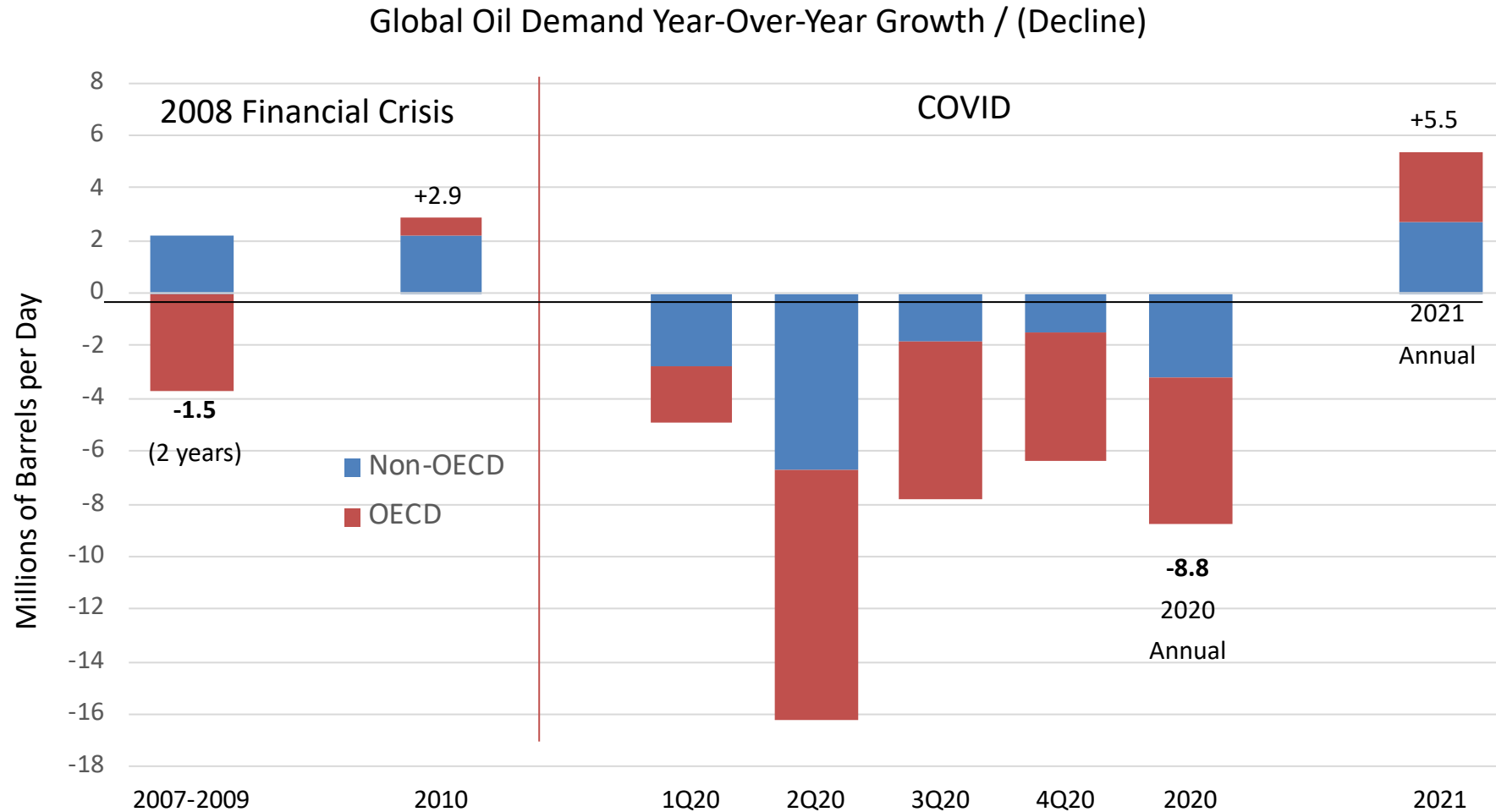AMY MYERS JAFFE

Oil Prices
It's still cyclical

Change in Global Oil Demand:
COVID vs. the 2008-2009 Financial Crisis

Global Oil Demand Year-Over-Year Growth / (Decline)

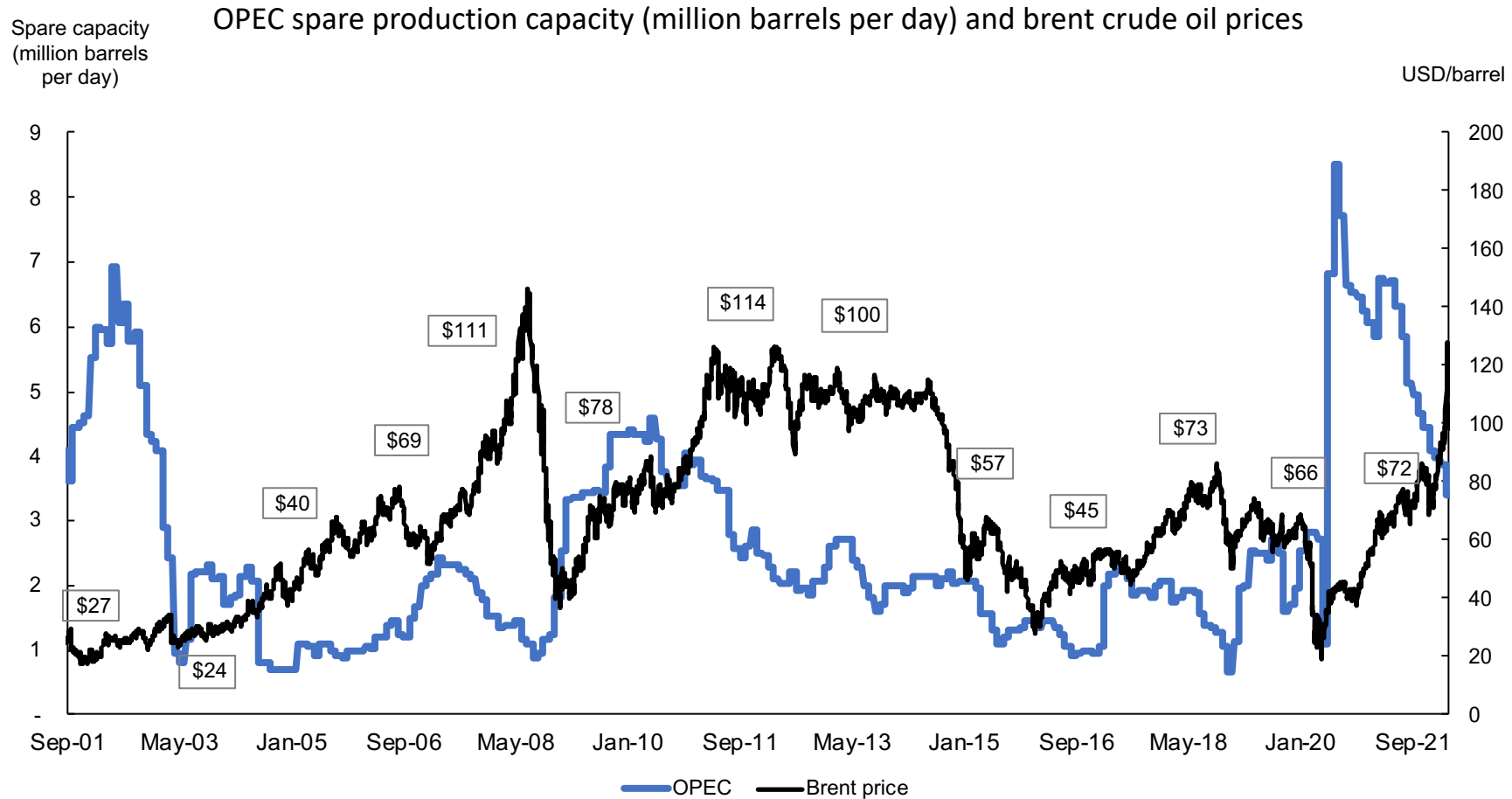*Year-over-year and quarter-over-quarter except where noted
Source: International Energy Agency, Oil Market Report, January 16, 2021 and IEA Annual Statistical Supplemental 2007-2009

Russian crude oil supply export cutoff in historical terms is more limited than people think and it didn't actually happen yet

Lost production (millions of barrels per day)

Event	Value
Six-Day War (1967)	2.0
Suez Crisis (1956-1957)	2.0
Iraqi oil export suspension (2001)	2.1
War in Iraq (2003)	2.3
Venezuelan strike (2002-2003)	2.6
Outbreak of Iran-Iraq war (1980-1981)	4.1
Iraqi invasion of Kuwait (1990-1991)	4.3
Arab-Israeli War, oil embargo (1973-1974)	4.3
Iranian Revolution (1978-1979)	5.6
Saudi drone strike (2019)	5.7
Russia potential outage (2022)	3.0

Source: Bloomberg & IEA (2019)

Changes in level of OPEC Spare Capacity

Spare capacity (million barrels per day)

OPEC spare production capacity (million barrels per day) and brent crude oil prices

USD/barrel

*spare capacity < 2.5 million barrels per day
*data labels correspond to the dates on the x-axis.
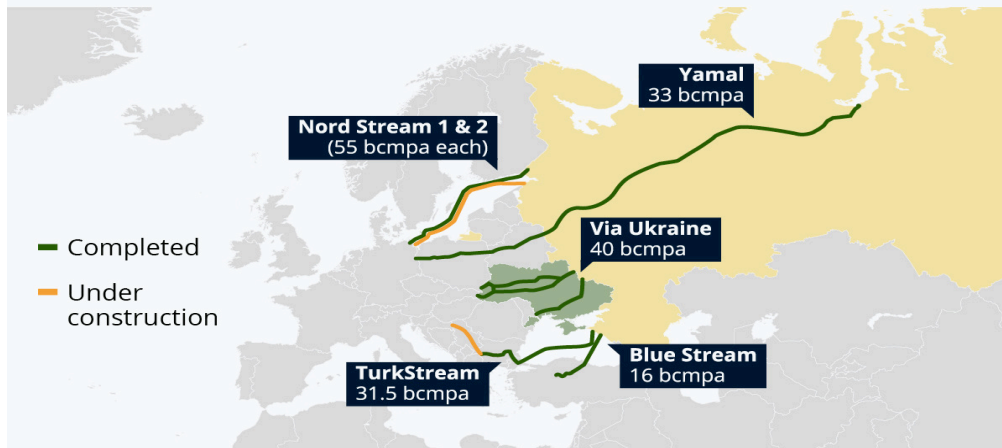Source: US Energy Information Administration, Bloomberg Terminal (Retrieved March 17, 2022)

Natural Gas is a different story

Global Gas Shock By the Numbers

The Gas Pipelines Linking Russia and Europe
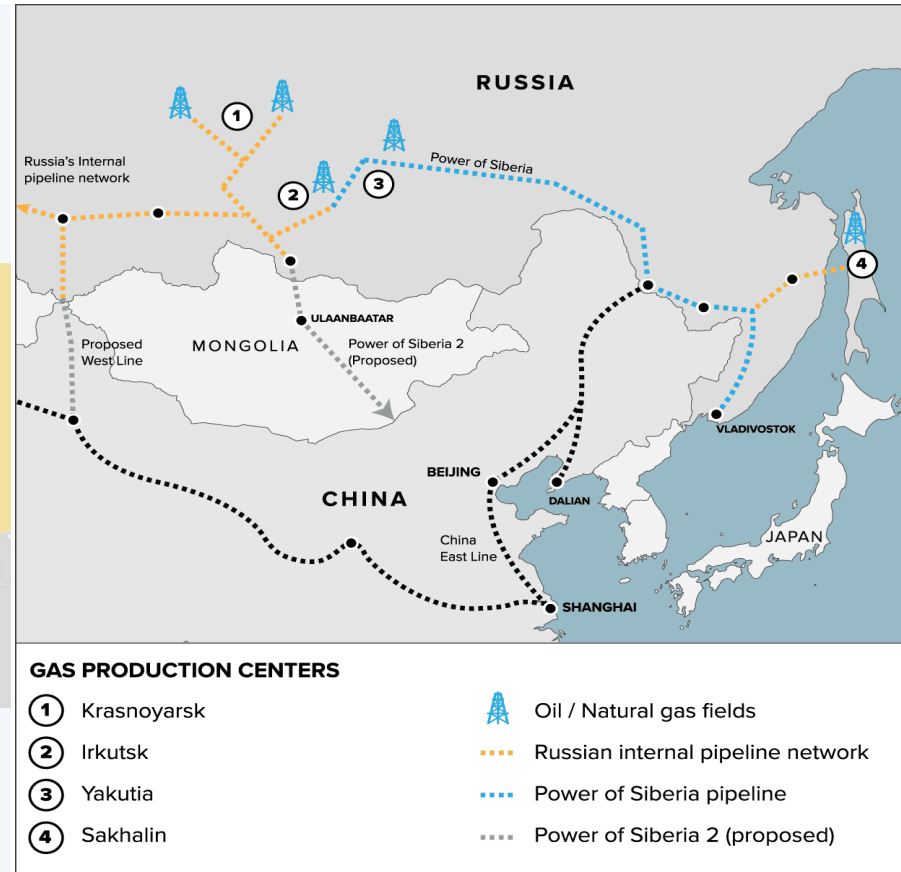
Major Russian-European natural gas pipelines and theoretical capacities (in billion cubic meters per annum)

Yamal
33 bcmpa

Nord Stream 1 & 2
(55 bcmpa each)

Via Ukraine
40 bcmpa

TurkStream
31.5 bcmpa

Blue Stream
16 bcmpa

— Completed
— Under construction

Ukraine: actual 2021 flow
Source: JPMorgan via The Economist

statista

GAS PRODUCTION CENTERS

① Krasnoyarsk
② Irkutsk
③ Yakutia
④ Sakhalin

🛢 Oil / Natural gas fields
⋯ Russian internal pipeline network
⋯ Power of Siberia pipeline
⋯ Power of Siberia 2 (proposed)

RUSSIA

Russia's Internal pipeline network
Power of Siberia
ULAANBAATAR
Proposed West Line
MONGOLIA
Power of Siberia 2 (Proposed)
CHINA
BEIJING
DALIAN
China East Line
SHANGHAI
VLADIVOSTOK
JAPAN

Pre-COVID Russian Gas to Europe **200 BCM/yr**

June Europe **^50-60 BCM/yr**

Piped to China **15 BCM/yr**

Piped to China 2025 **38 BCM/yr**

US LNG added 2.3 bcf/d of export capacity in 2022: to 13.9 bcf/d; Will reach 16.3 bcf/d by 2024
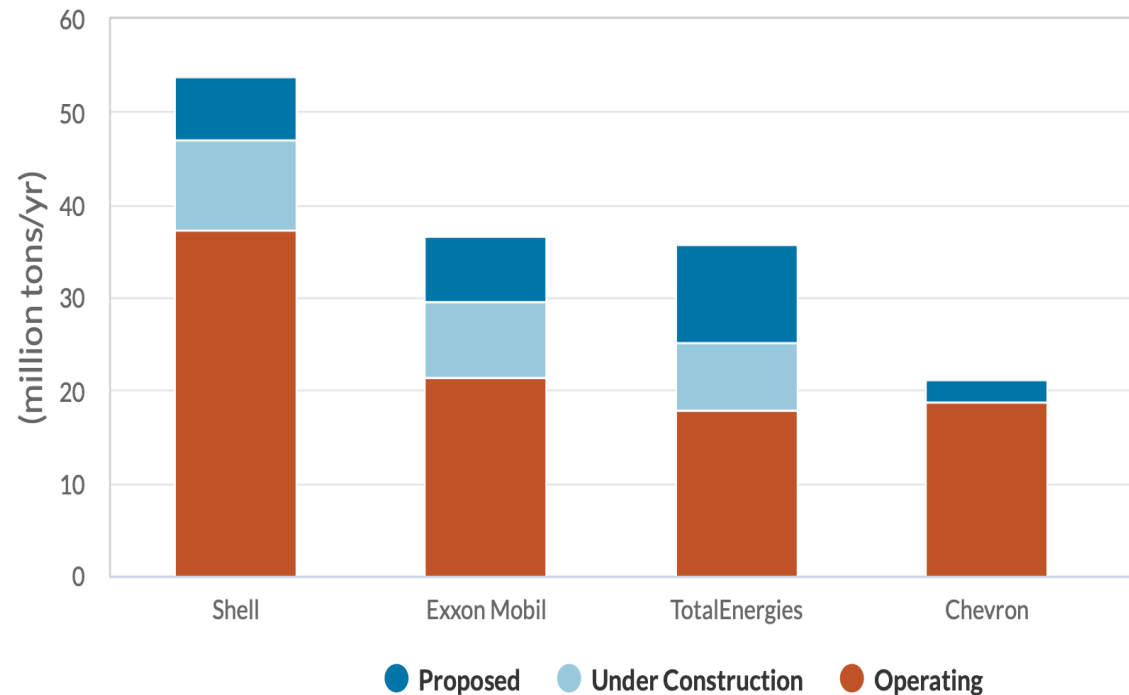
Global LNG Projects "Supply hole" By the Numbers

IOC MAJORS Additions

Under Construction: 28.3 mt/yr

Proposed: 29.6 mt/yr

MAJORS' EQUITY LNG CAPACITY

y-axis: (million tons/yr), scale 0 to 60

x-axis categories: Shell, Exxon Mobil, TotalEnergies, Chevron

Legend: ● Proposed ● Under Construction ● Operating

NOTES: Shell operating capacity excludes Sakhalin LNG, Total excludes Yemen; Shell expansion capacity excludes Sakhalin and Abadi (up for sale), Total excludes Russian LNG.
Not included in "proposed" but worth watching: further expansion at Coral (Exxon), East Med FLNG (Chevron), Qatar NFS (potentially Total, Shell, Exxon), Tangguh Train 4 (BP).
Source: Energy Intelligence Global LNG Project Database

Expected New Russian LNG Now On Hold:

BALTIC LNG – 13 mt/yr

ARCTIC LNG 2 – 20 mt/yr
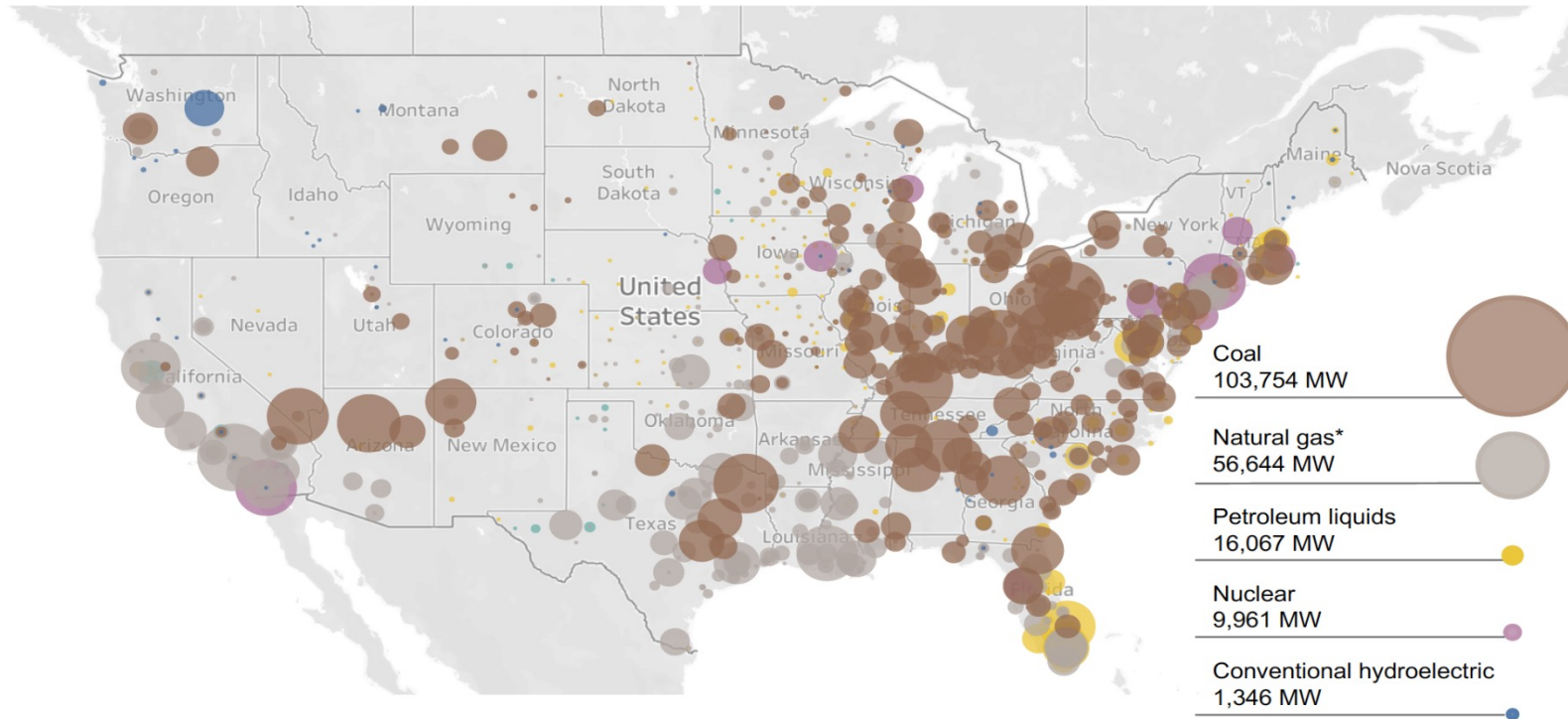*Now only 60% completed and not coming on line for 2023*

Ob LNG - 6.6 mt/yr

Total/Potential Supply Hole: 39.6 mt/yr

Will Global Natural Gas Supply Shock Hasten Pivot to Green?

Current Average Age for Operating US Coal-fired Generation is 45 years

U.S. Power Plant Retirements, January 2011 – November 2021

Legend:
- Coal 103,754 MW
- Natural gas* 56,644 MW
- Petroleum liquids 16,067 MW
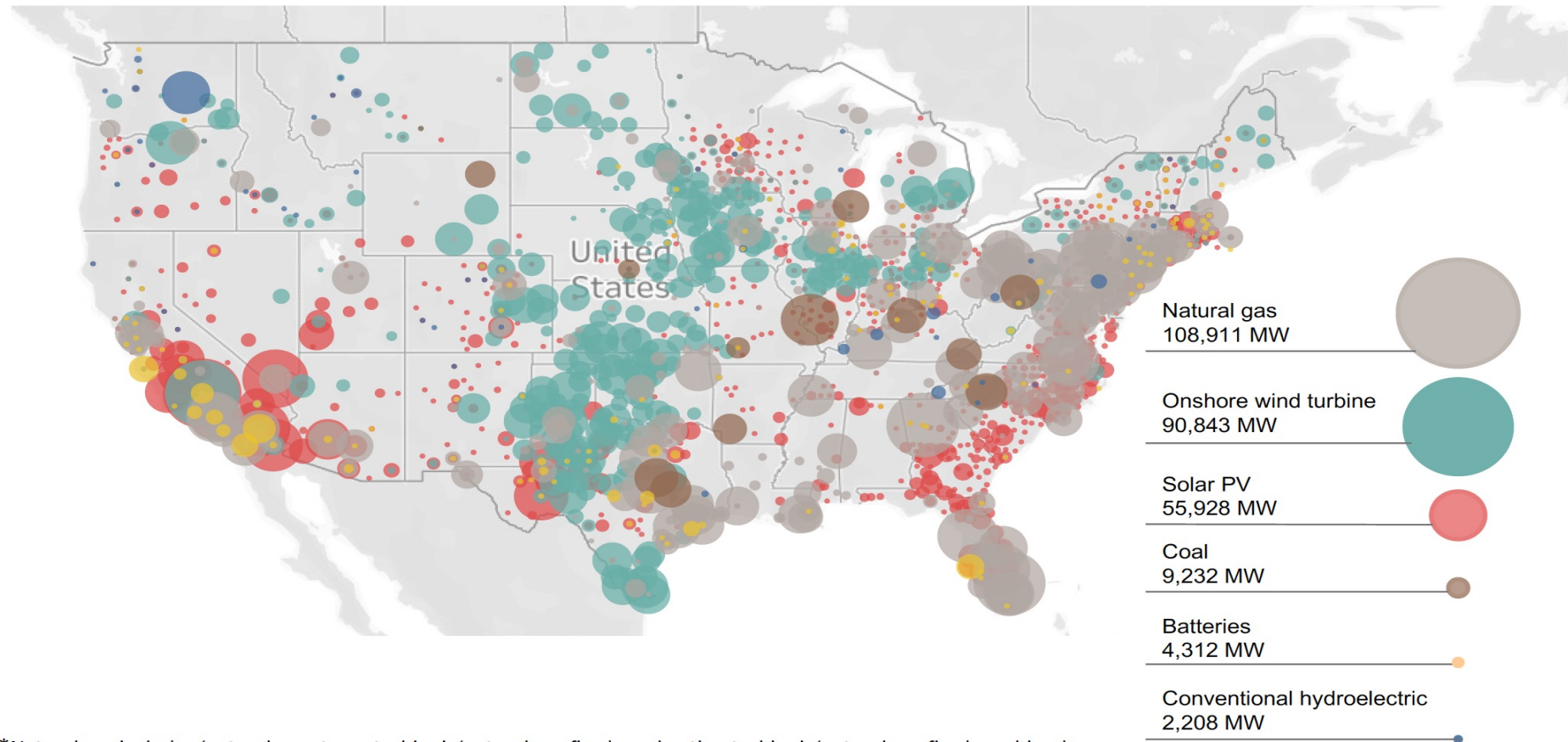- Nuclear 9,961 MW
- Conventional hydroelectric 1,346 MW

*Natural gas includes 'natural gas steam turbine', 'natural gas fired combustion turbine', 'natural gas fired combined cycle', 'natural gas internal combustion engine', and 'other natural gas'.

Source: EIA Preliminary Monthly Electric Generator Inventory, November 2021

Absent US federal regulation…

U.S. Power Plant Additions, January 2011 – November 2021

Natural gas
108,911 MW

Onshore wind turbine
90,843 MW

Solar PV
55,928 MW

Coal
9,232 MW
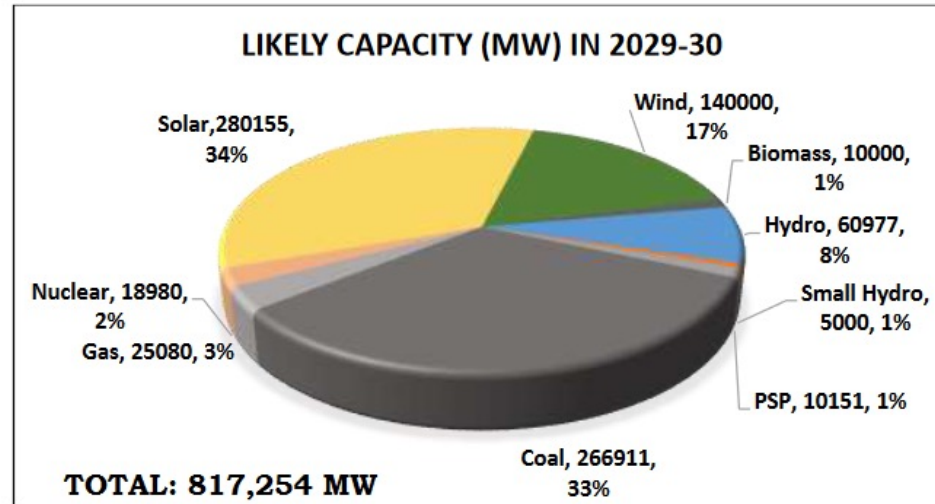
Batteries
4,312 MW

Conventional hydroelectric
2,208 MW

*Natural gas includes 'natural gas steam turbine', 'natural gas fired combustion turbine', 'natural gas fired combined cycle', 'natural gas internal combustion engine', and 'other natural gas'.

Source: EIA Preliminary Monthly Electric Generator Inventory, November 2021
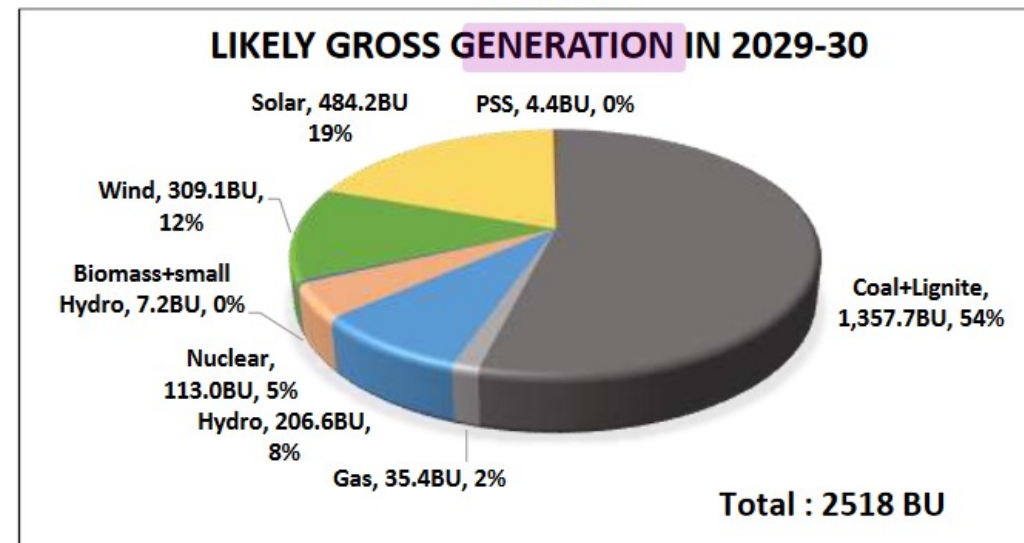
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India has ambitious renewables targets for 2030

Exhibit 8

LIKELY CAPACITY (MW) IN 2029-30

- Wind, 140000, 17%
- Biomass, 10000, 1%
- Hydro, 60977, 8%
- Small Hydro, 5000, 1%
- PSP, 10151, 1%
- Coal, 266911, 33%
- Gas, 25080, 3%
- Nuclear, 18980, 2%
- Solar, 280155, 34%

TOTAL: 817,254 MW

- 25 GW of old inefficient units to retire between 2022 and 2030.
- Renewables now 40% of installed capacity and targeted to expand to 61%.
- 450 GW of renewables capacity by 2030.
- Natural gas not targeted for growth
- Reliance Energy - $10 billion pledged to renewables, plus green H2; ONGC investing in offshore wind.

Source: Central Electricity Authority (2020)

Exhibit 9

LIKELY GROSS GENERATION IN 2029-30

- Solar, 484.2BU, 19%
- PSS, 4.4BU, 0%
- Wind, 309.1BU, 12%
- Biomass+small Hydro, 7.2BU, 0%
- Nuclear, 113.0BU, 5%
- Hydro, 206.6BU, 8%
- Gas, 35.4BU, 2%
- Coal+Lignite, 1,357.7BU, 54%

Total : 2518 BU

* including Generation from hydro imports.

China also has also ambitious targets for renewable energy
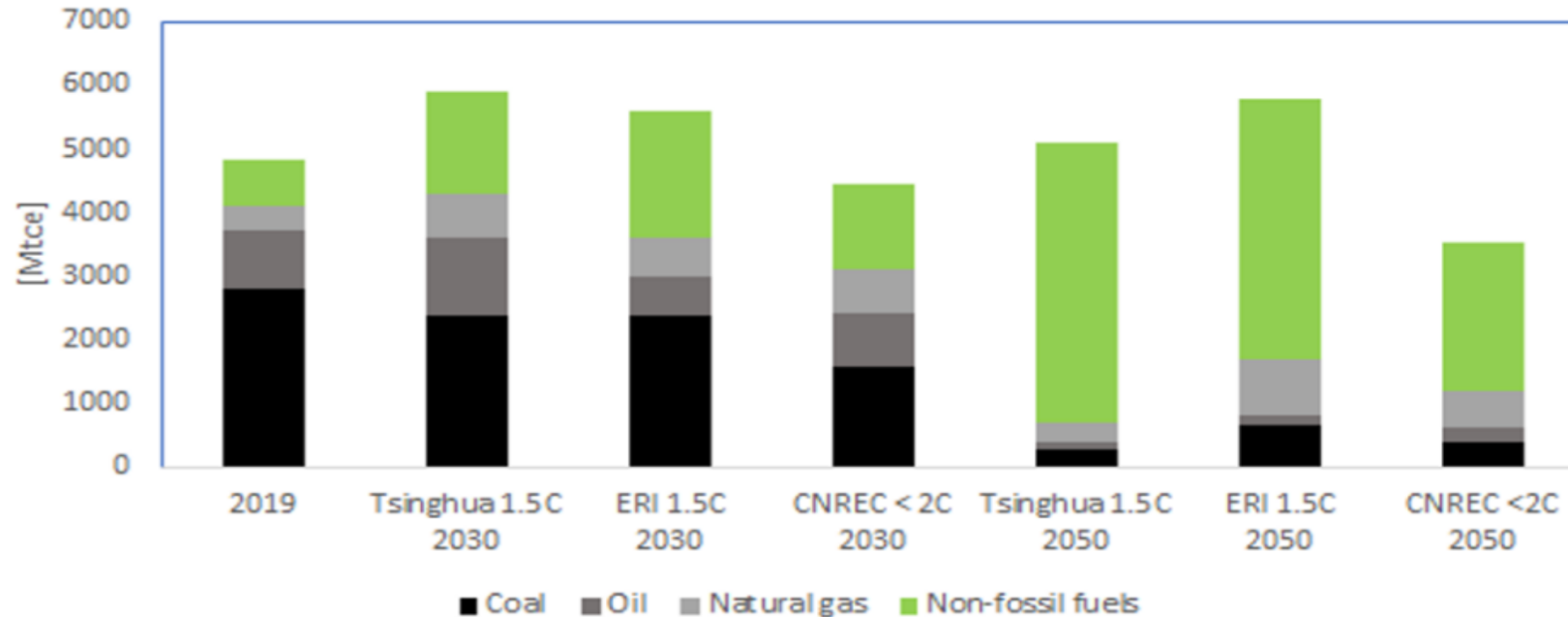
While expanded use of natural gas to 2030 is part of China's net zero 2050 planning, China's top priority is to grow domestic renewables and nuclear

The new competitor to natural gas: US annual installation of battery storage is soaring despite supply chain problems and rising costs, led by California, Puerto Rico.
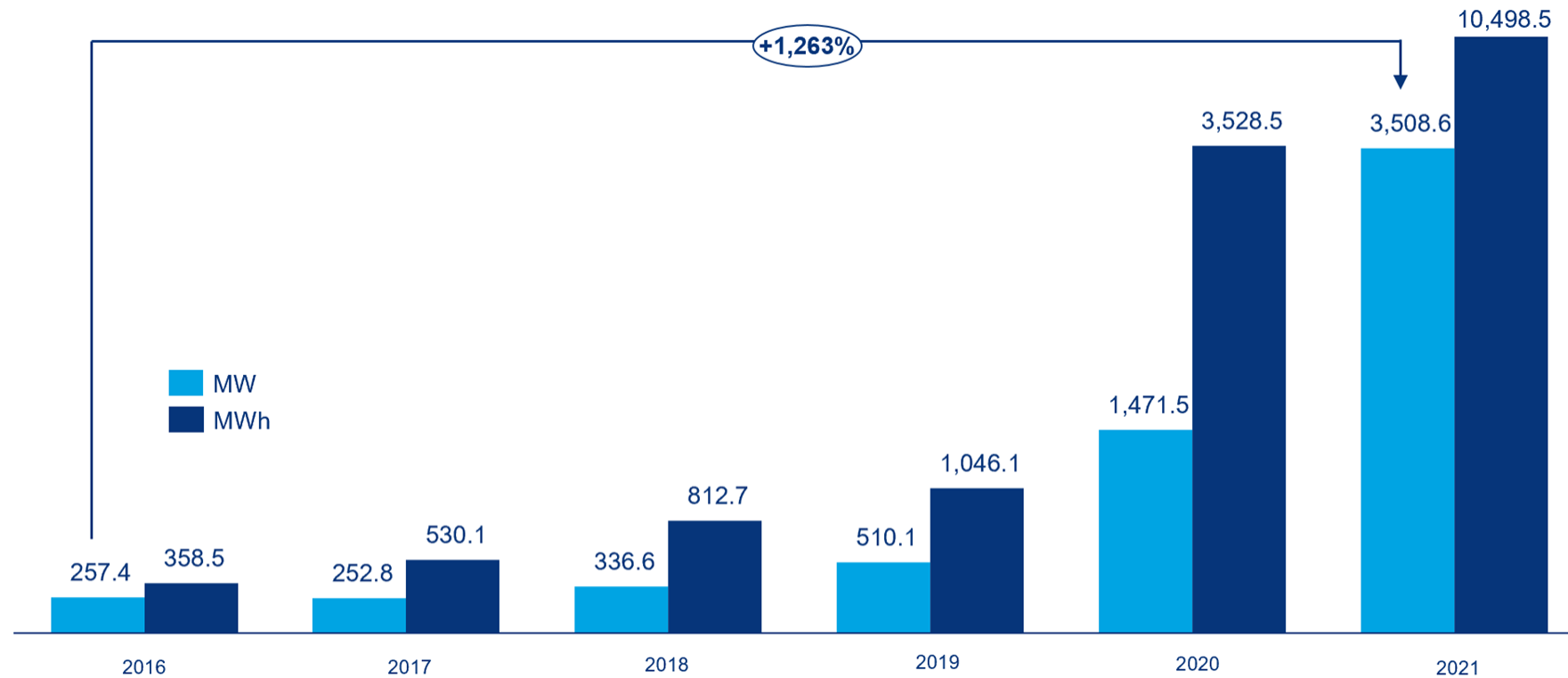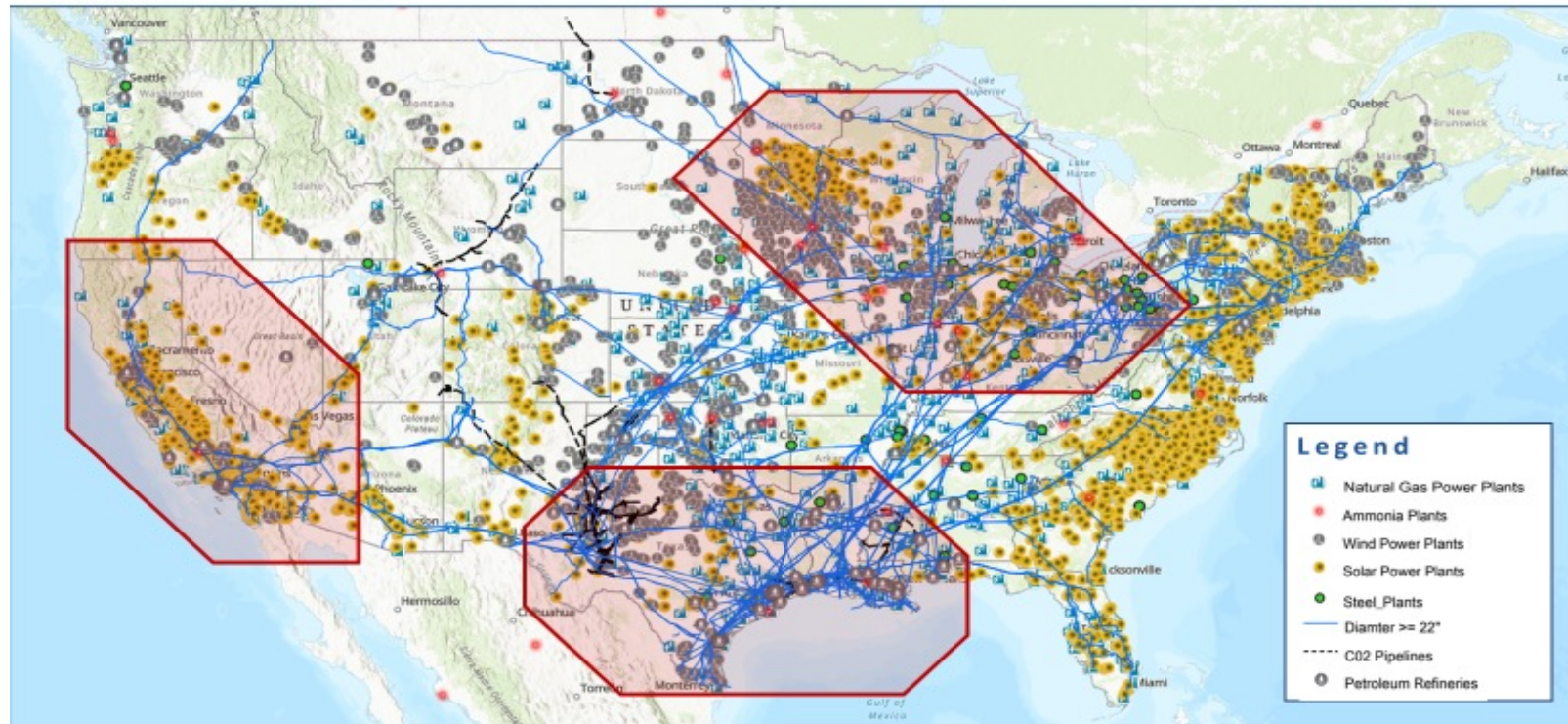

Source: Wood MacKensie

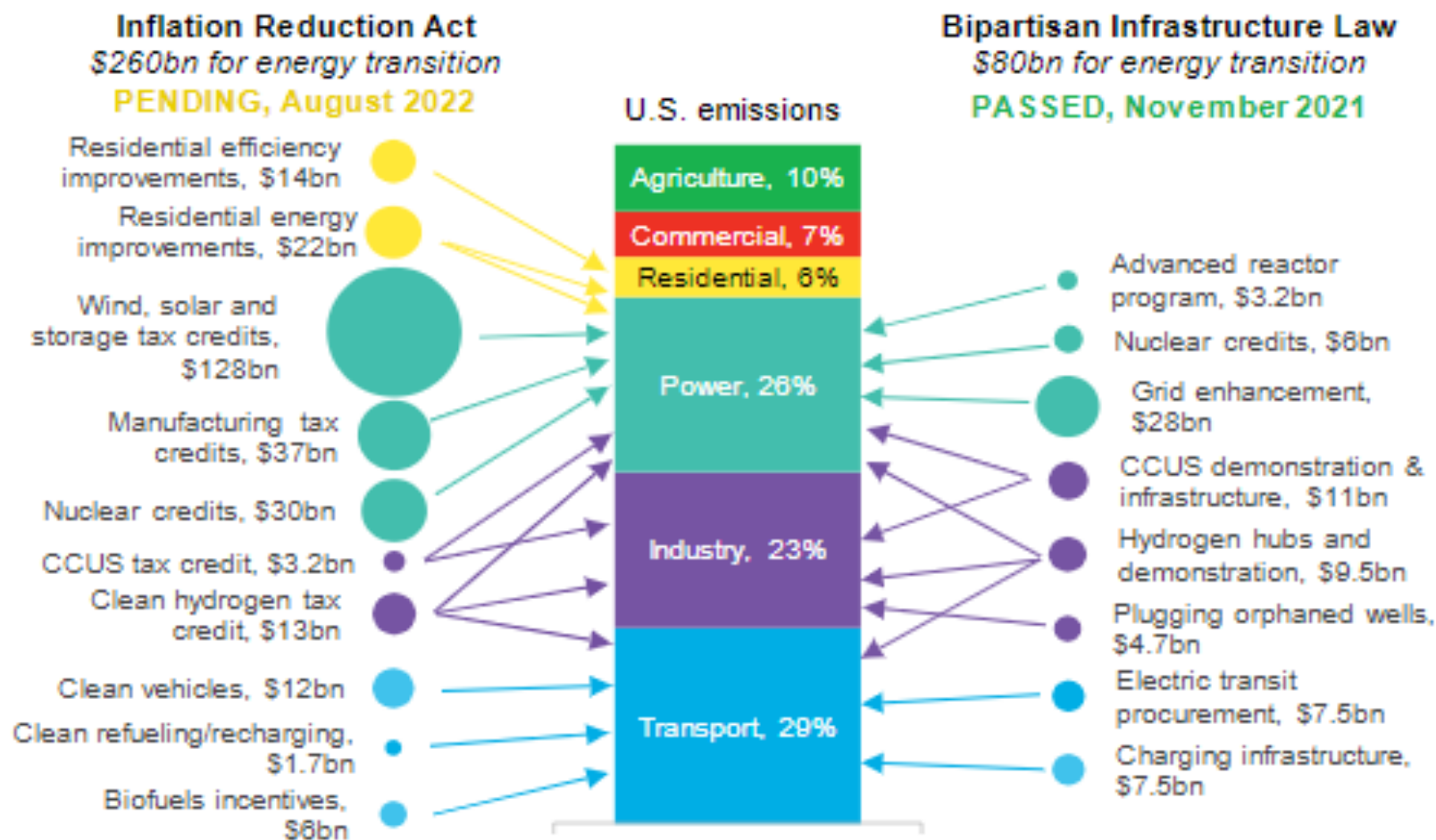**Supply disruptions matter. Expect Texas to be next.**

Matching Existing infrastructure With Energy Transition – Green H2, H2-Nat gas blending, and Renewable natural gas plus carbon sequestration and storage

Regional Hydrogen Hubs

Figure 1: Estimated 2022-31 energy transition spending in Inflation Reduction Act and Bipartisan Infrastructure Law

Inflation Reduction Act
$260bn for energy transition
PENDING, August 2022

U.S. emissions

Bipartisan Infrastructure Law
$80bn for energy transition
PASSED, November 2021

Residential efficiency improvements, $14bn

Residential energy improvements, $22bn

Wind, solar and storage tax credits, $128bn

Manufacturing tax credits, $37bn

Nuclear credits, $30bn

CCUS tax credit, $3.2bn

Clean hydrogen tax credit, $13bn

Clean vehicles, $12bn

Clean refueling/recharging, $1.7bn

Biofuels incentives, $6bn

Agriculture, 10%

Commercial, 7%

Residential, 6%

Power, 26%

Industry, 23%

Transport, 29%

Advanced reactor program, $3.2bn

Nuclear credits, $6bn

Grid enhancement, $28bn

CCUS demonstration & infrastructure, $11bn

Hydrogen hubs and demonstration, $9.5bn

Plugging orphaned wells, $4.7bn

Electric transit procurement, $7.5bn

Charging infrastructure, $7.5bn

Source: EIA, EPA, Joint Committee on Taxation, BloombergNEF. Note: Chart only captures tax credits and incentives, not grant programs or loans. Bn is billion. CCUS is carbon capture, utilization and storage.

Federal dollars targeting US energy innovation

- **REMORA – retrofit device that captures CO2 from tailpipes of diesel trucks**

- **UNIVERSAL HYDROGEN – light weight hydrogen storage capsules**

- **DOMINION – 30% Hydrogen-70% Nat Gas Blending for Intermountain power turbine plus H2 green electrolyzers and storage**

Strategies that attract traditional workers are not enough to entice other groups back to traditional employment.

Employee experience factors driving appeal for traditional and nontraditional workers, ranking

Factors	Reasons people who quit took a new traditional job[1]	Reasons nontraditionalists would return to a traditional job[2]
Career development and advancement	1	7
Adequate total compensation	2	2
Meaningful work	3	3
Workplace flexibility	4	1
Reliable and supportive people at work	5	5
Support for health and well-being	6	4
Sustainable work expectations	7	9
Caring and inspiring leaders	8	10
Inclusive and welcoming community	9	8
Geographic ties and travel demands	10	11
Safe workplace environment	11	6
Resource accessibility	12	12

[1]Respondents who quit a job anytime between Apr 2021 and Apr 2022 and took a new traditional job (n = 799).
[2]Respondents who would consider returning to a traditional job (n = 1,963).
Source: Subset of respondents from McKinsey's 2022 Great Attrition, Great Attraction 2.0 global survey (n = 13,382)

McKinsey & Company

With innovation comes different workforce requirements

- **Mission Driven**
- **Work-Life Balance**
- **Inspiring, visible leadership**
- **Room for Advancement**