Renewables, Hydrocarbons, & The Future Of The US Electric Grid

Robert Bryce presentation to:

Florida Municipal Electric Association

Ponte Vedra Beach, FL

24 July 2025

Florida Power By The Numbers

- **Nat gas generation provides *75% of the state's electricity***
- **FL is fifth-largest nat gas consumer in US**
- **Second-largest electricity user after TX**
- **In-state gas production is tiny (3.5 Bcf/yr, 0.01% of US)**
- **54% of electricity is used in homes, largest share in US**
- **Ranks #29 in residential price ($0.15/kWh)**

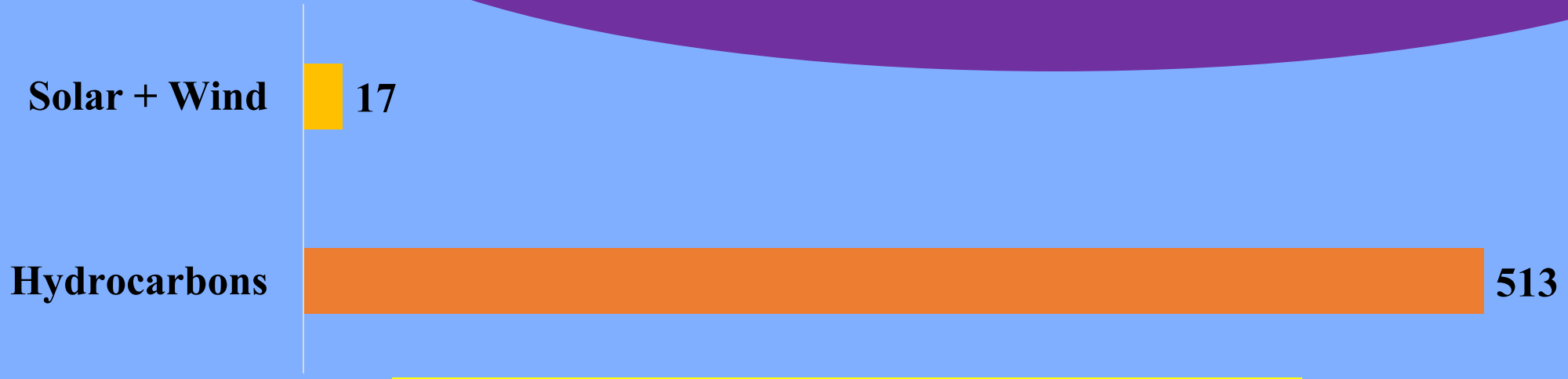
Source: EIA, https://www.eia.gov/state/print.php?sid=FL , https://www.eia.gov/state/rankings/?sid=US#/series/31 , https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php

Five Points:

- What energy transition?
- Land-use conflicts are raging
- Inflation + AI + surging electricity demand
- N2N: Nat gas to nuclear
- Florida's fuel-supply vulnerability

Where's That Energy Transition?

Global hydrocarbon use is 30x larger than *solar + wind combined.* And in 2024, hydrocarbon consumption grew 2.7x faster than solar + wind combined (8 EJ vs 3 EJ)



Global primary energy use, in EJ, 2024

Source: Statistical Review of World Energy 2025

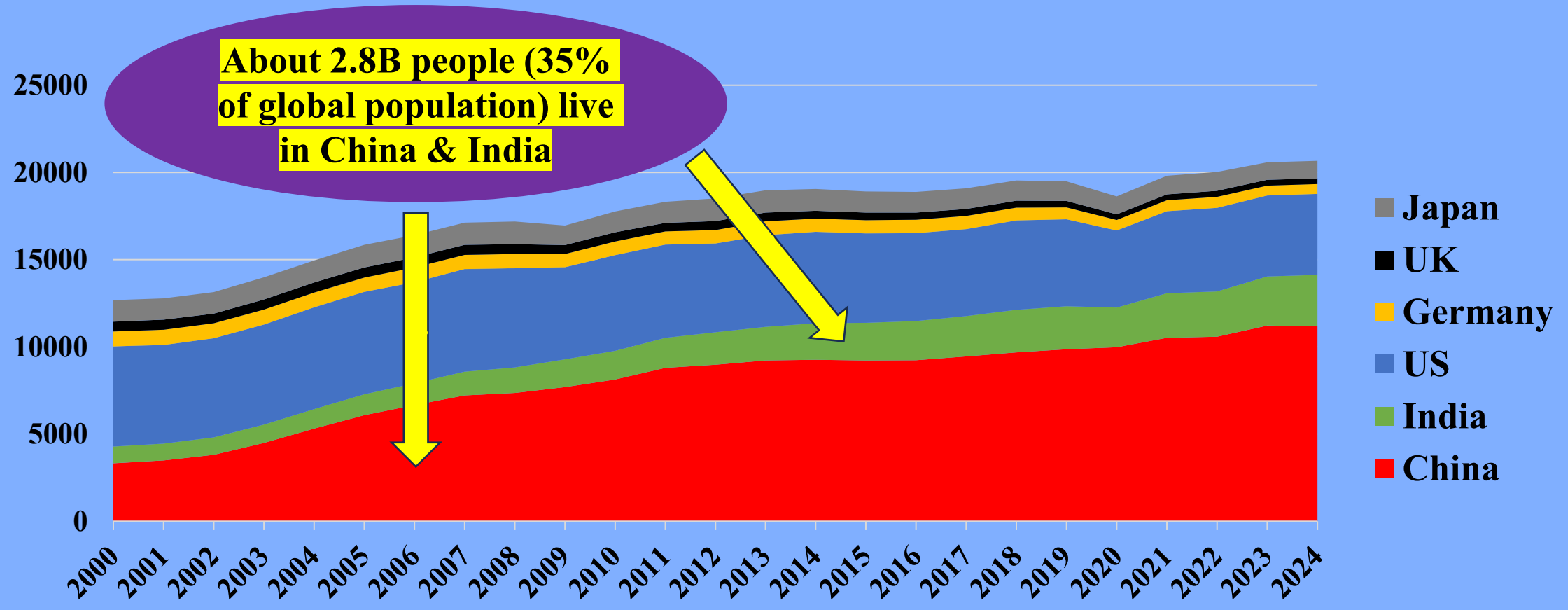
In 2024, Global Gas Use Grew 1.3x Faster Than Solar + Wind Combined. Hydrocarbons Grew 2.7x Faster

Change in global primary energy use, in EJ, 2024

Source: Statistical Review of World Energy 2025

China & India Are The Emissions Story

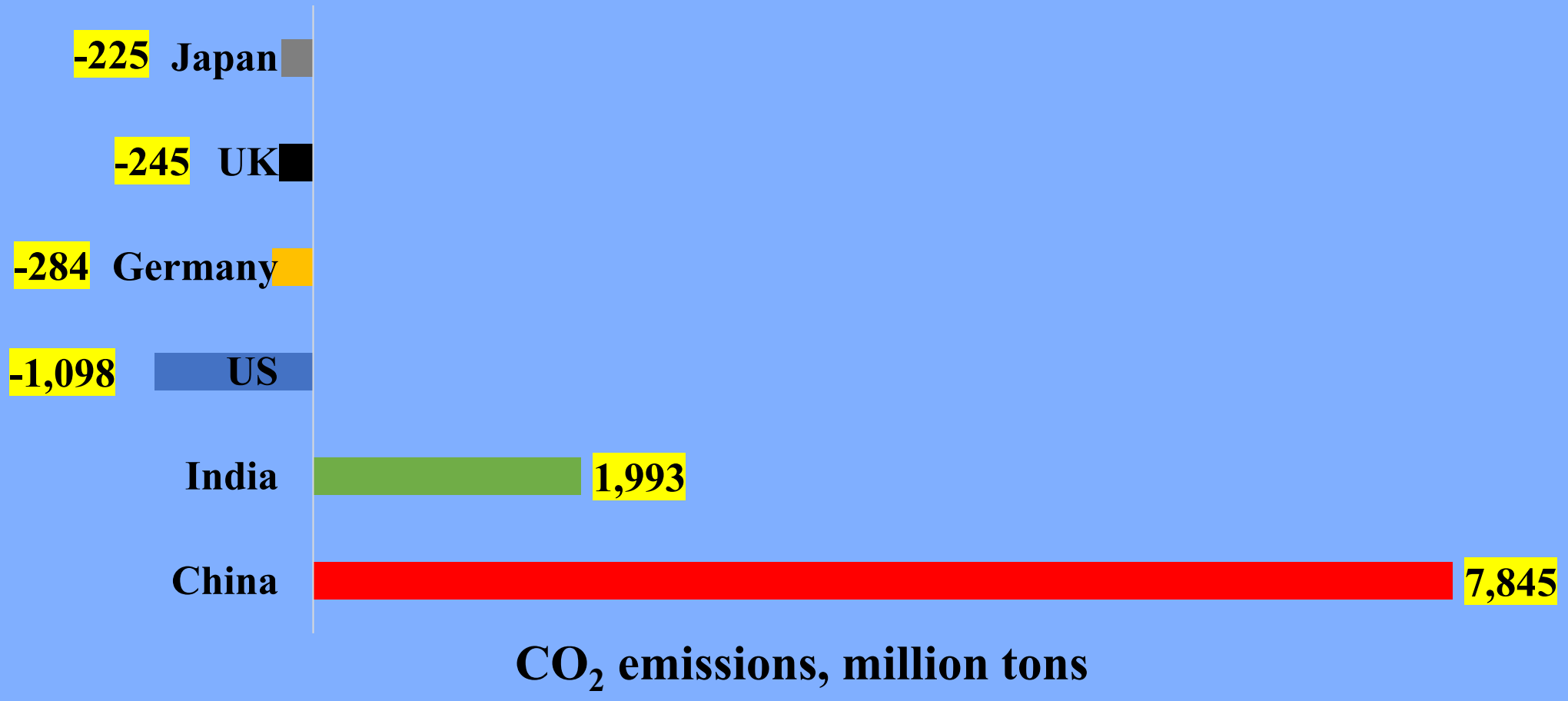
CO_2 Emissions In Six Largest Economies



Million tons per year, 2000 tp 2024

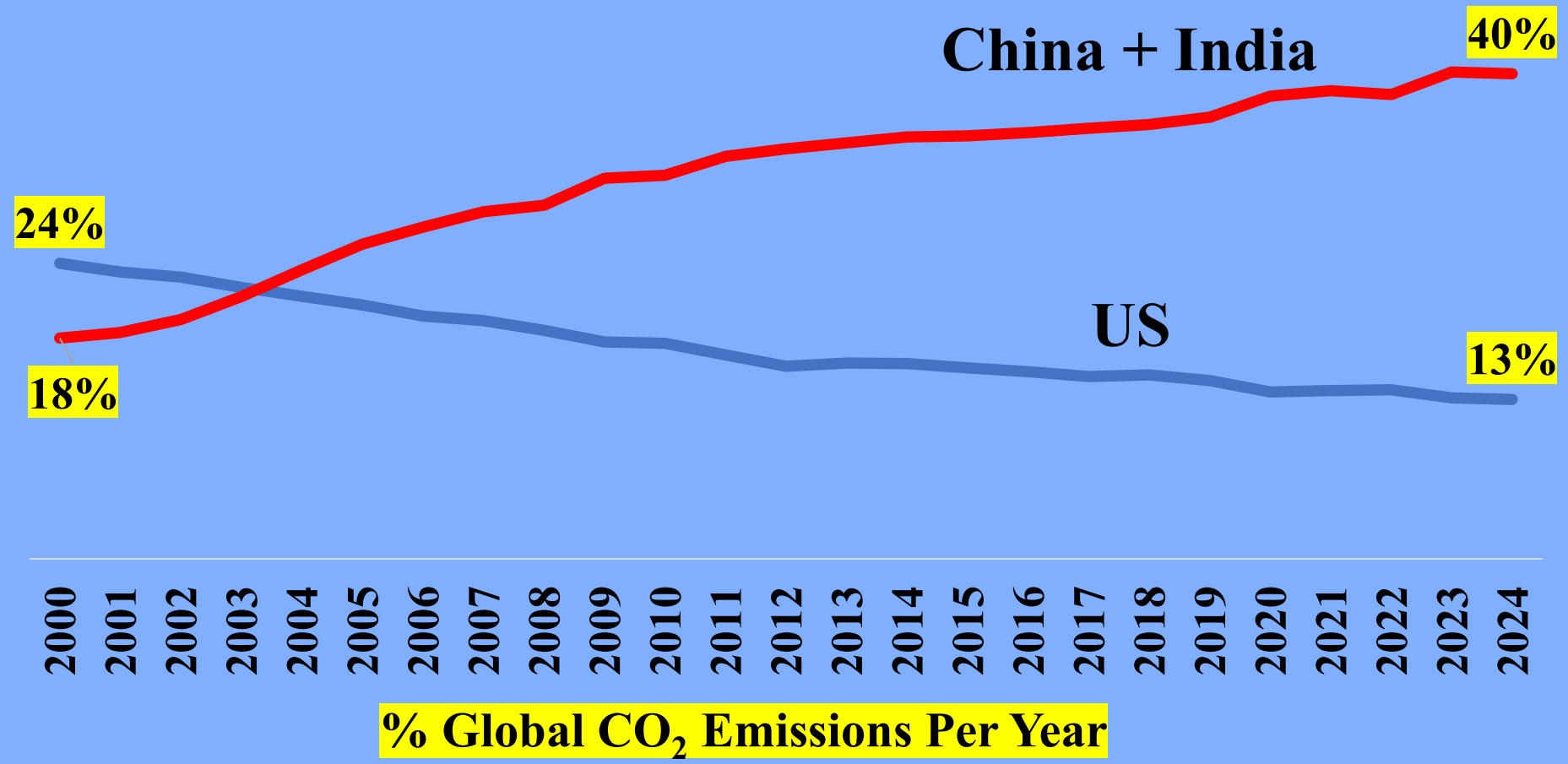
Source: Statistical Review of World Energy 2025

Change In CO_2 Emissions In The Six Largest Economies, 2000 to 2024



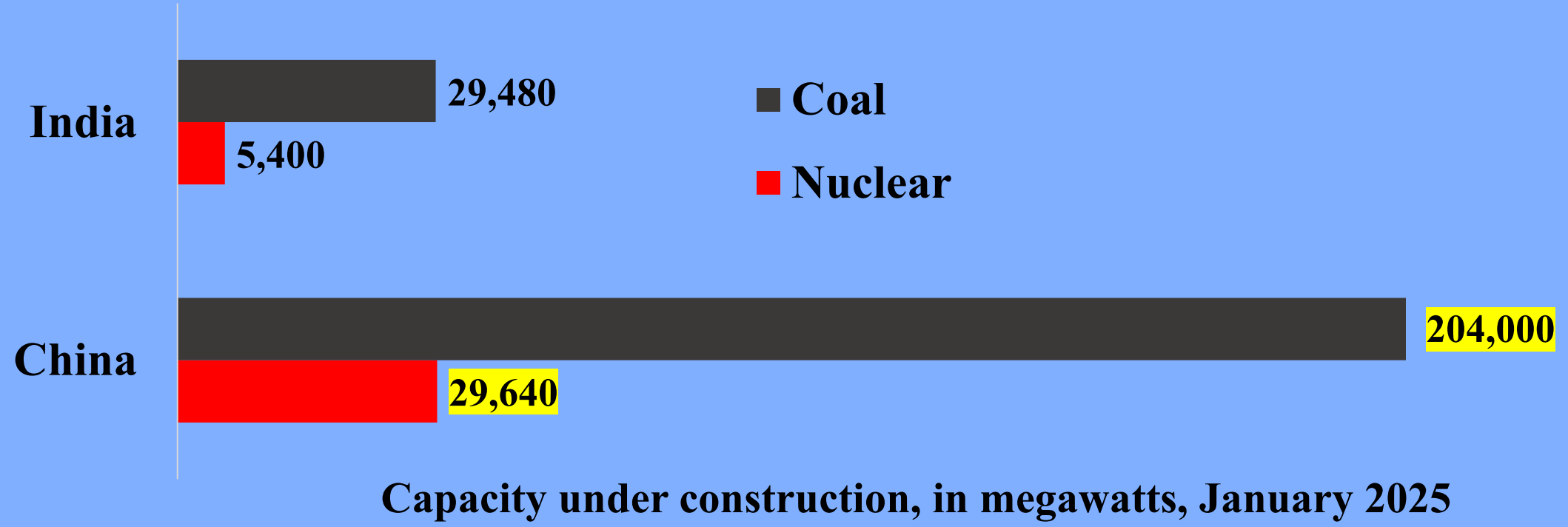
Source: Statistical Review of World Energy 2024

Share Of Global CO_2 Emissions, US v. China + India, 2000 to 2024



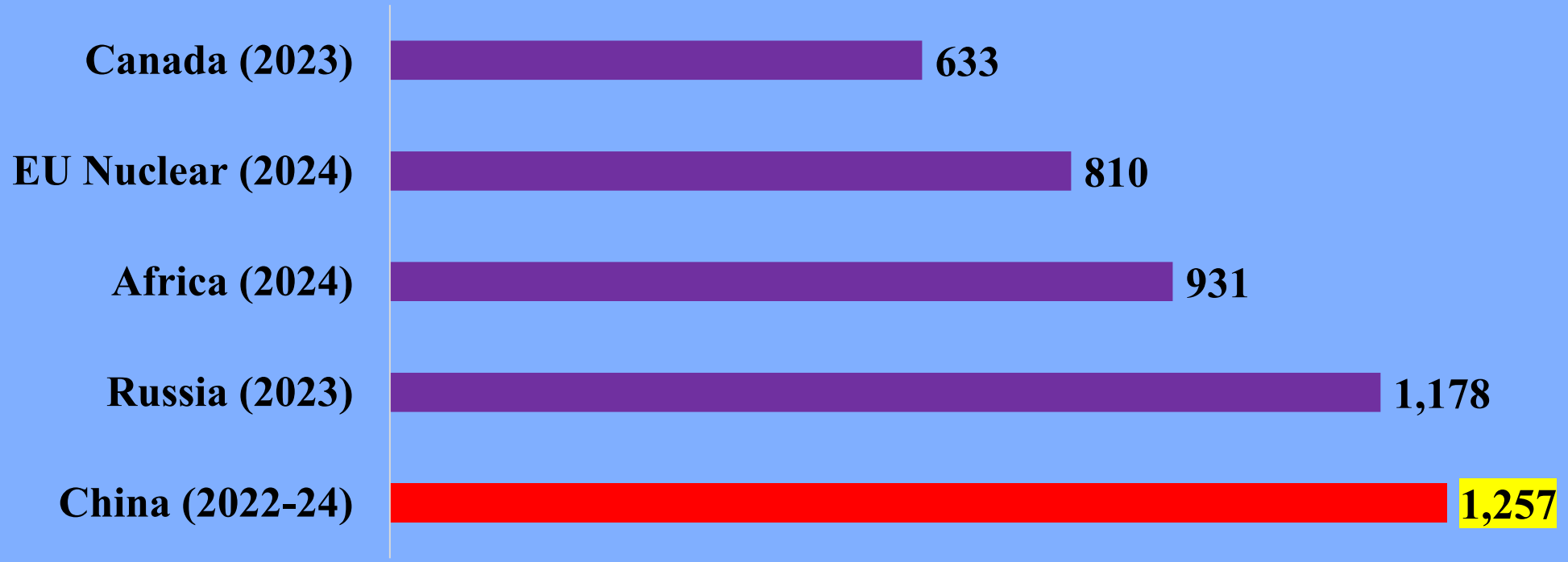
Source: Statistical Review of World Energy, 2025

>50% Of New Nuclear Capacity Is Being Built In China & India, But Their Coal-Fired Capacity Is Growing >5x Faster



Sources: IAEA, https://pris.iaea.org/pris/worldstatistics/underconstructionreactorsbycountry.aspx
Global Energy Monitor, https://docs.google.com/spreadsheets/d/1_6AkrRZOn3ZXhSV9O6tZnX-m7aJsfG9HiQ_iEqBkbW8/edit?gid=1228809590#gid=1228809590
https://docs.google.com/spreadsheets/d/1sHBsK_Ez7C9XA4HKRQSvopO4IvGSLz65jxdG0GQXeVk/edit?gid=1236850196#gid=1236850196

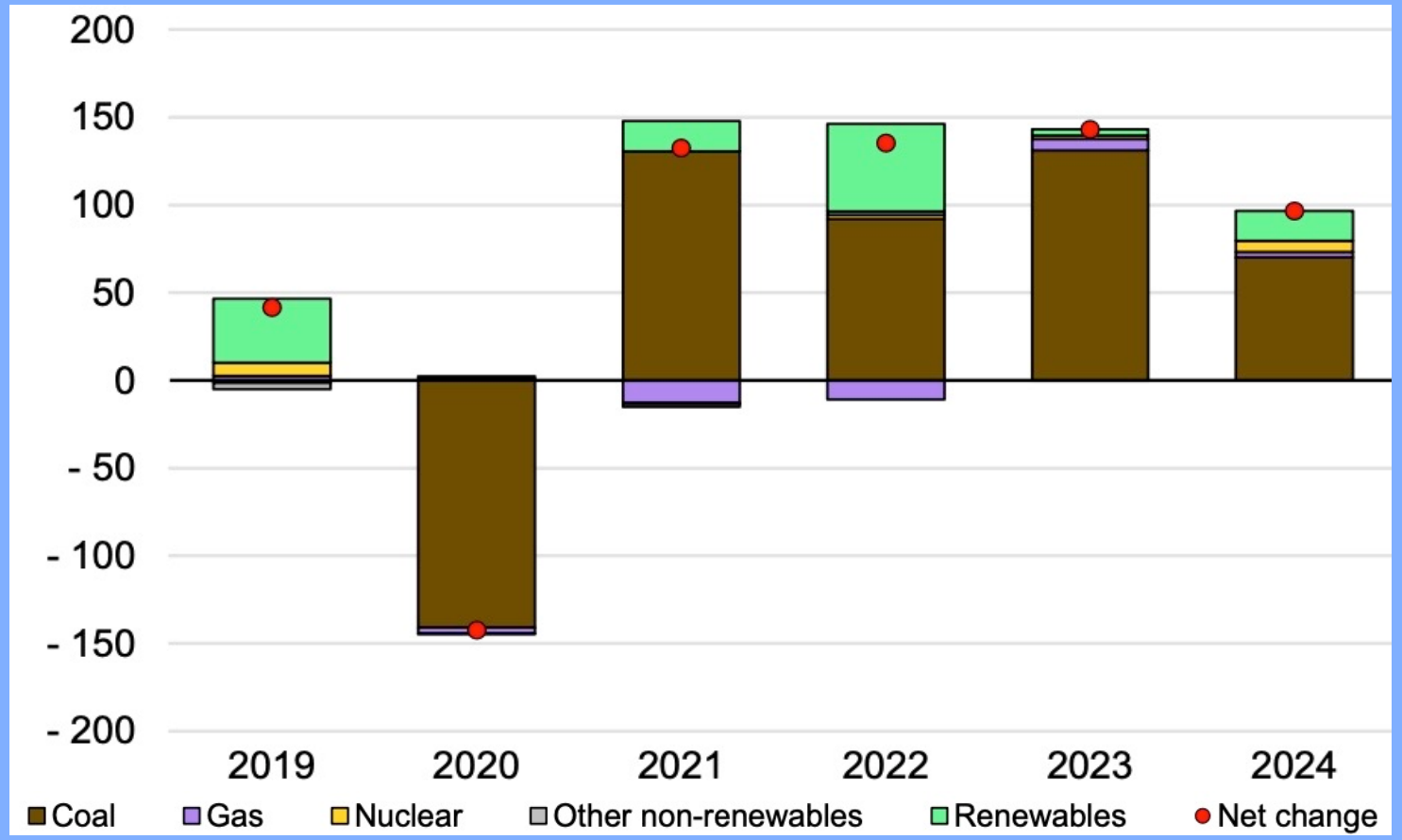
China's Electricity Demand Growth Is Gobsmacking



Growth in China's electricity generation from 2022 to 2024, compared to other countries/regions, in TWh

Source: IEA Electricity 2025, https://www.iea.org/reports/electricity-2025

India's Coal-Fired Generation Is Surging



Change in electricity generation by source, TWh, 2019 to 2024

Electricity demand in India increased by 5.8% in 2024... Coal-based generation remains the backbone of India's electricity mix, accounting for 74% of the total share in 2024...The government plans for a minimum of 80 GW of new capacity to come from coal-based power plants by 2030.

— IEA, Electricity 2025, Feb. 14, 2025

Source: IEA, Electricity 2025, https://www.iea.org/reports/electricity-2025

Big Wind: Friction From Nebraska To Norway

MidAmerican Energy Abandons Plan To Add 30 Wind Turbines, Madison County Residents Celebrate: 'How Awesome'

Cherokee County panel adopts 1-year wind farm moratorium

Reno Commission approves moratorium on wind, to consider development ban in zoned areas

Moonlight Range Wind Farm project axed by Queensland government

San Bernardino County bans large-scale solar, wind in some areas

4 Druze seriously injured, 12 cops hurt in massive riots against Golan wind farm

Gage County extends ban on new wind or solar permits, through mid-July

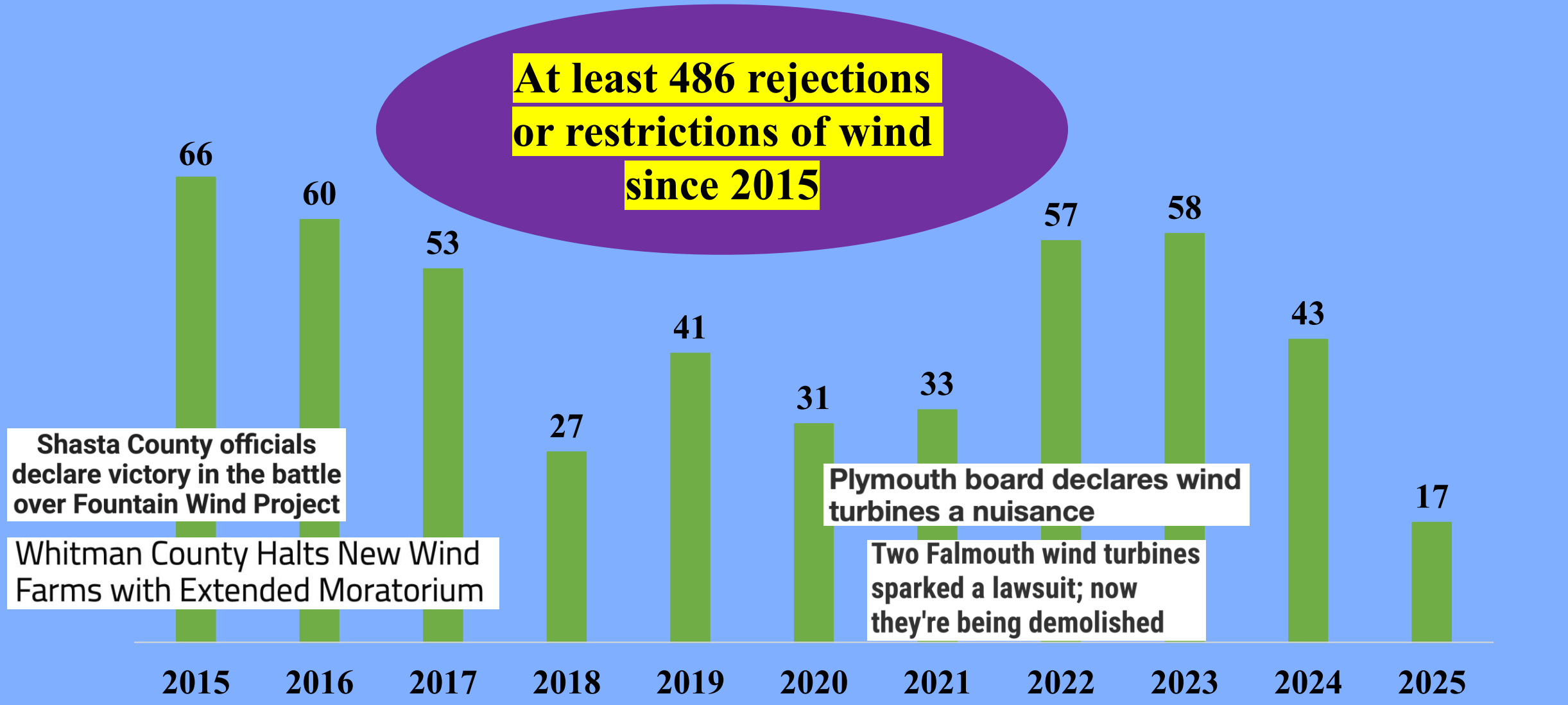
County planning and zoning commission to consider potential wind energy regulation changes

Wednesday, January 13th 2021, 12:50 PM CST

Norwegian wind farms violate rights of Sámi reindeer herders, says court

Source: Media outlets

US Wind Energy Rejections, 2015 To 2025



Source: Renewable Rejection Database

Enel Must Remove 84 Wind Turbines In Osage County At Cost Of $300 Million

The Osage Nation won permanent injunctive relief and "ejectment of the wind turbine farm for continuing trespass."

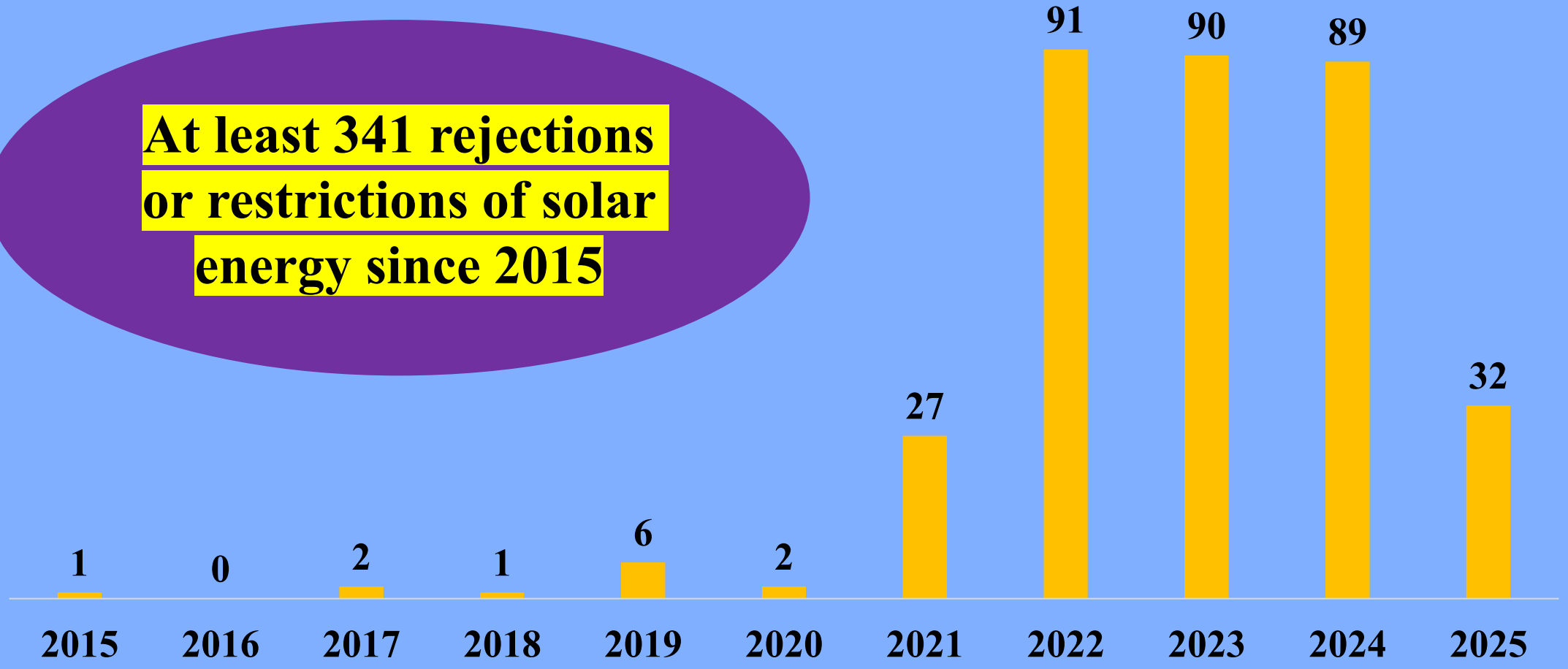
Enel's "refusal to obtain a lease constitutes interference with the sovereignty of the Osage Nation and is sufficient to constitute irreparable injury."

— Federal Judge Jennifer Choe-Graves, December 20, 2023

Source: Robertbryce.substack.com

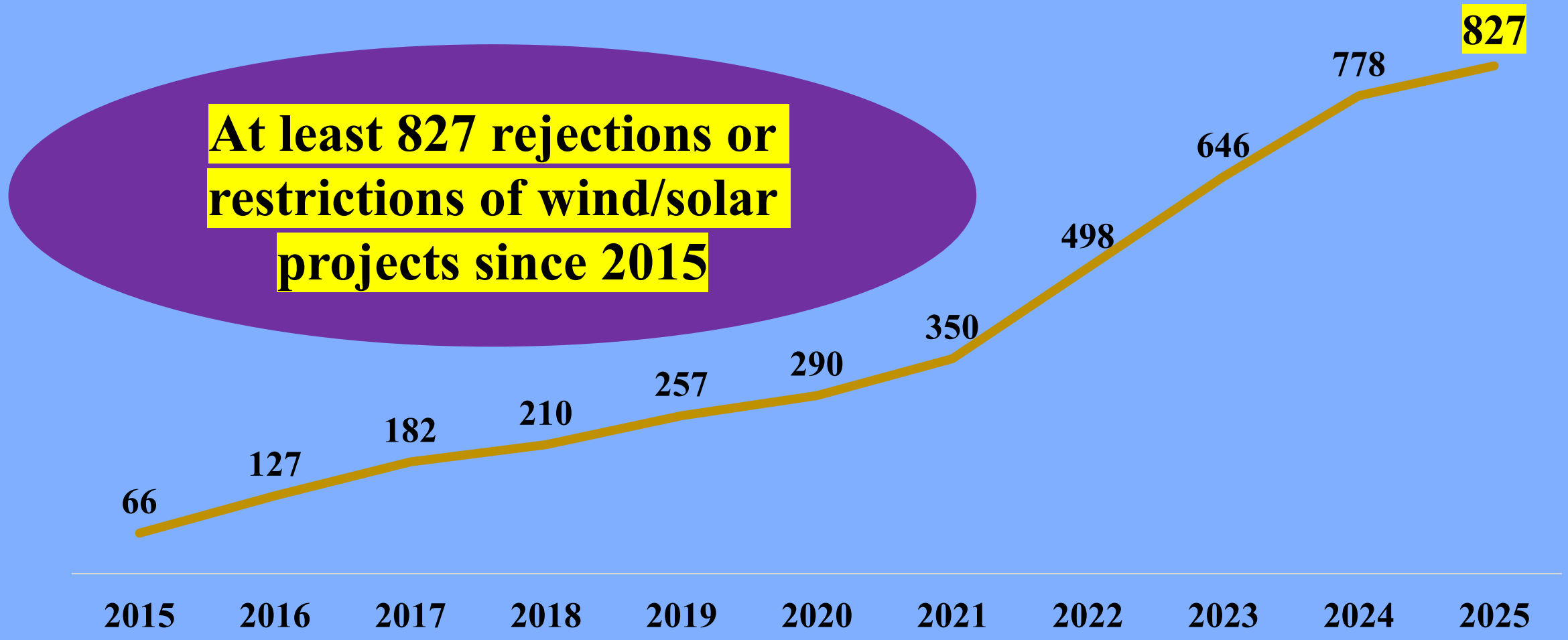
US Solar Energy Rejections, 2015 To 2025

At least 341 rejections or restrictions of solar energy since 2015



Source: Renewable Rejection Database

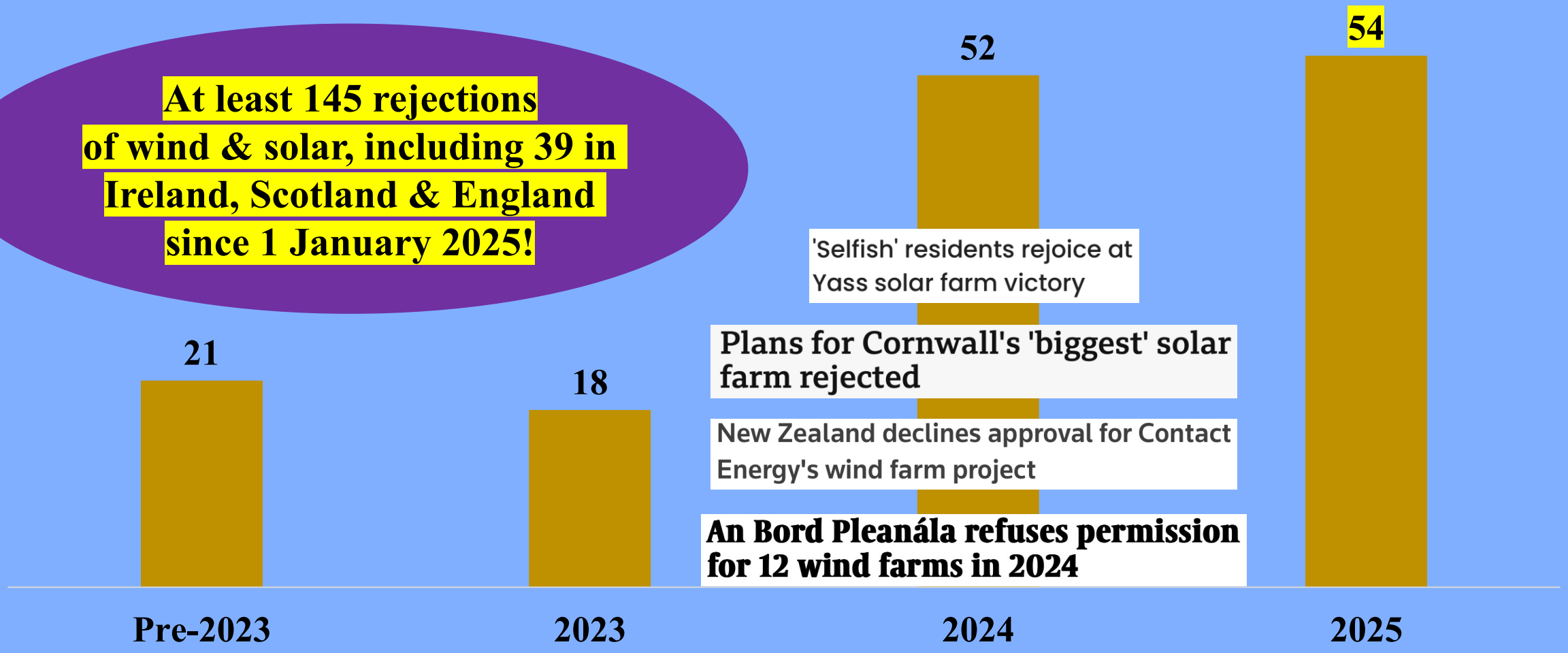
Cumulative US Wind & Solar Rejections, 2015 To 2025



Source: Renewable Rejection Database

Global Wind & Solar Rejections, Pre-2023 to 2025

At least 145 rejections of wind & solar, including 39 in Ireland, Scotland & England since 1 January 2025!



Source: Global Renewable Rejection Database

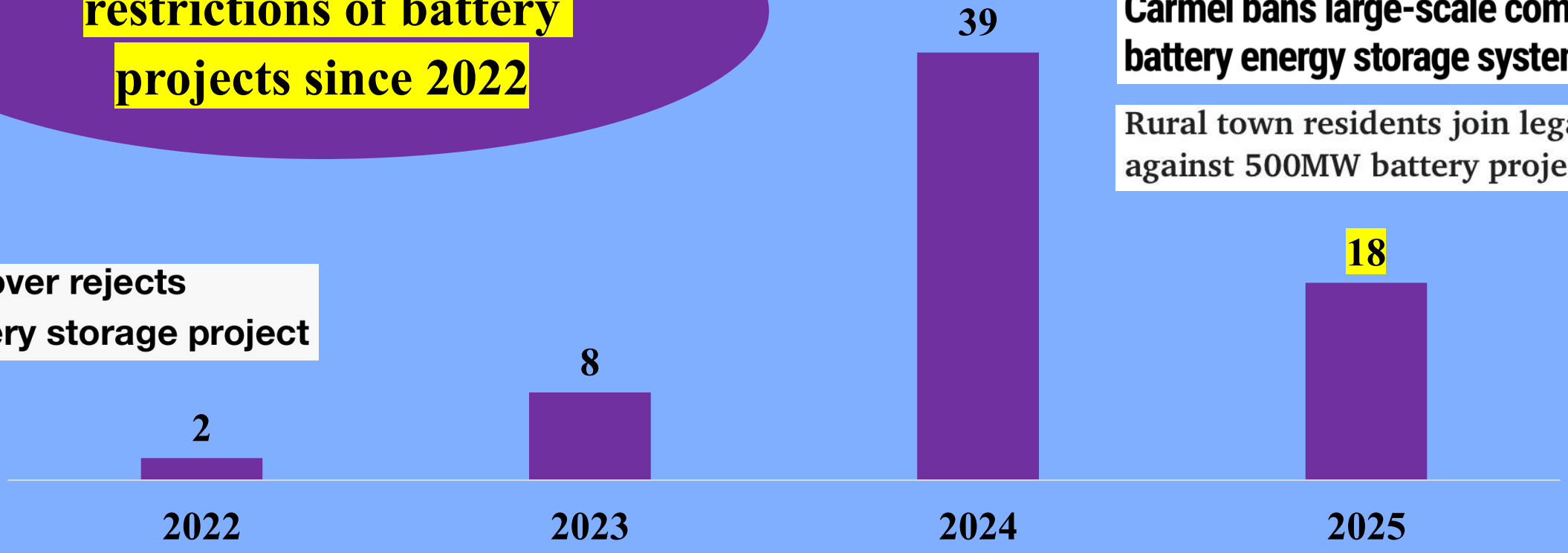
Global Battery Rejections, 2022 To 2025

At least 67 rejections or restrictions of battery projects since 2022

Carmel bans large-scale commercial battery energy storage systems

Rural town residents join legal battle against 500MW battery project

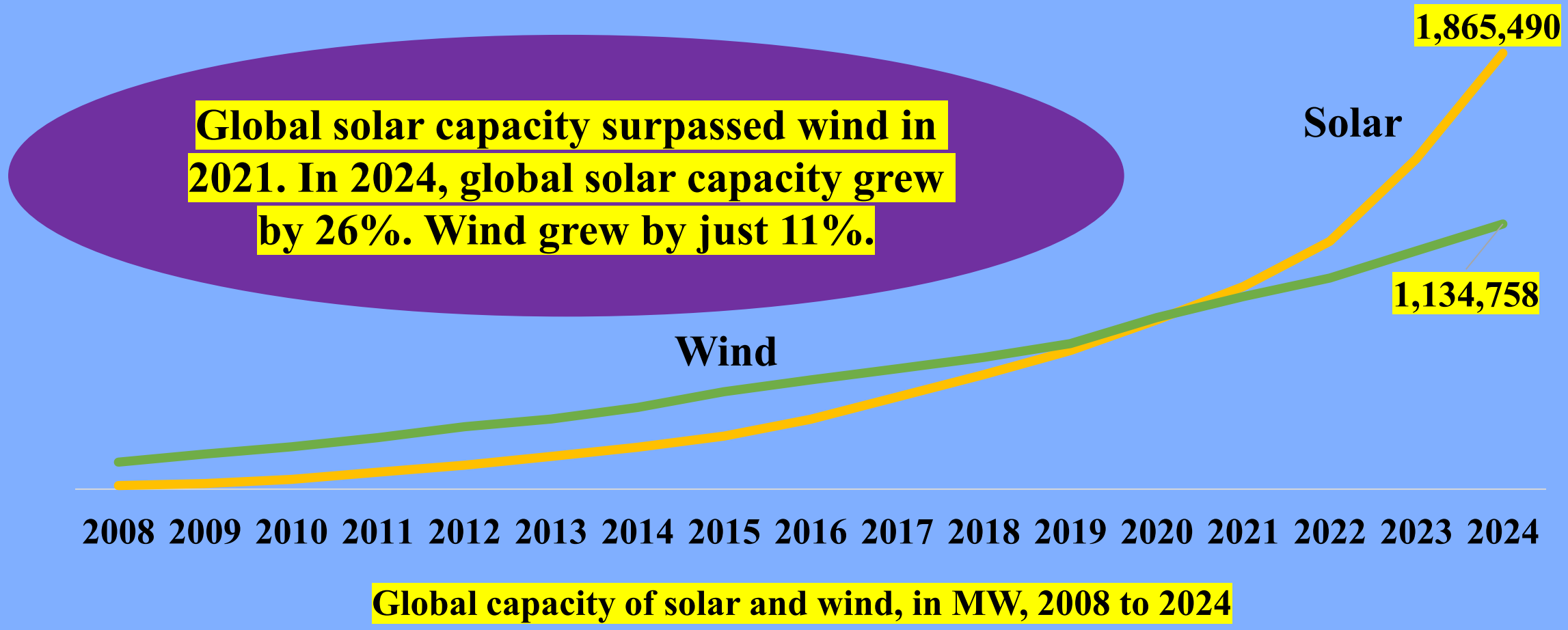
Hanover rejects battery storage project



Rejections or restrictions per year

Source: Global Battery Rejection Database

Globally, Solar Capacity Is Leaving Big Wind In The Shade

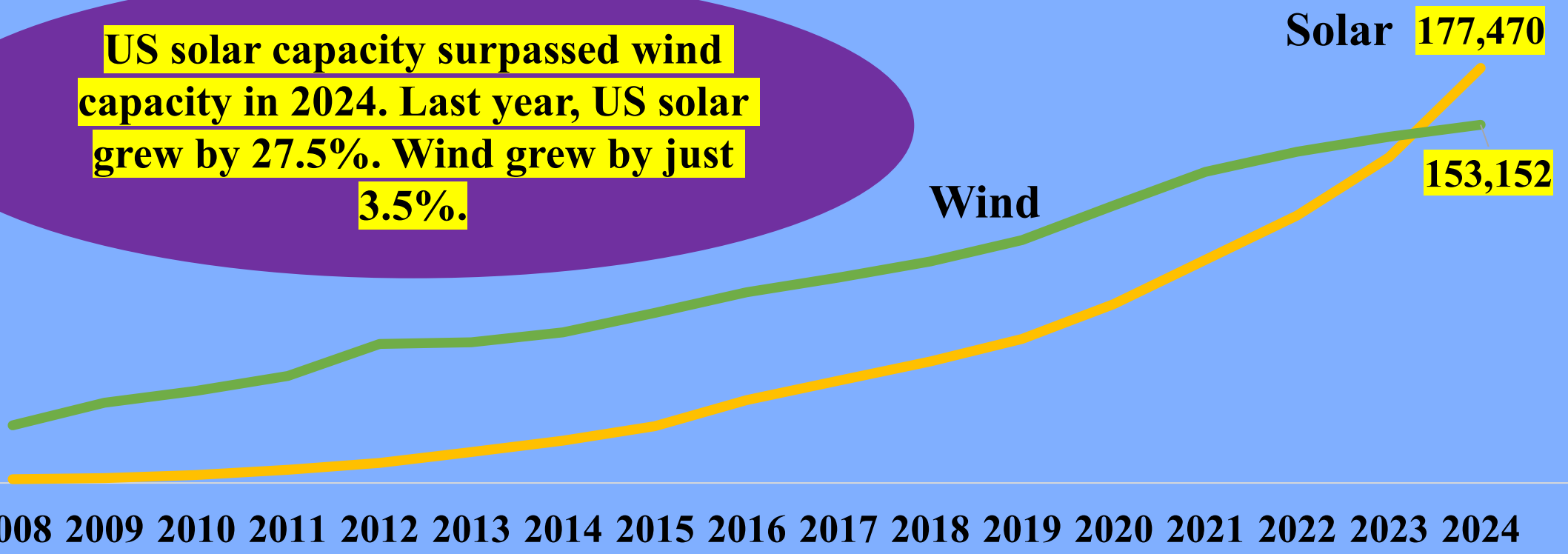


Global capacity of solar and wind, in MW, 2008 to 2024

Source: Statistical Review of World Energy 2025

The Same Thing Is Happening Here In The US

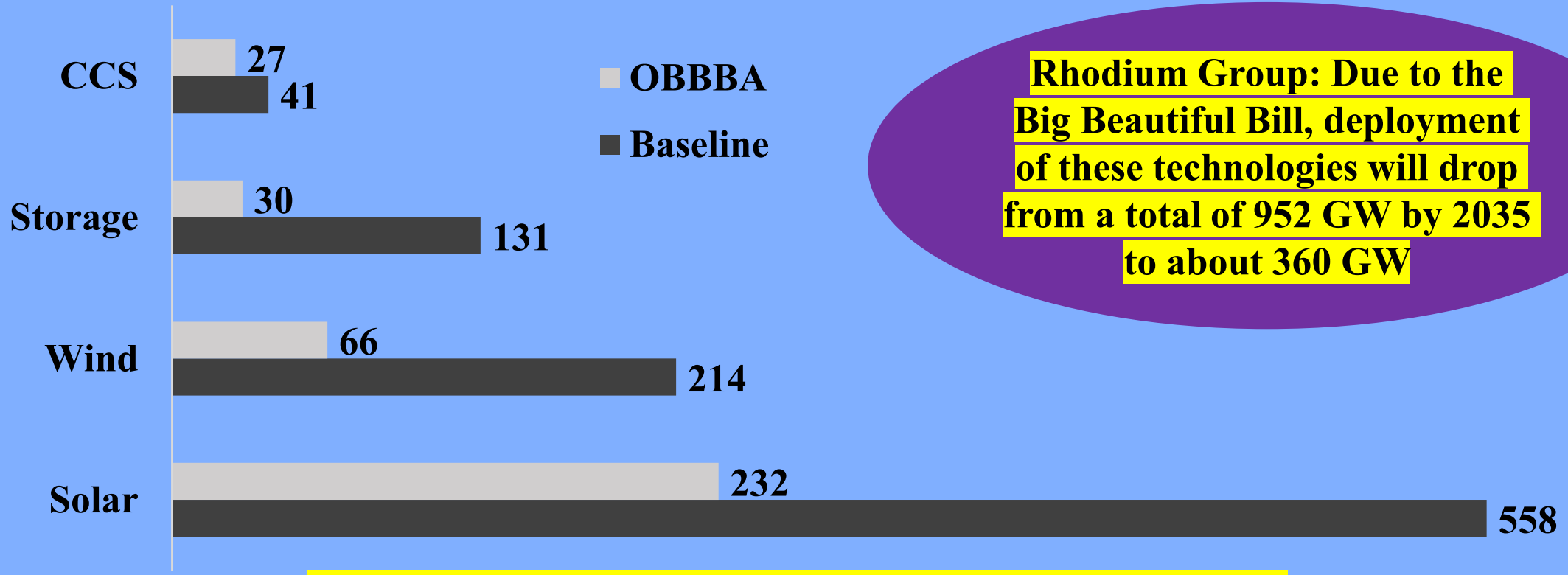
US solar capacity surpassed wind capacity in 2024. Last year, US solar grew by 27.5%. Wind grew by just 3.5%.



US capacity of solar and wind, in MW, 2008 to 2024

Source: Statistical Review of World Energy 2025

What Will The OBBBA Mean For Solar, Wind, & Storage?



Rhodium Group: Due to the Big Beautiful Bill, deployment of these technologies will drop from a total of 952 GW by 2035 to about 360 GW

Cumulative new additions to the grid, in GW, 2025 to 2035

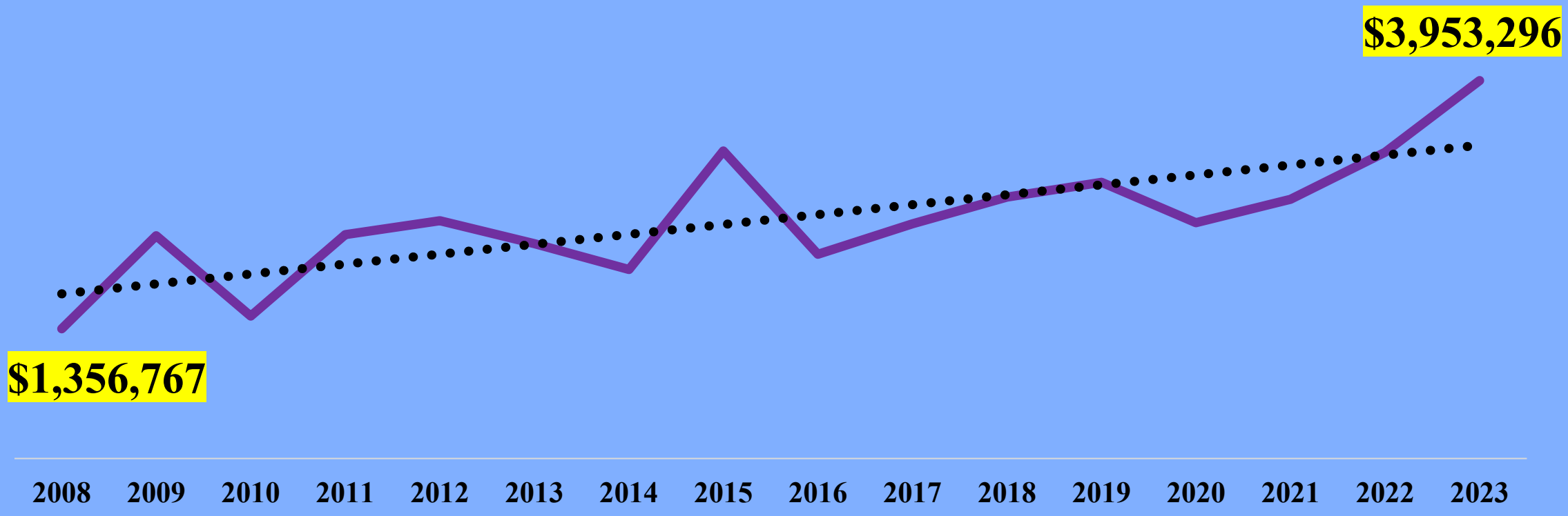
Source: Rhodium Group, (mid emissions scenario) https://tinyurl.com/3rnabam7

Inflation Is Surging Across Energy & Power Supply Chains. Long Wait Times For Key Components Are Common

- **Wait times for large gas turbines: 4 years**
- **Price increases over past 2 years: 50 to 75%**
- **Wait for high-power transformers: 4 to 5 years**
- **Lead times for equipment increase with voltage**
- **"If we had the parts, we don't have the people. And if we had the people, we don't have the parts."**

Source: EIA https://www.eia.gov/todayinenergy/detail.php?id=61483#:~:text=Last%20year%20marks%20the%20third,Bcf%2Fd)%20in%202023.

Between 2008 & 2023, Per-Mile Cost Of New HV Transmission Tripled



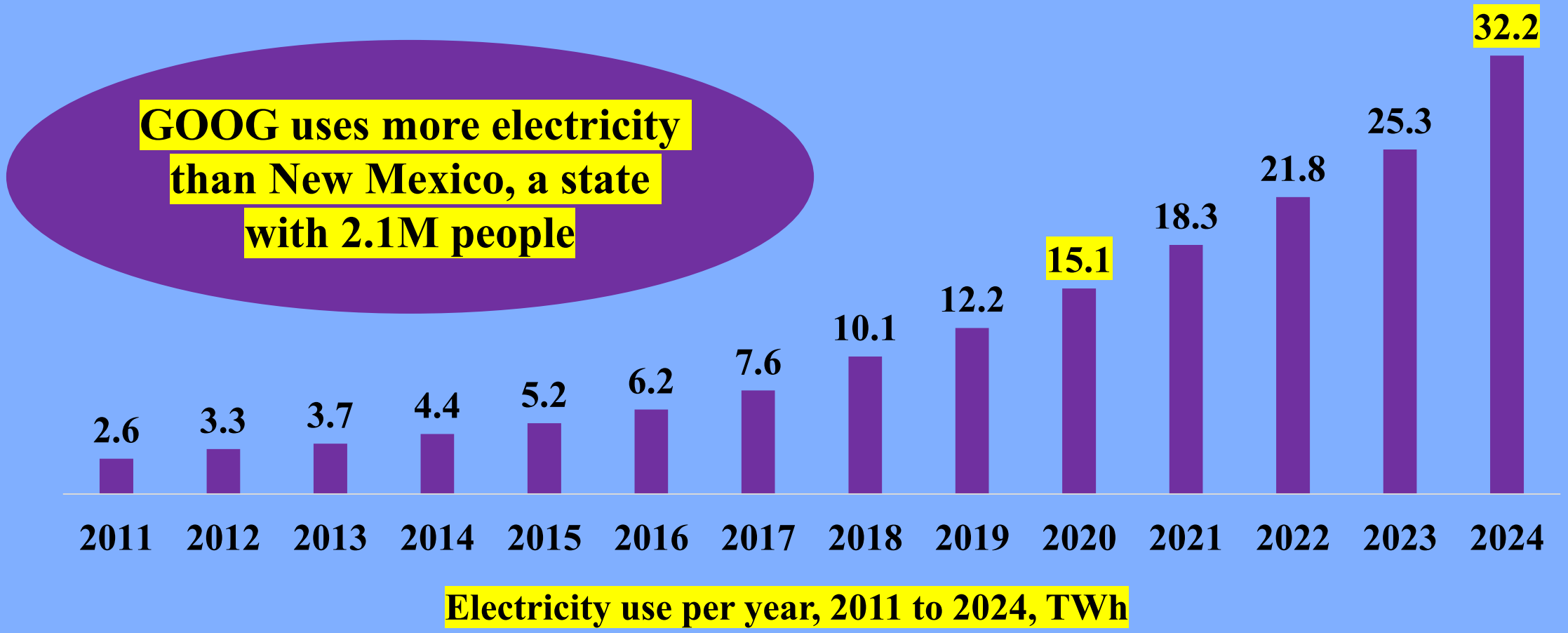
Cost per mile, 230 kV and above, per year

Source: C Three Group

What About AI? How Much Power? How Much Gas?

- **S&P Global: By 2040, "electricity demand in the US is expected to grow by 35-50% driven by a combination of underlying economic growth, large industrial loads like datacenters and manufacturing."**
- **"The next five years pose a major risk of supply and demand imbalance."**
- **"Natural gas-fired capacity and other firm resources like batteries will be critical to provide capacity and balancing support."**
- **"The ability of renewables and batteries to respond to new demand growth is constrained by siting and permitting barriers."**

Since 2020, GOOG's Electricity Has Doubled & It Will Continue Rising Due To AI



Source: https://www.gstatic.com/gumdrop/sustainability/google-2024-environmental-report.pdf , https://www.gstatic.com/gumdrop/sustainability/google-2019-environmental-report.pdf, https://www.gstatic.com/gumdrop/sustainability/google-2025-environmental-report.pdf

AI Will Be Fueled By Natural Gas

Williams Inks $1.6B Deal to Provide Natural Gas & Power Infrastructure

Why Gas Pipelines Are the Unsung Heroes of AI Data Center Expansion

Entergy Louisiana Eyes 2.2 GW of New Gas-Fired Generation to Support Data Center Demand

Requests to connect to ~70 data centers in 12 states

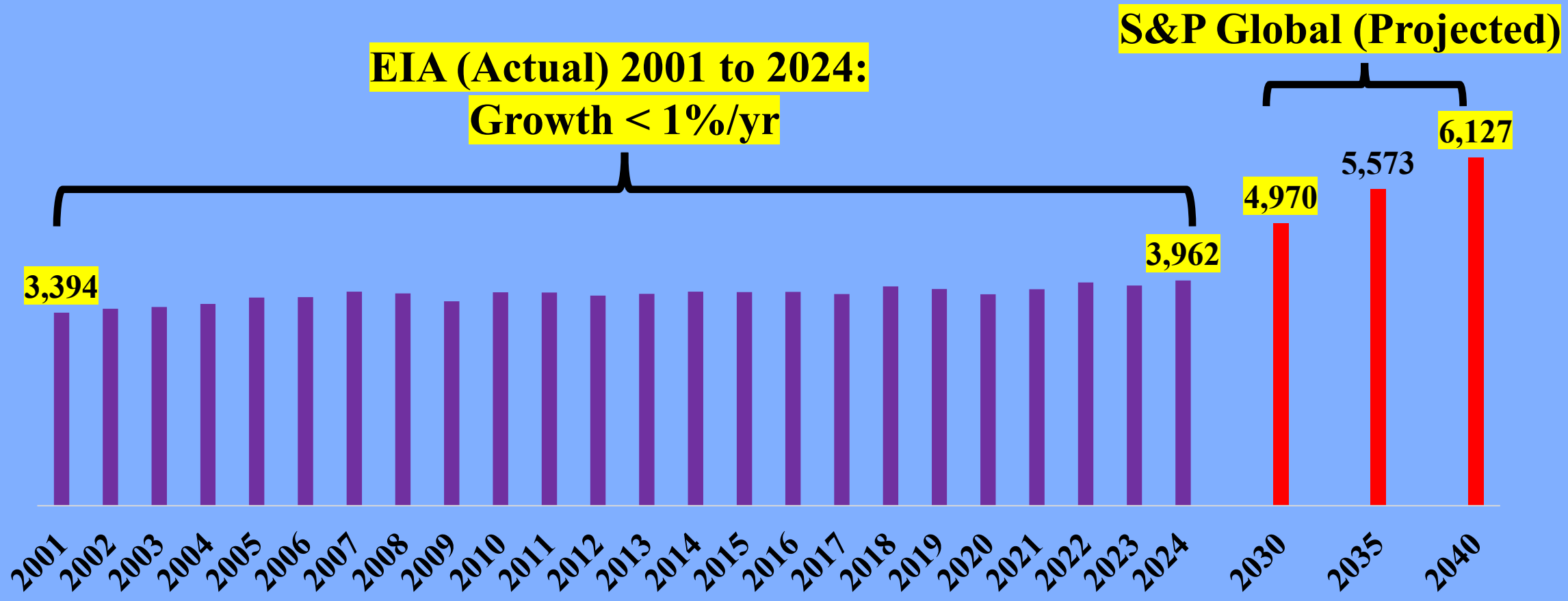
Kinder Morgan foresees big boost to natural gas demand from AI operations

Requests to connect to ~200 data centers in 14 states across our footprint

HYPERSCALE

Crusoe Adds 4.5 GW Natural Gas to Fuel AI, Expands Abilene Data Center to 1.2 GW

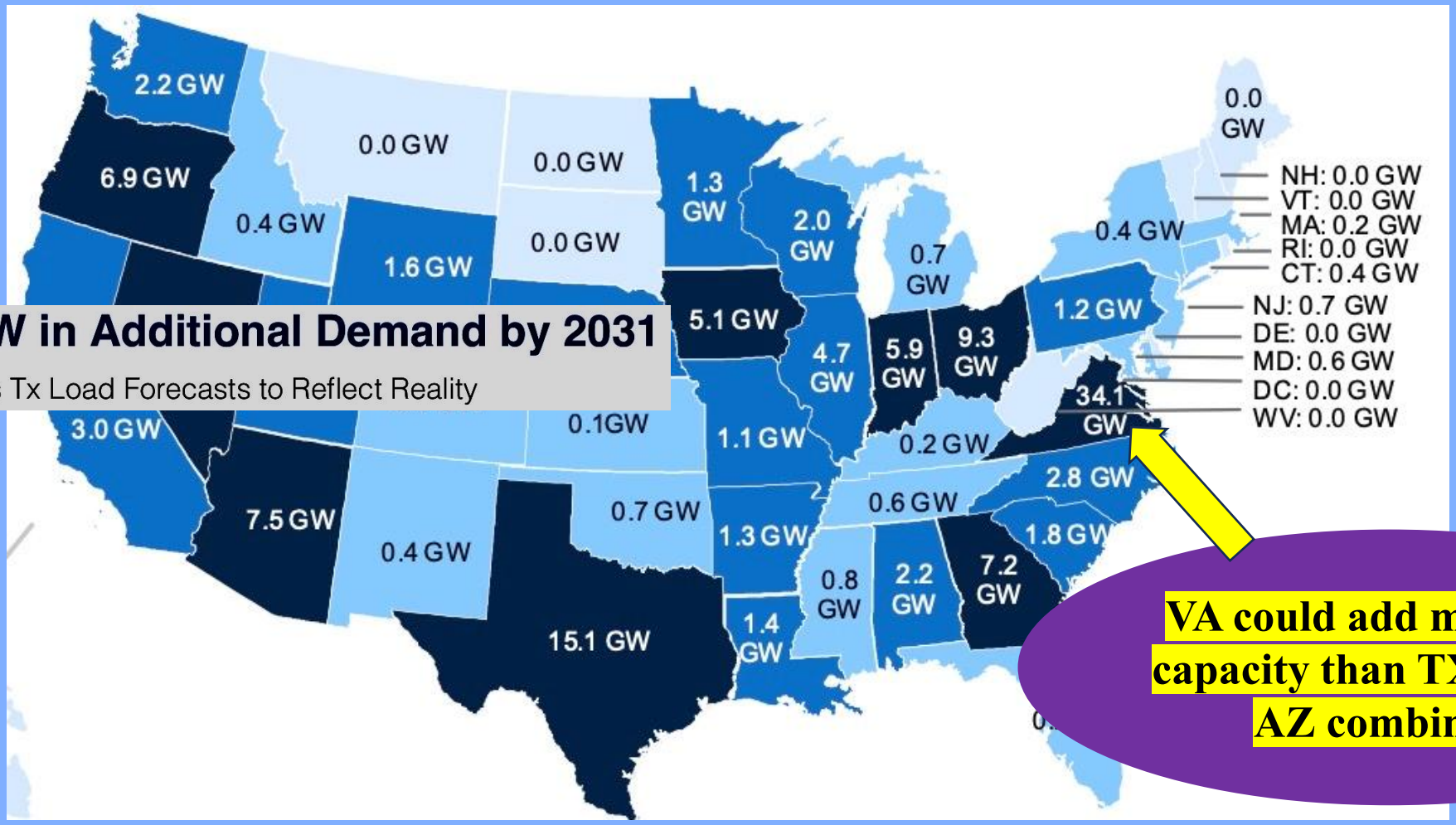
S&P Global: US Electricity Use Will Jump 25% By 2030 & 50% By 2040!



Electricity sales 2001 to 2024, in TWh, and projected to 2040

Source: EIA , https://cleanpower.org/wp-content/uploads/gateway/2025/03/US_National_Power_Demand_Study_2025_ExecSummary.pdf and S&P Global, https://cleanpower.org/wp-content/uploads/gateway/2025/03/US_National_Power_Demand_Study_2025_ExecSummary.pdf

Data Center Growth Will Be Concentrated In VA, TX, OH, AZ, GA, OR, & IN



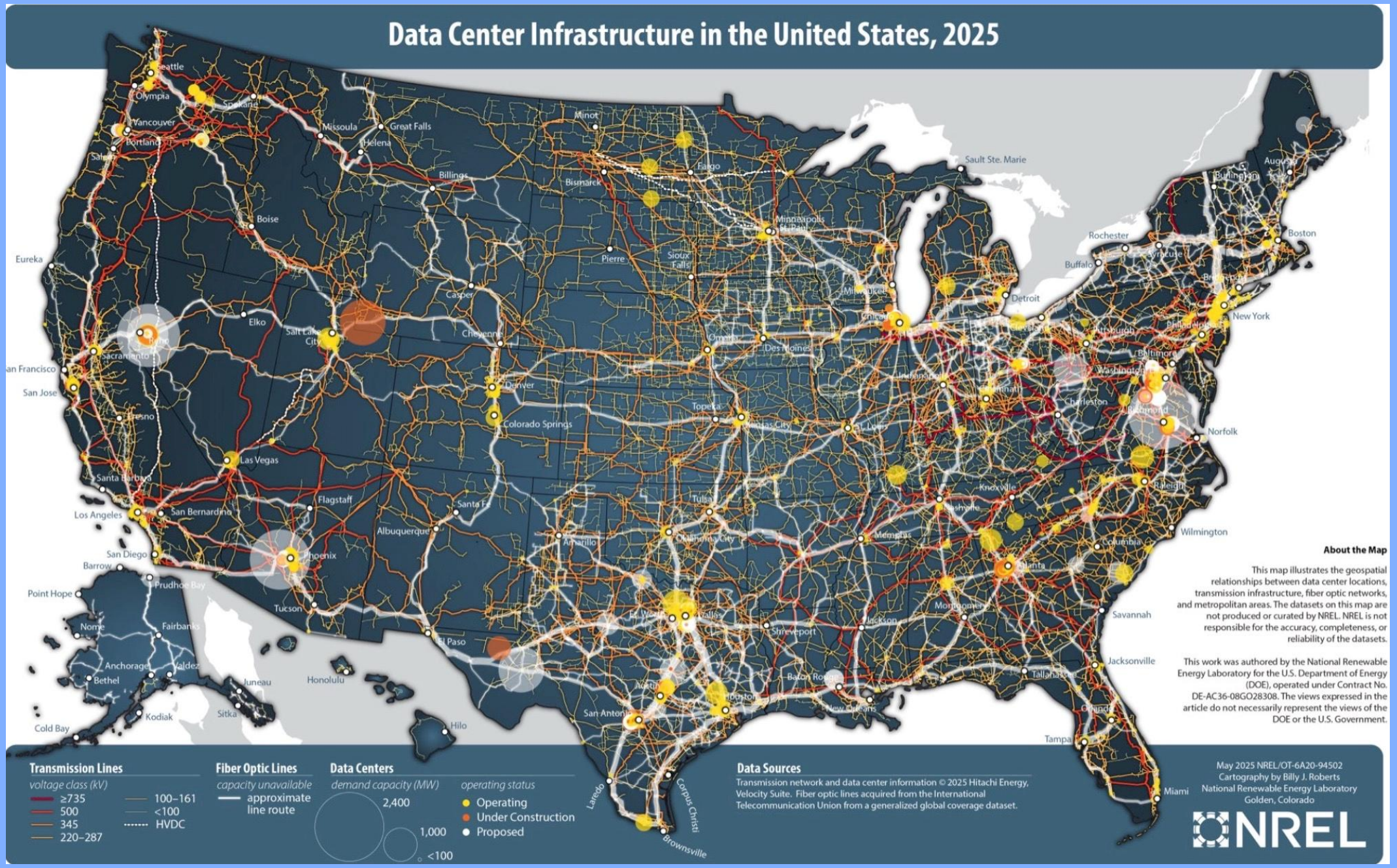
ERCOT: 60 GW in Additional Demand by 2031

Grid Operator Adjusts Tx Load Forecasts to Reflect Reality

VA could add more new capacity than TX, OH, & AZ combined!

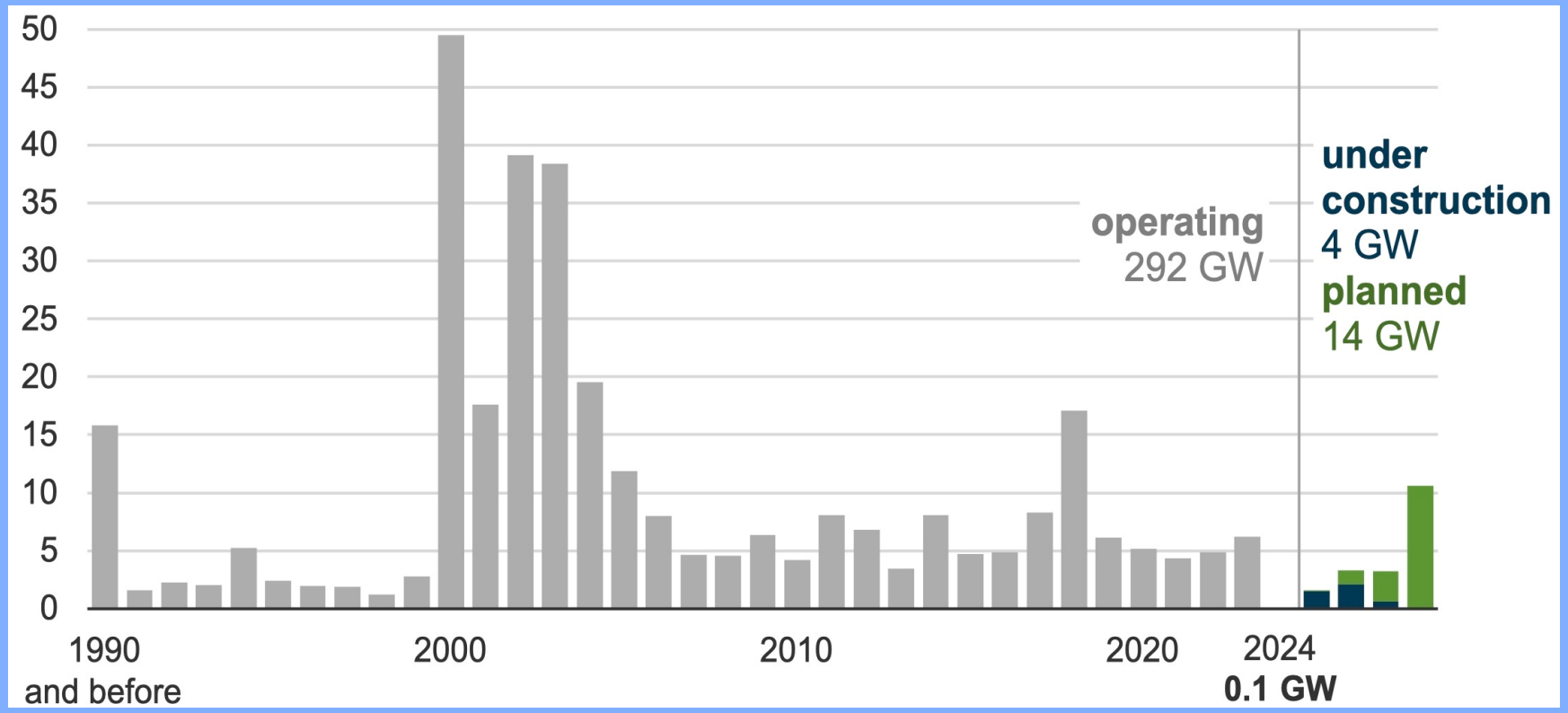
New data center capacity expected by 2030

Source: Boston Consulting Group, Datacenter Hawk



Source: NREL, https://www.nrel.gov/docs/gen/fy25/94502.jpg

More Gas-Fired Capacity Is On The Way: ~19 GW By 2028



US combined-cycle capacity by operating year, GW, 1990 to 2028

Electricity generators fueled by natural gas have provided more electricity to the US than any other sources since 2016.

— EIA, June 11, 2025

Source: EIA, https://www.eia.gov/todayinenergy/detail.php?id=65464

Value Of Big Five Tech Companies v. 106 US Utilities

Source: https://finance.yahoo.com/sectors/utilities/ Yaho Finance

N2N:Natural Gas To Nuclear

Why Natural Gas?

- It's relatively cheap
- Global CH_4 resources are super abundant/widely distributed
- Low political risk, can be burned in turbines & ICEs
- Gas-fired generation in developing world is ***miniscule***
- US gas pipeline/storage network is huge

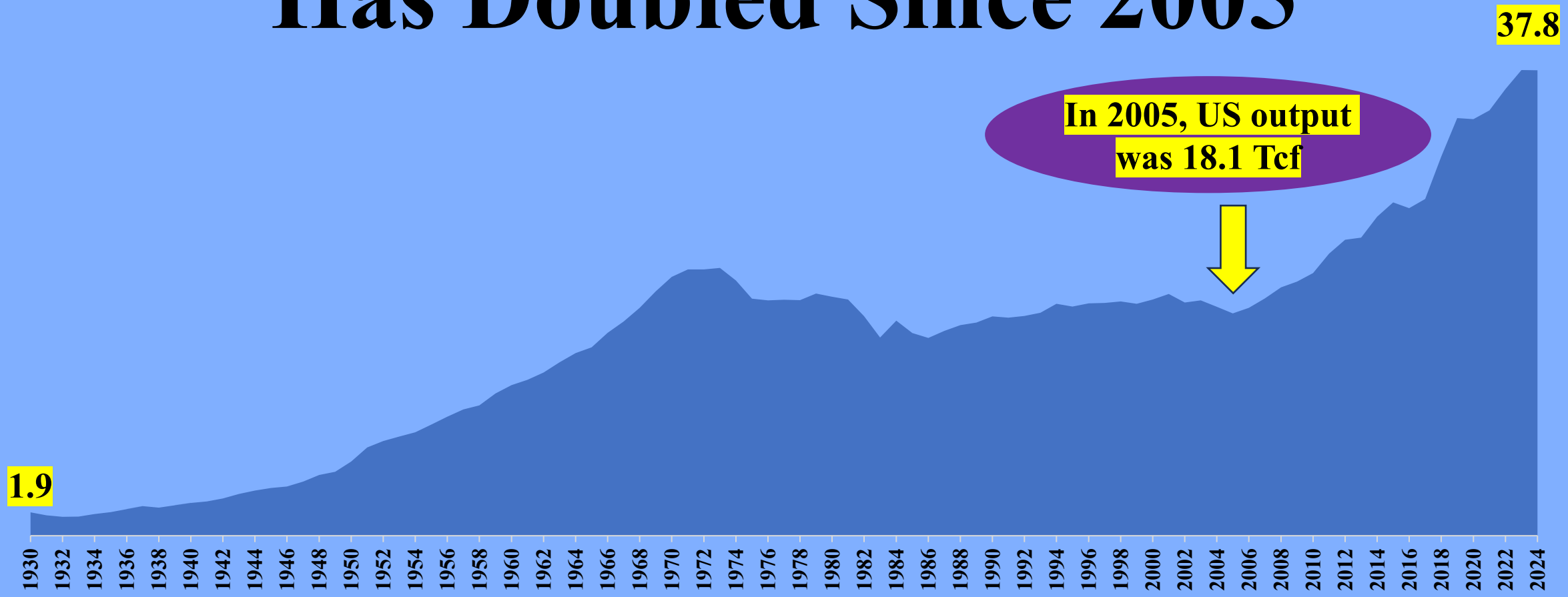
Two Decades Ago, Everyone Believed The US Was Running Out Of Natural Gas

Gas production has peaked in North America...unless there's some huge find that nobody has any idea where it would be.

— Lee Raymond, CEO, Exxon Mobil, 2007

Source: https://www.reuters.com/article/world/exxon-says-n-america-gas-production-has-peaked-idUSN21633104/

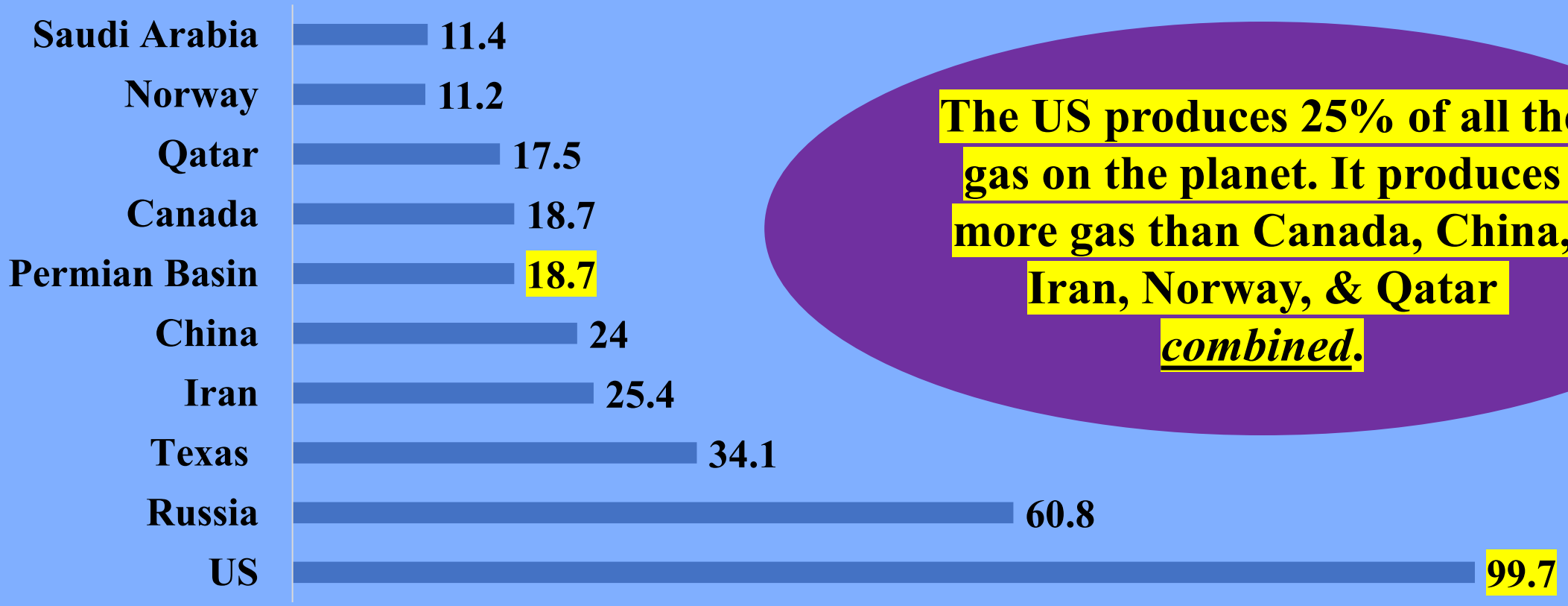
US Natural Gas Production Has Doubled Since 2005



US natural gas production, Tcf/year, 1930 to 2024

Source: EIA

The US Is A Natural Gas Superpower



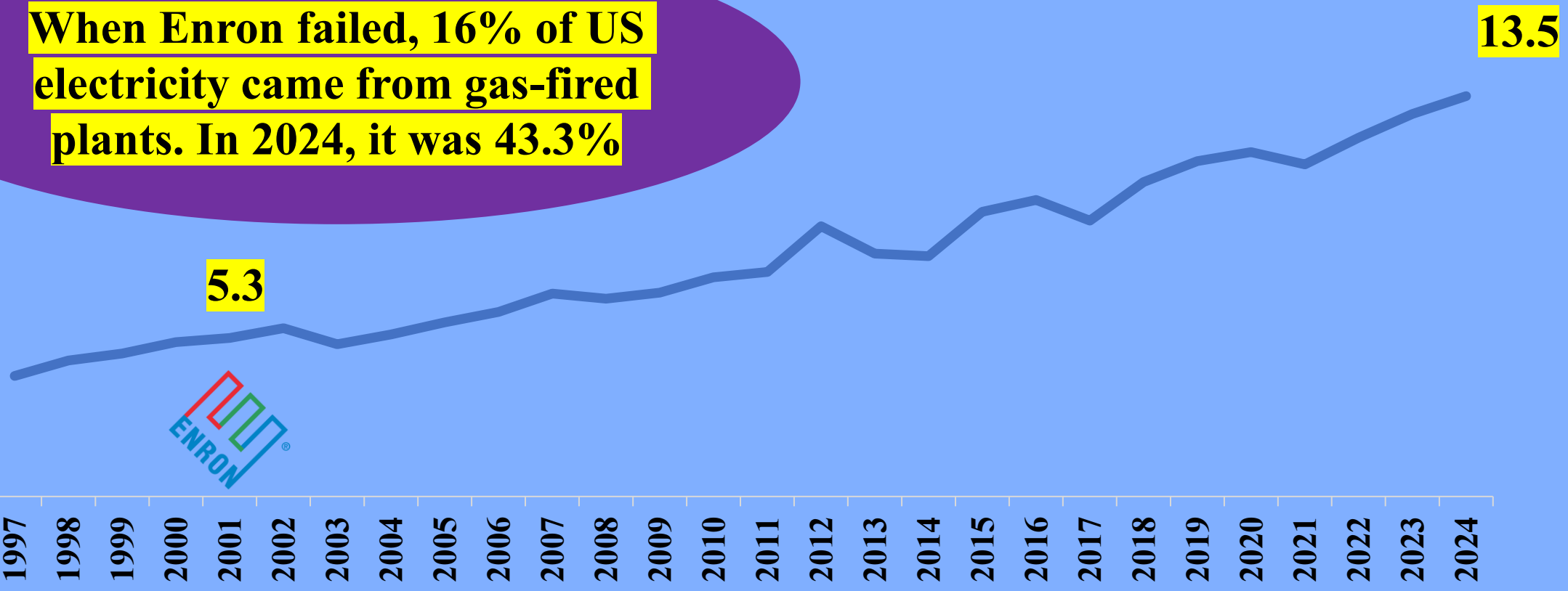
The US produces 25% of all the gas on the planet. It produces more gas than Canada, China, Iran, Norway, & Qatar *combined*.

2024 gas production, Bcf/d

Source: Statistical Review of World Energy 2025, TXOGA. Note: Numbers for TX and Permian are for March 2025.

Since 2001, Gas-Fired Power Production Has Nearly Tripled

When Enron failed, 16% of US electricity came from gas-fired plants. In 2024, it was 43.3%

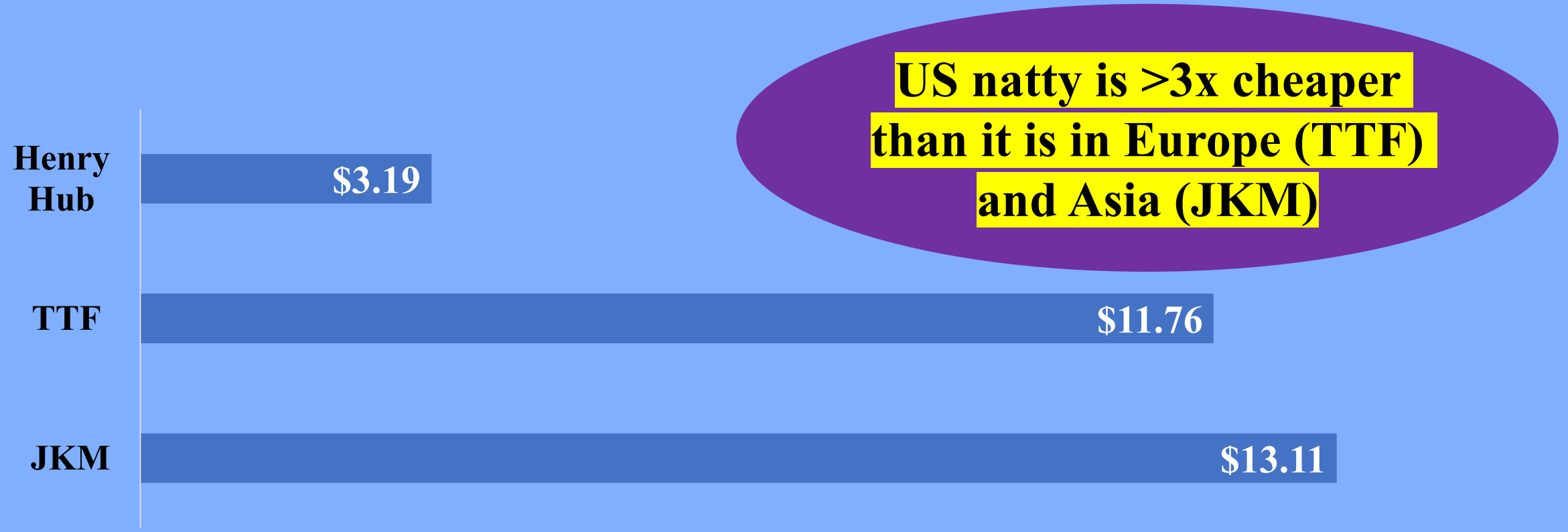


US power burn, 1997 to 2024, Tcf/year

Source: EIA, https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm https://www.eia.gov/tools/faqs/faq.php?id=427&t=3 Statistical Review of World Energy

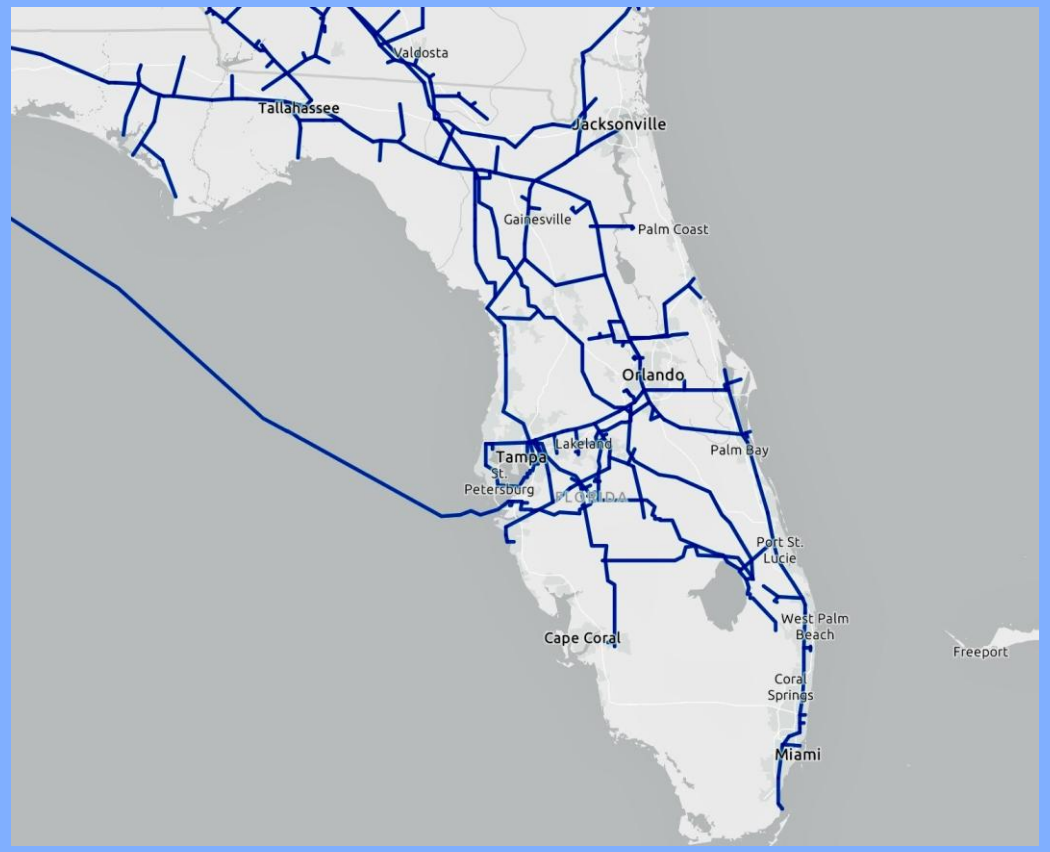
US Has A Price Advantage Over ROW

Nat Gas Prices: Henry Hub vs. JKM & TTF



Source: CME Group

BUT...Florida's Nat Gas Supply Lines Are Long & Vulnerable



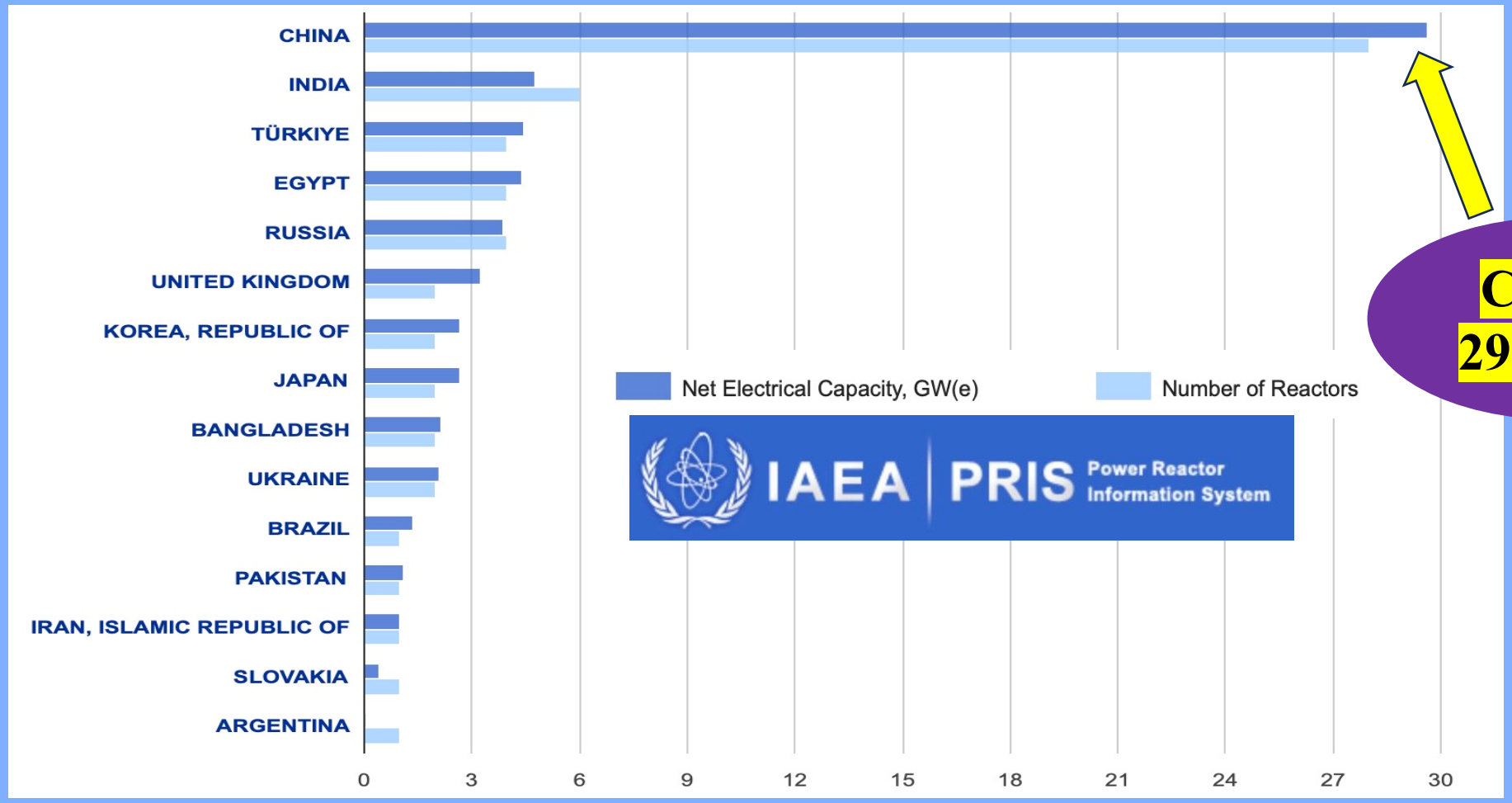
Interstate and intrastate gas pipelines

Source: EIA, https://atlas.eia.gov/datasets/eia::natural-gas-interstate-and-intrastate-pipelines/explore?location=28.047407%2C-82.235580%2C6.00

Why Nuclear?

- Needs 2,000x less land than wind, 200x less than solar
- Can be built near load centers
- Energy security, fuel diversity, grid stability
- Price hedge against natural gas
- Zero emissions

Here's The IAEA's List Of Reactors Under Construction. Where's The US?



Sources: IAEA, https://pris.iaea.org/pris/worldstatistics/underconstructionreactorsbycountry.aspx

51 Companies Want To Sell SMRs

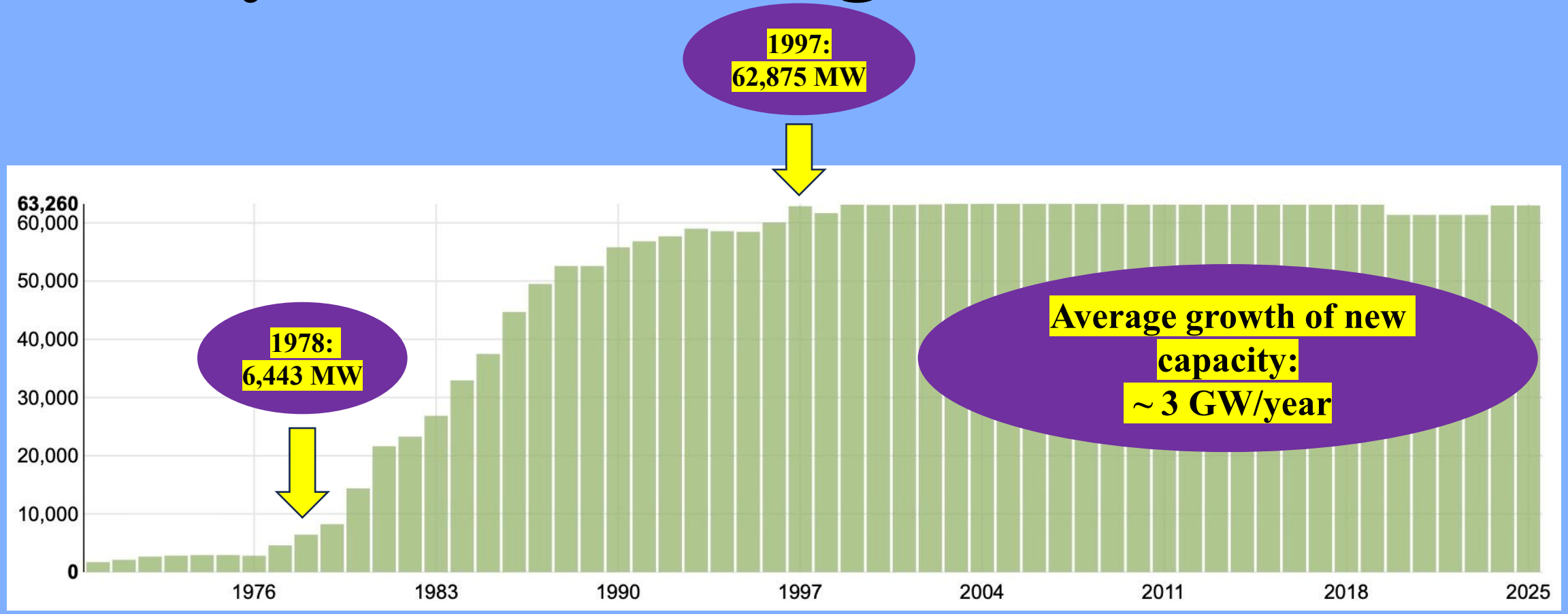
Which Ones Will Survive?

What Chemistry? What Size (MW)? Cost? When?

1. Steady Energy
2. Oklo
3. NuScale Power
4. Kairos Power
5. Rolls-Royce
6. GE Hitachi
7. Westinghouse
8. TerraPower
9. Terrestrial Energy
10. ARC Clean Technology
11. X-energy
12. General Atomics
13. Holtec International
14. Aalo
15. Rosatom
16. China Nat'l Nuclear Corp
17. Last Energy
18. Blue Energy
19. Radiant Nuclear
20. Thorcon
21. Flibe Energy
22. Moltex Energy
23. Ultra Safe Nuclear
24. Natura Resources
25. NuWard (EDF)
26. Newcleo
27. Core Power
28. Exodys Energy
29. Shine Technologies
30. Nano Nuclear
31. Curio Energy
32. Copenhagen Atomics
33. Seaborg Technologies
34. Blykalla (LeadCold)
35. Dual Fluid
36. BWX Technologies
37. Smart Power
38. NuCube Energy
39. Thorizon
40. Calogena
41. Deep Atomic
42. MicroNuclear
43. Huaneng
44. HolosGen
45. U-Battery
46. NPCIL (India)
47. Mitsubishi Heavy Ind.
48. KEPCO
49. Gen4 Energy
50. StarCore
51. Terra Innovatum

Sources: Company websites, Perplexity

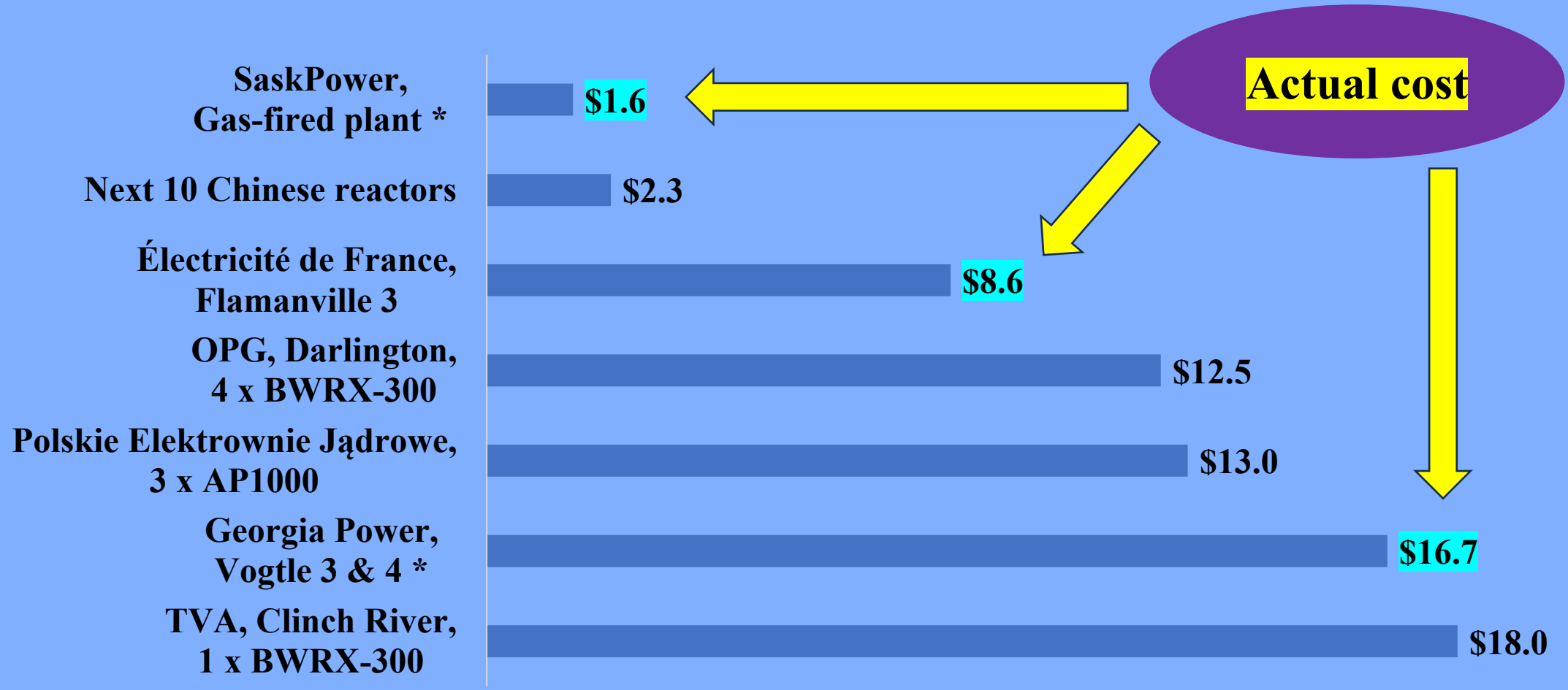
France Rapidly Expanded Its Fleet By Standardizing Its Reactors



Operable nuclear capacity, MWe, 1970 to 2025

Sources: World Nuclear Association, https://tinyurl.com/2e5bmyv6

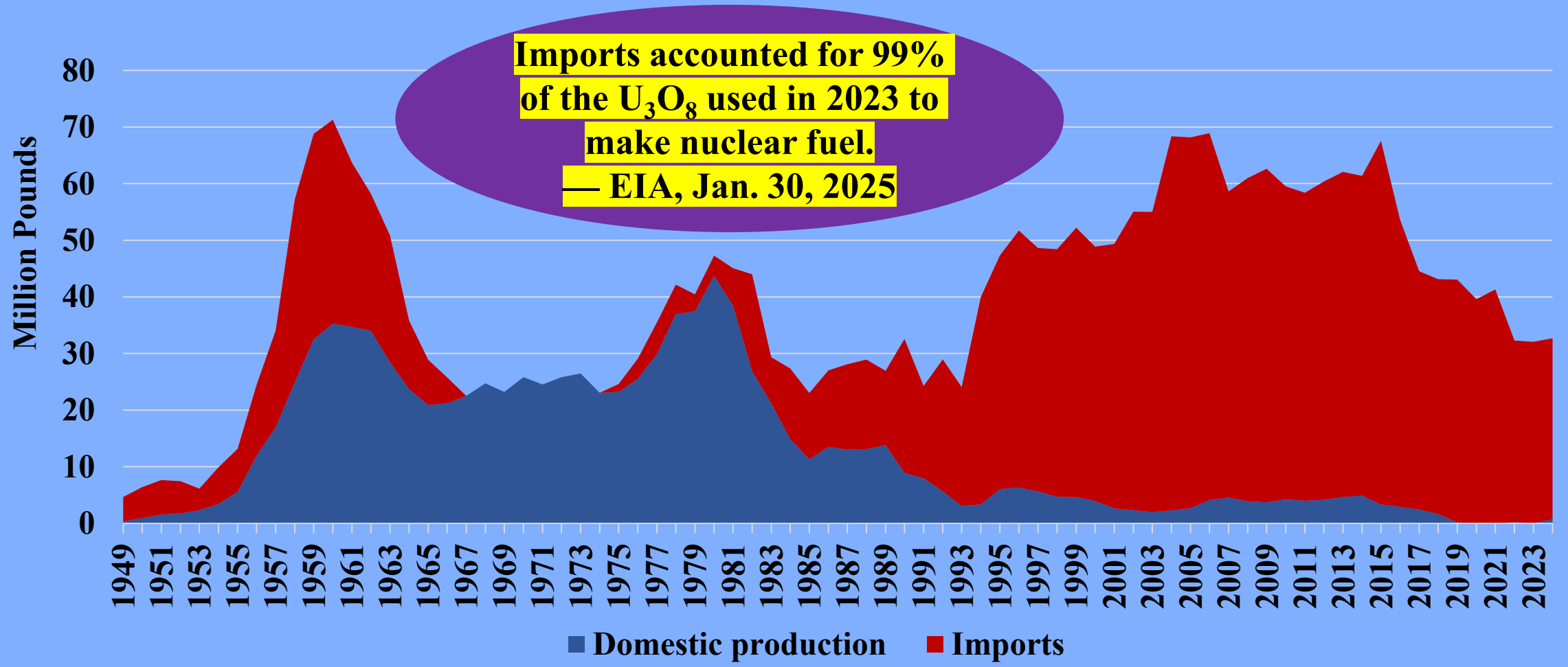
Reactors Are Still Too Expensive



Estimated cost per megawatt of new capacity, $US million

Sources: Media reports

US Production Of Uranium Oxide Vs. Imports, 1949 to 2024



Source: EIA, EPM , https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf Table 8.2, https://www.eia.gov/todayinenergy/detail.php?id=64444

Top Issues For FMEA

- Florida's power grid is too dependent on nat gas — and all of it is imported via long pipelines
- Solar can't scale
- Affordability, reliability, and resilience
- Go nuclear? When? Where? What's the cost?

Energy security is national security

Energy realism is energy humanism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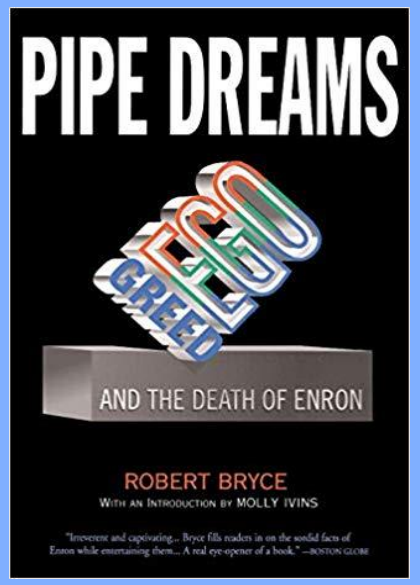

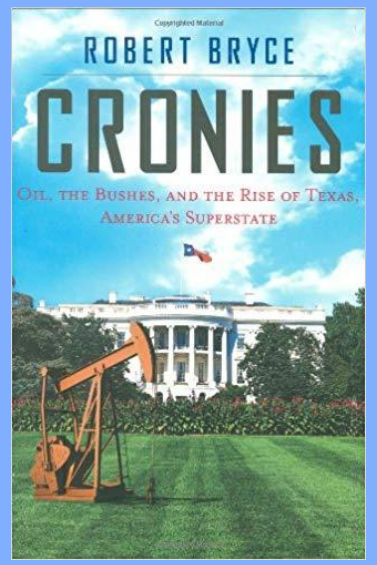

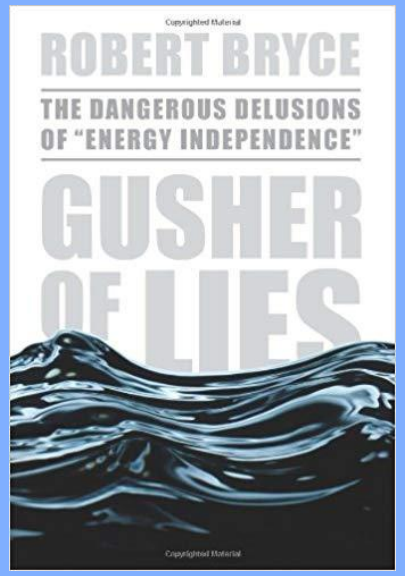

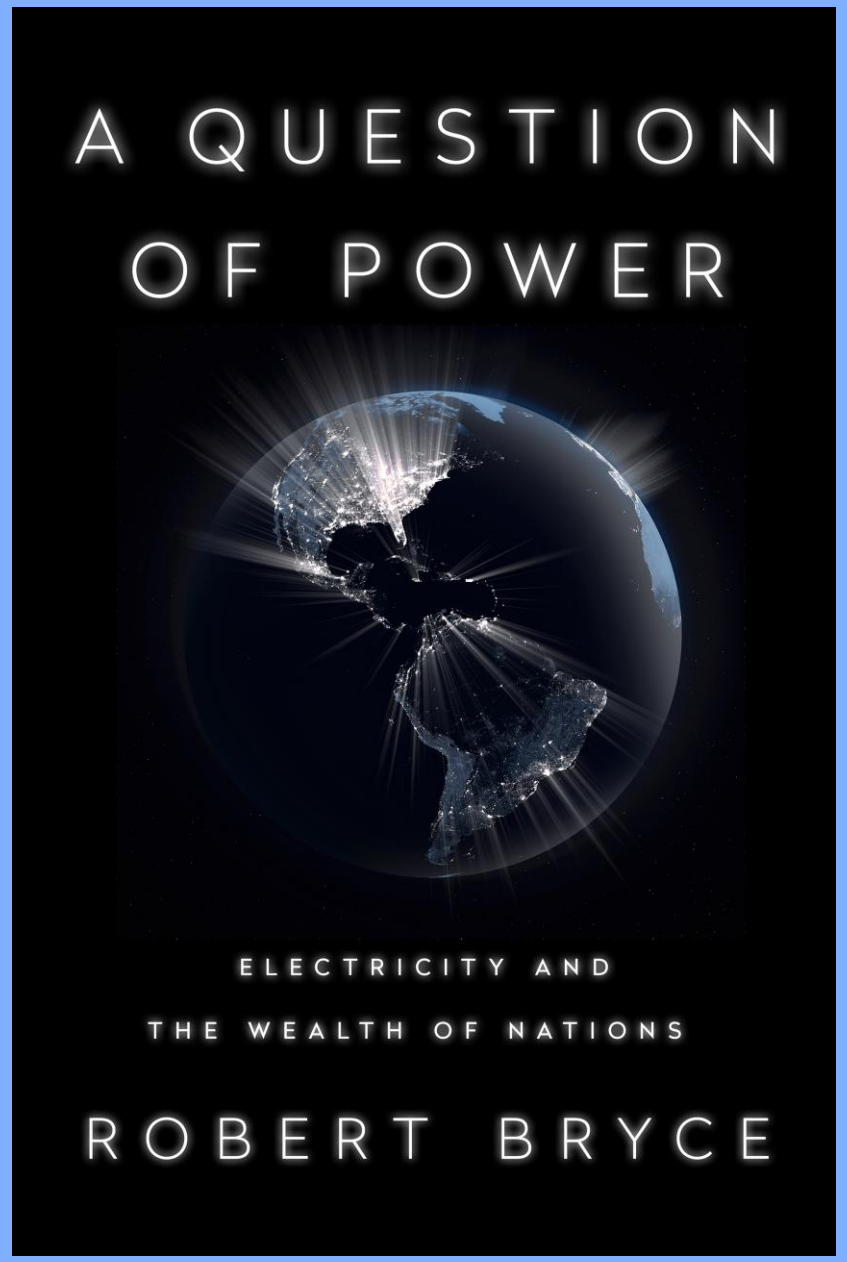

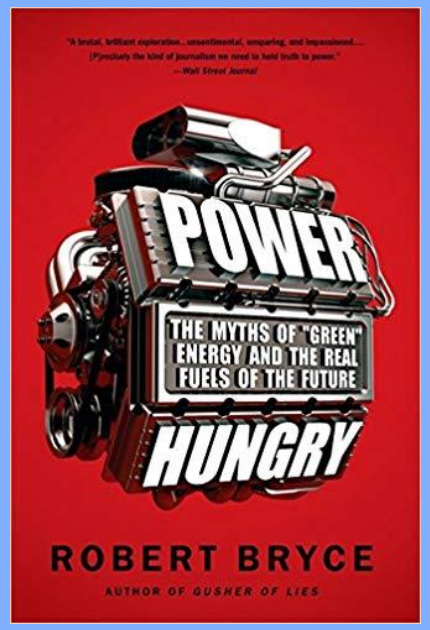

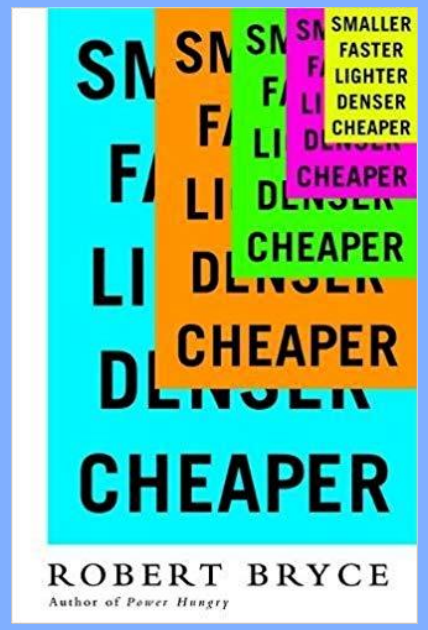

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Thank you