

A Resource Insider Podcast on Natural Gas

Without fossil fuel-based fertilizers, agriculture can support, at most, 3 billion people on plant-based diets, vs. today's 8 billion on mixed diets.

Daniel Yergin: "... this is a \$90 trillion world economy that gets 80% of its energy from hydrocarbons. It's not going to change overnight."

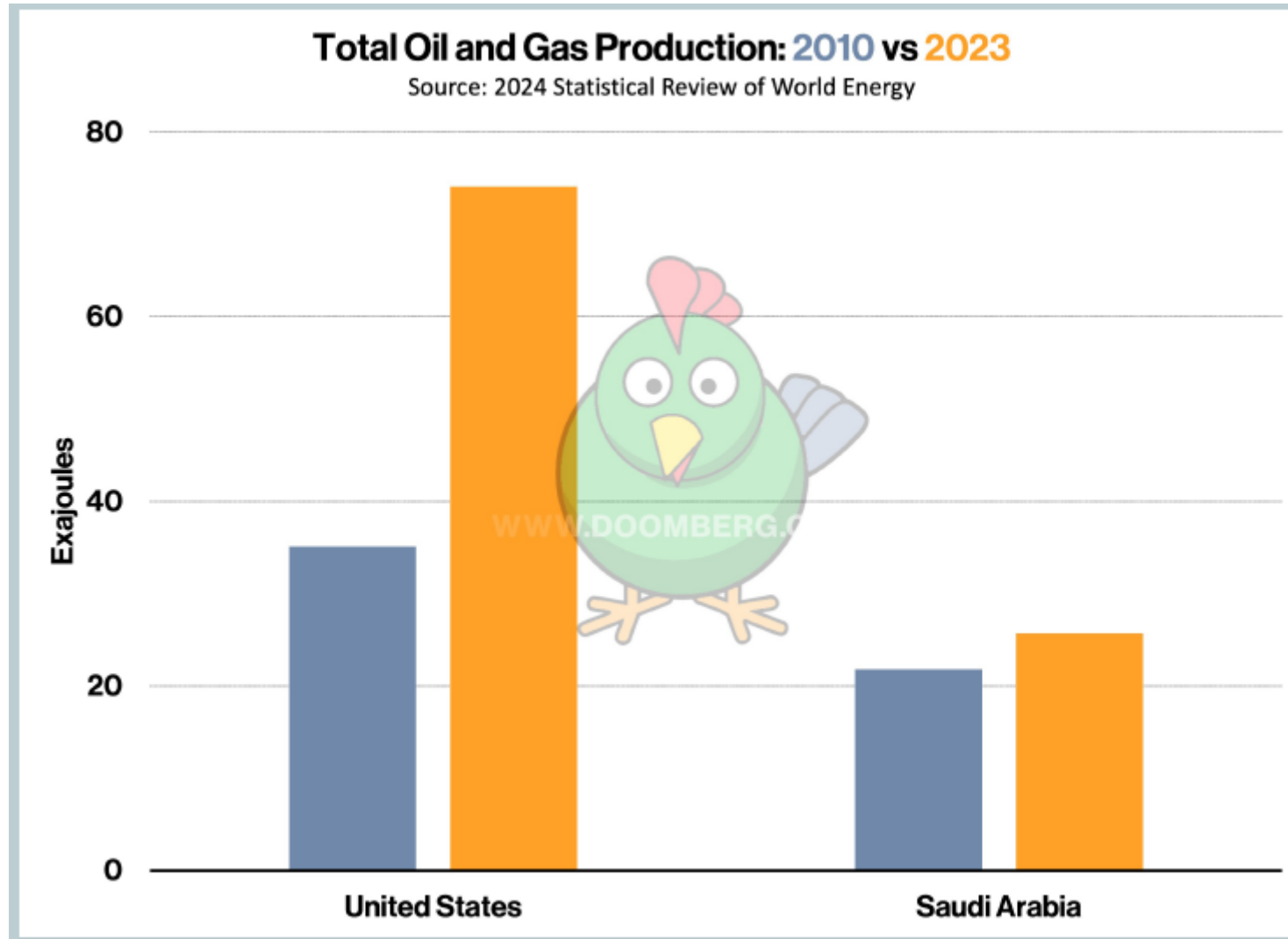


2023	Oil Exports 1000s B/day
US	9108
Saudi Arabia	8282
Russian Federation	6736
Canada	4836
West Africa	3285
North Africa	2025
Mexico	1271
Other Middle East (ex SA)	15018

The US is the world's energy superpower

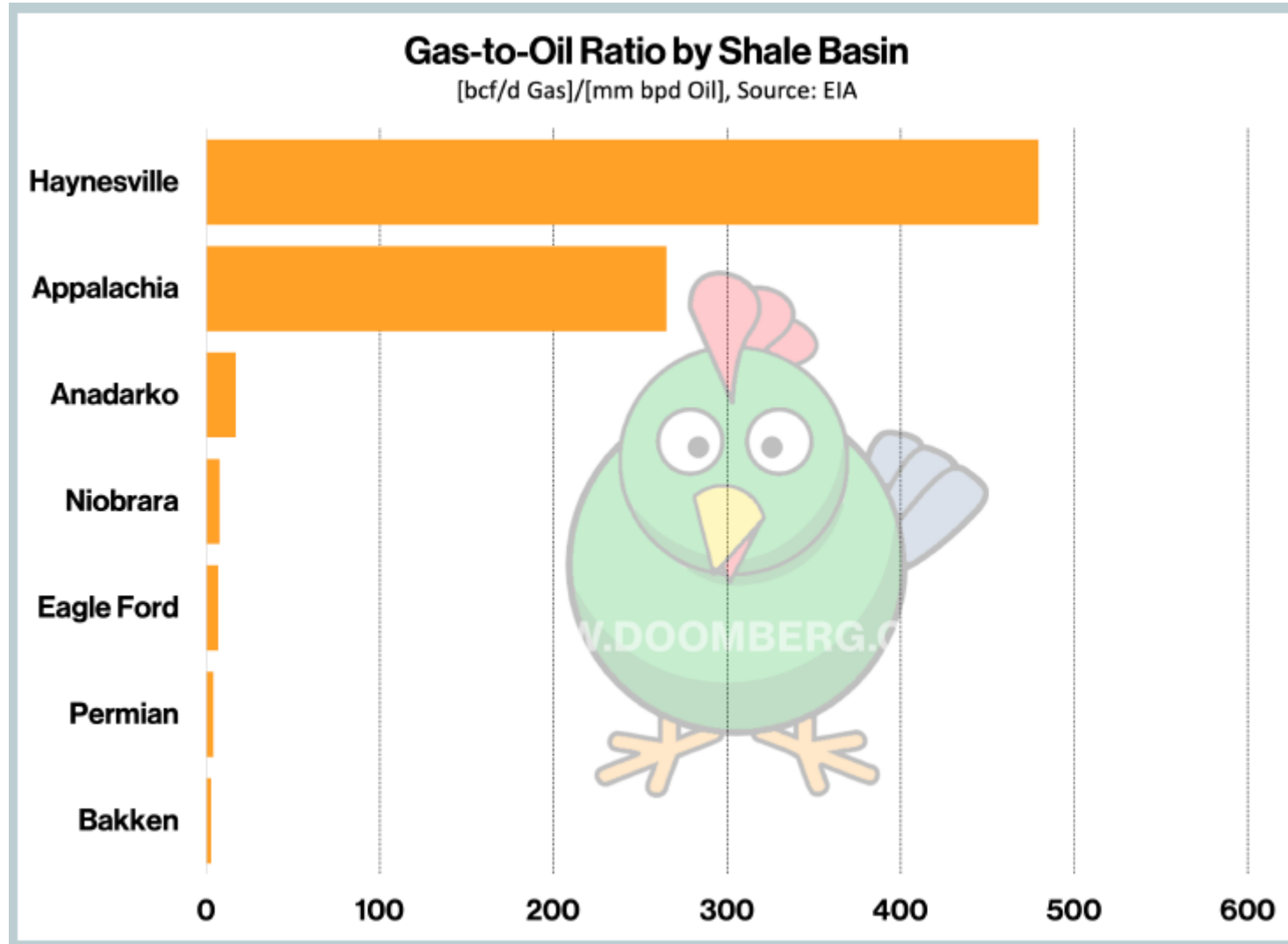
2023	LNG Exports BCM
US	114.4
Qatar	108.4
Australia	107.4
Russian Federation	42.7
Malaysia	36.3
Algeria	19.0
Nigeria	17.5
Indonesia	16.1
Oman	15.3
Papua New Guinea	11.5
Trinidad & Tobago	10.5

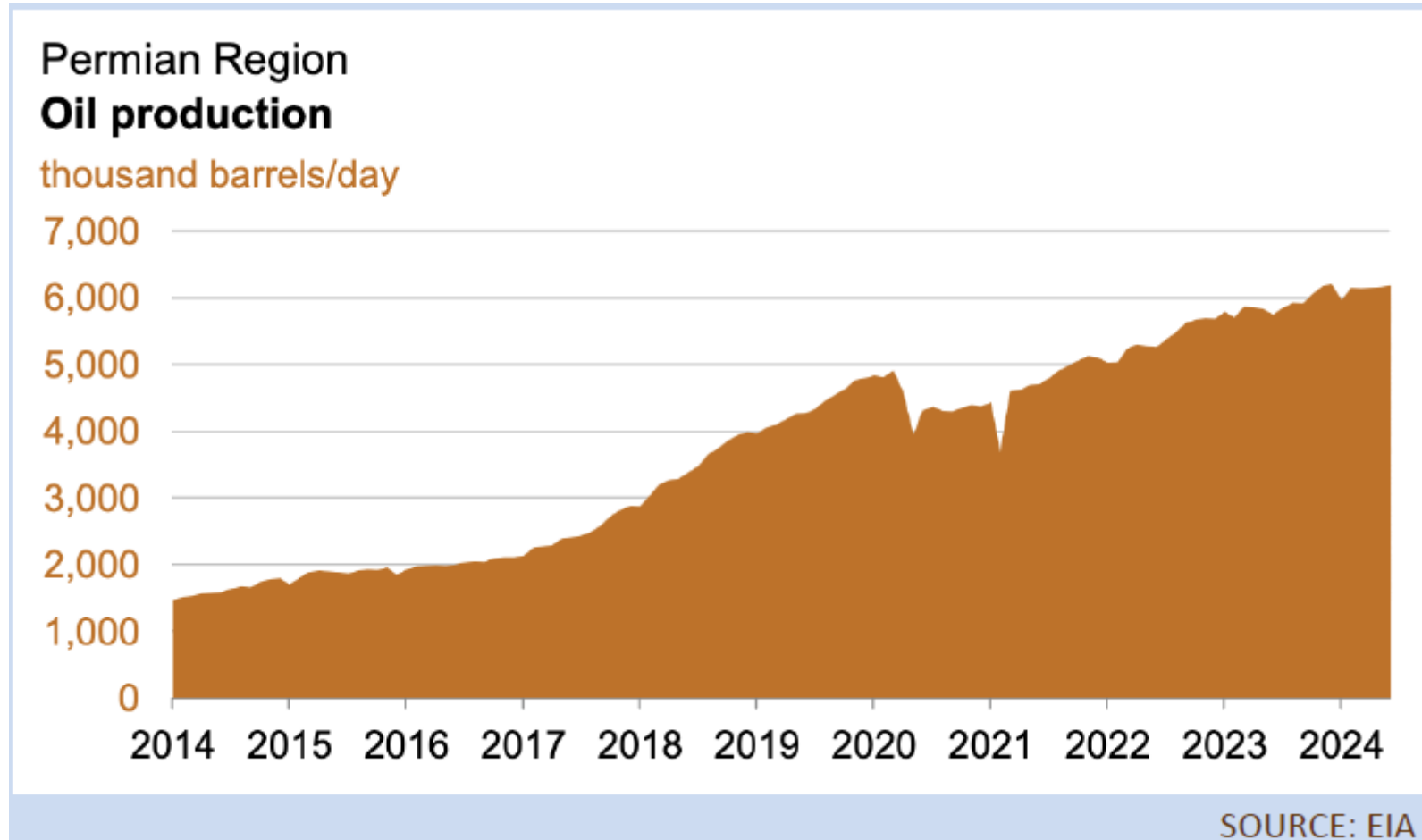
2023	Oil Production 1000s B/day
US	19358
Saudi Arabia	11389
Russian Federation	11075
Canada	5653
Iran	4662
Iraq	4355
China	4198
United Arab Emirates	3922
Brazil	3502
Kuwait	2908



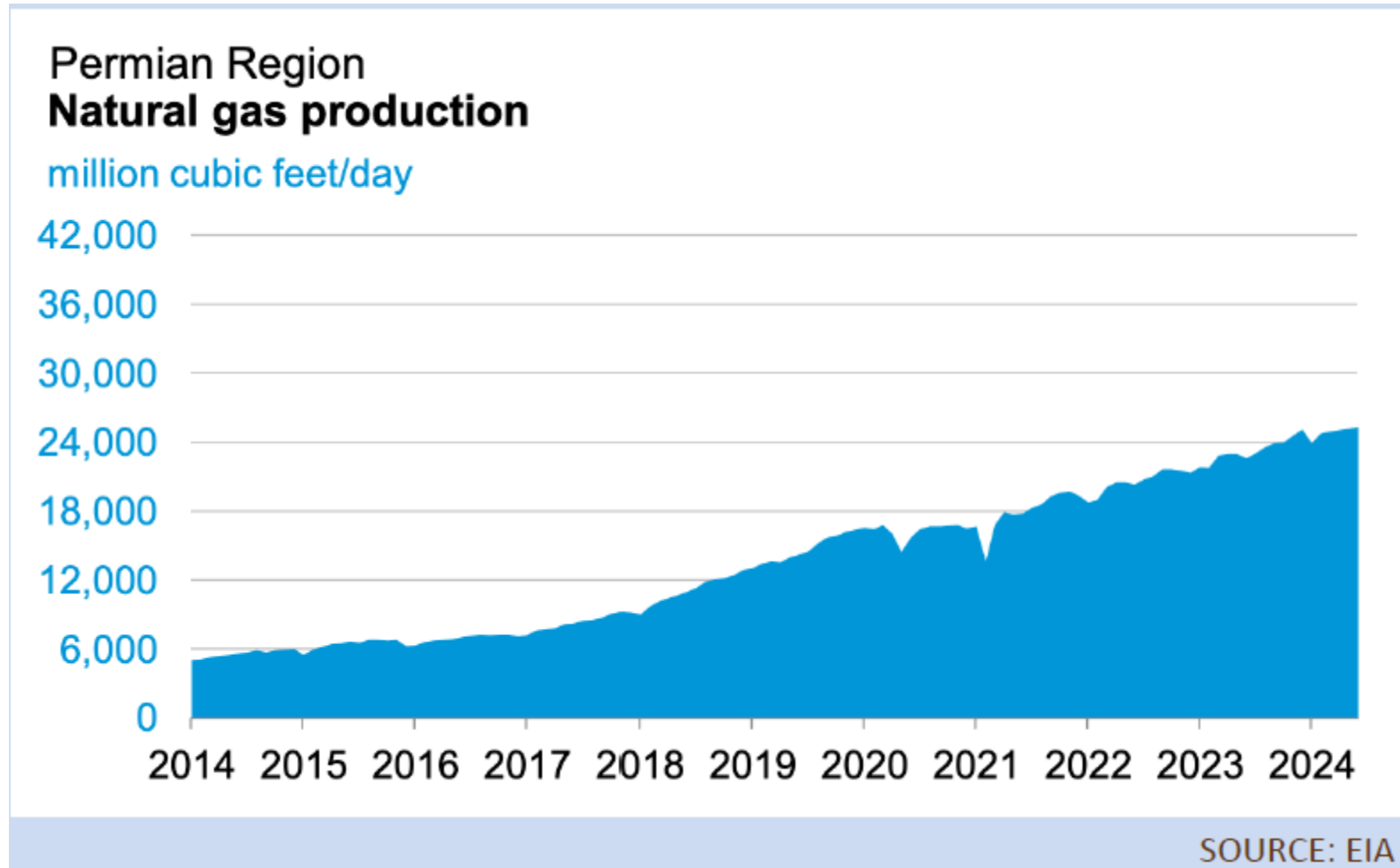
Shale in the U.S.





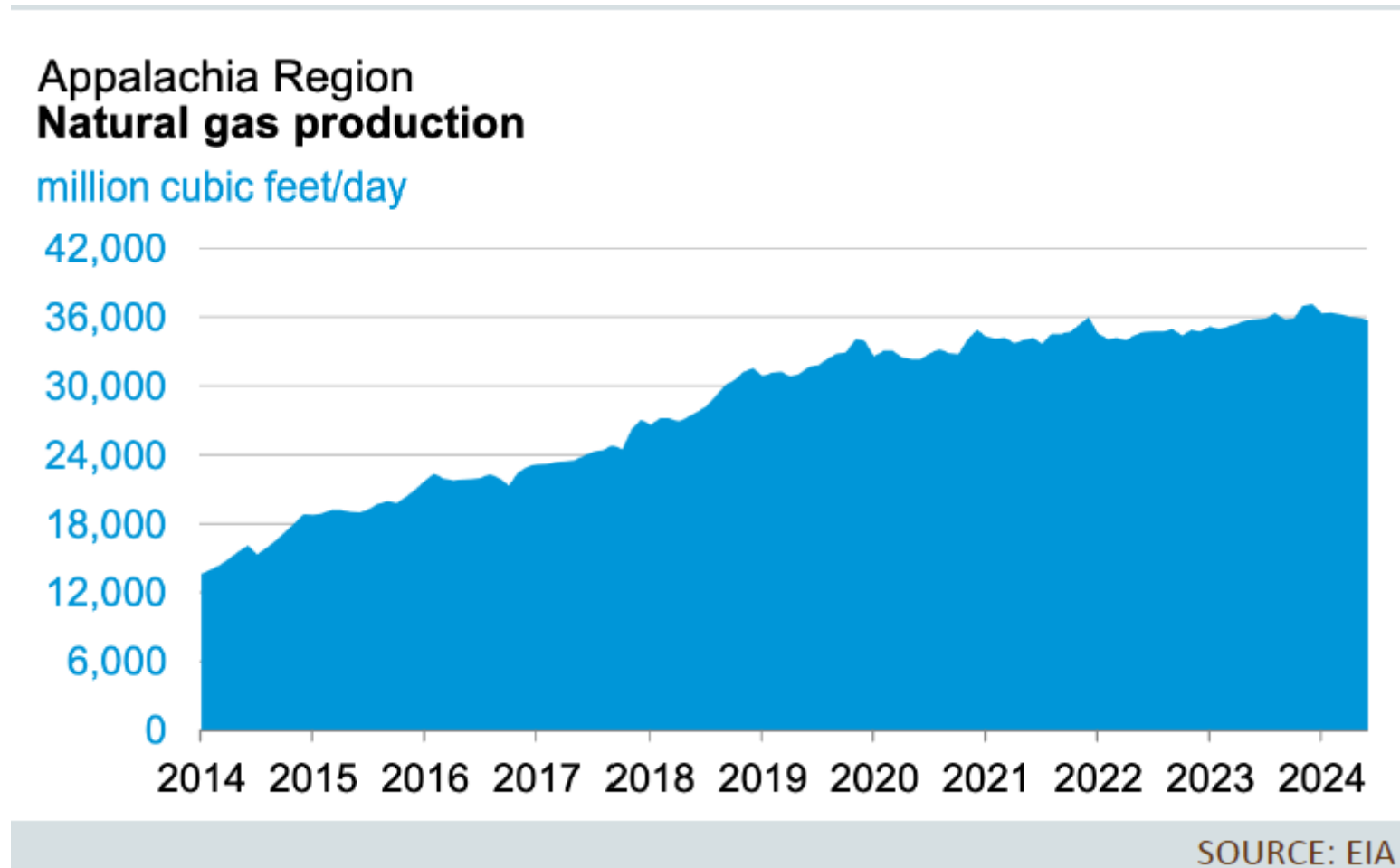


Permian Natural Gas Production

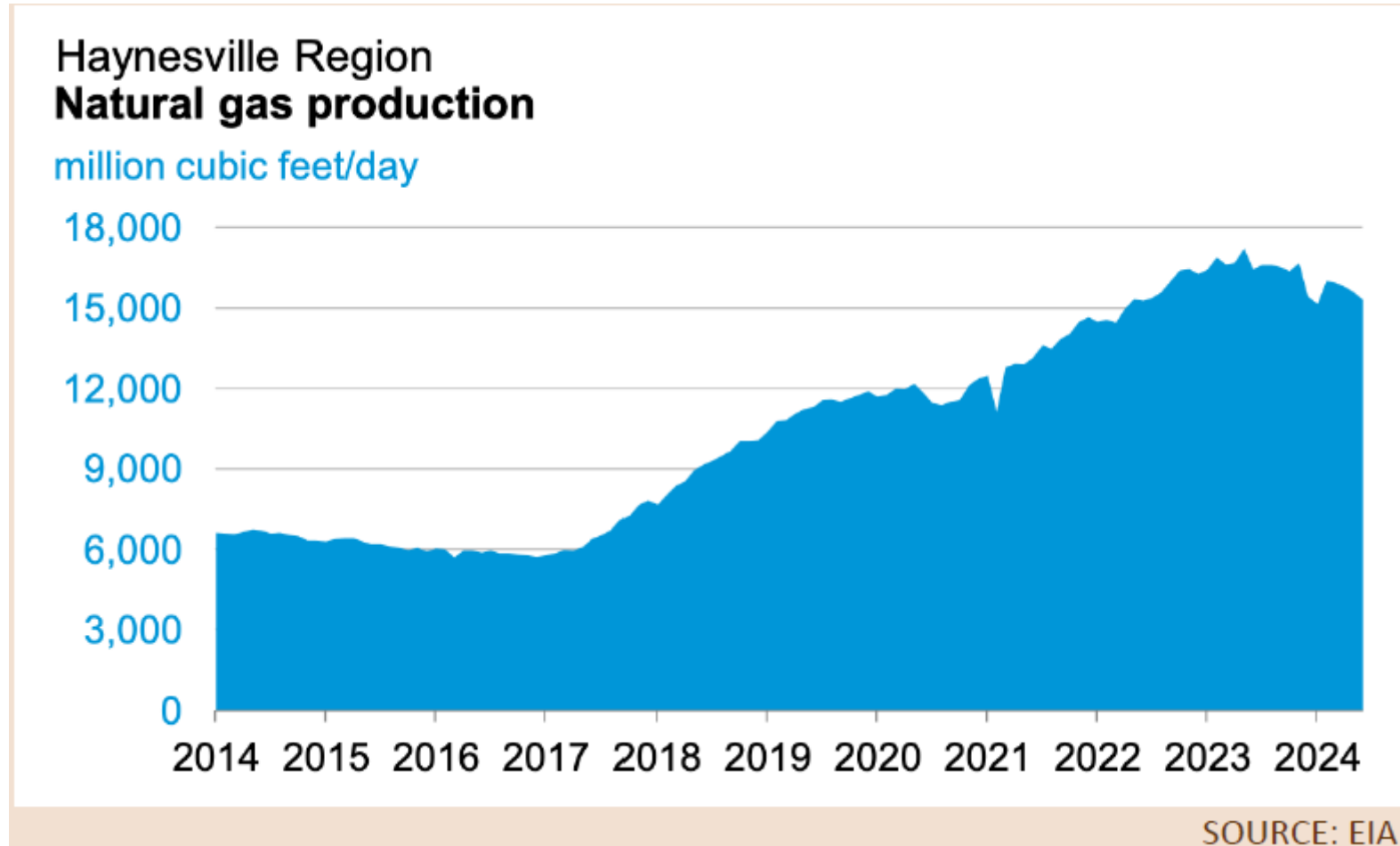


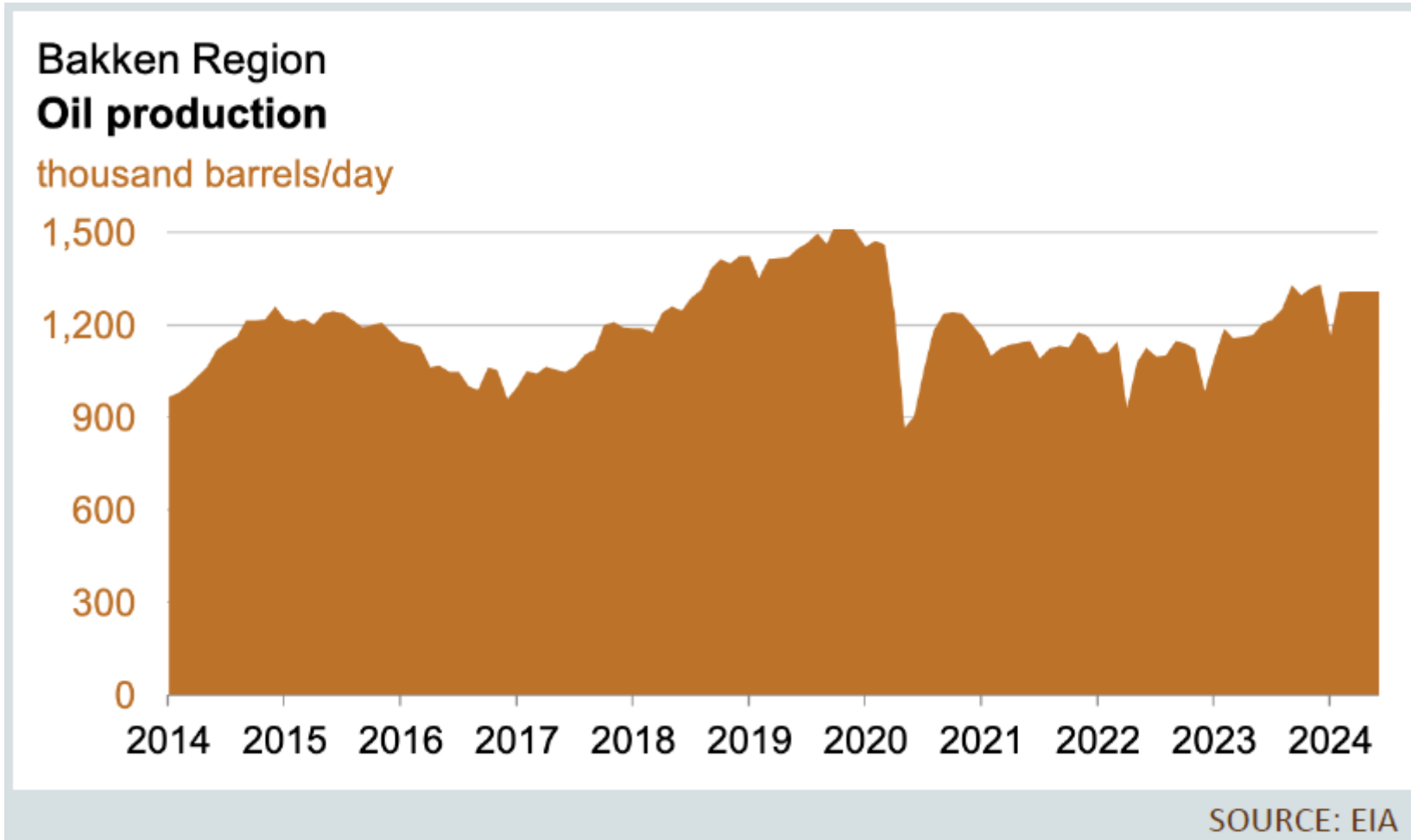
- 3rd in global natural gas production if standalone country
- 50% more daily natural gas production than Qatar

Appalachia Natural Gas Production (Marcellus and Utica)

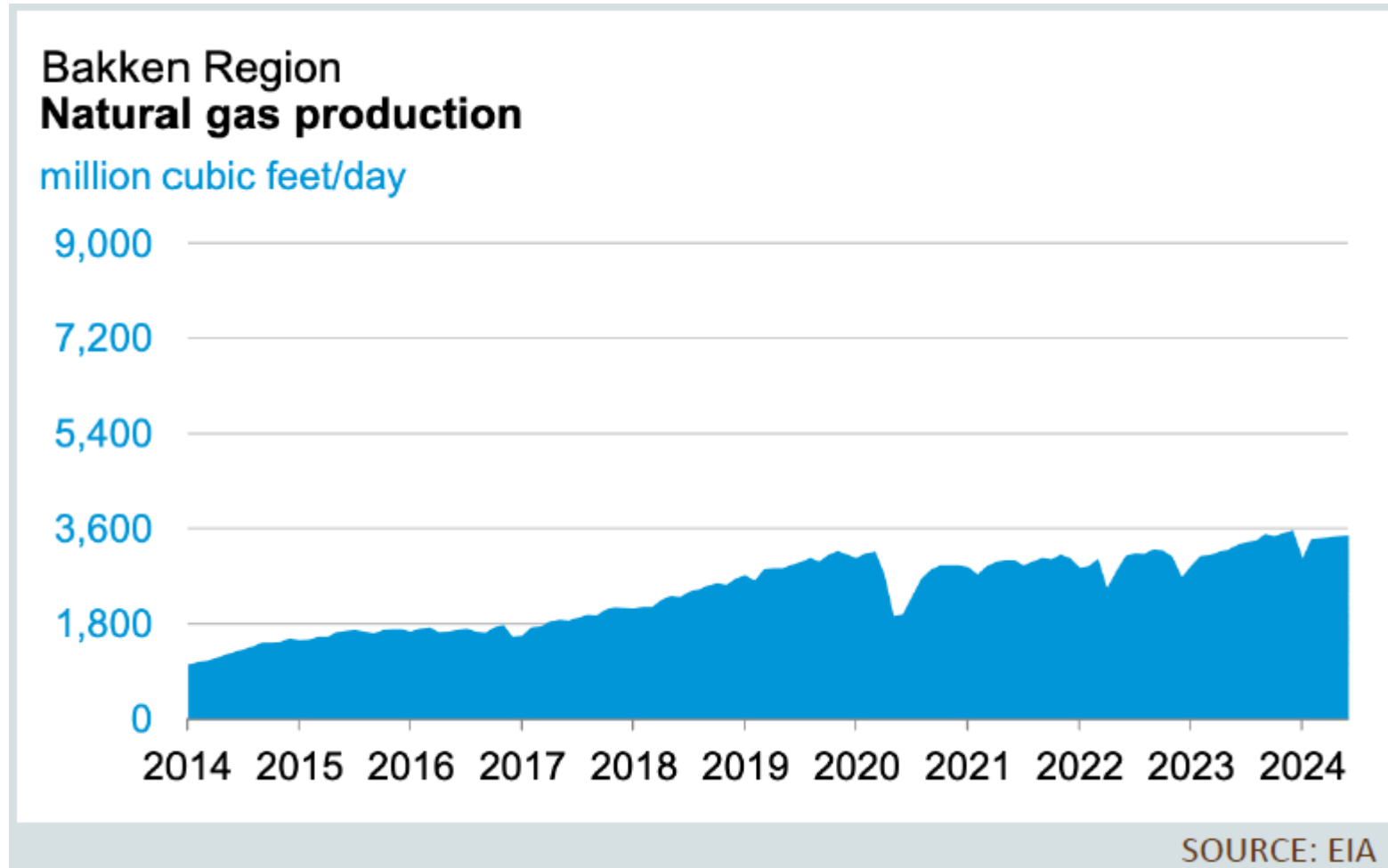


Haynesville Natural Gas Production





Bakken Natural Gas Production



1. Cement
2. Steel
3. Plastics and Petrochemicals
4. Fertilizer

Let's just take a look at one of those four pillars.

65-70% of the world caloric food intake is related to 4 grains:

- Wheat
- Rice
- Corn
- Soybeans



All require intense use of nitrogen fertilizers

- The goal of fertilizing grains is to increase the yield



There are only three types of fertilizers:

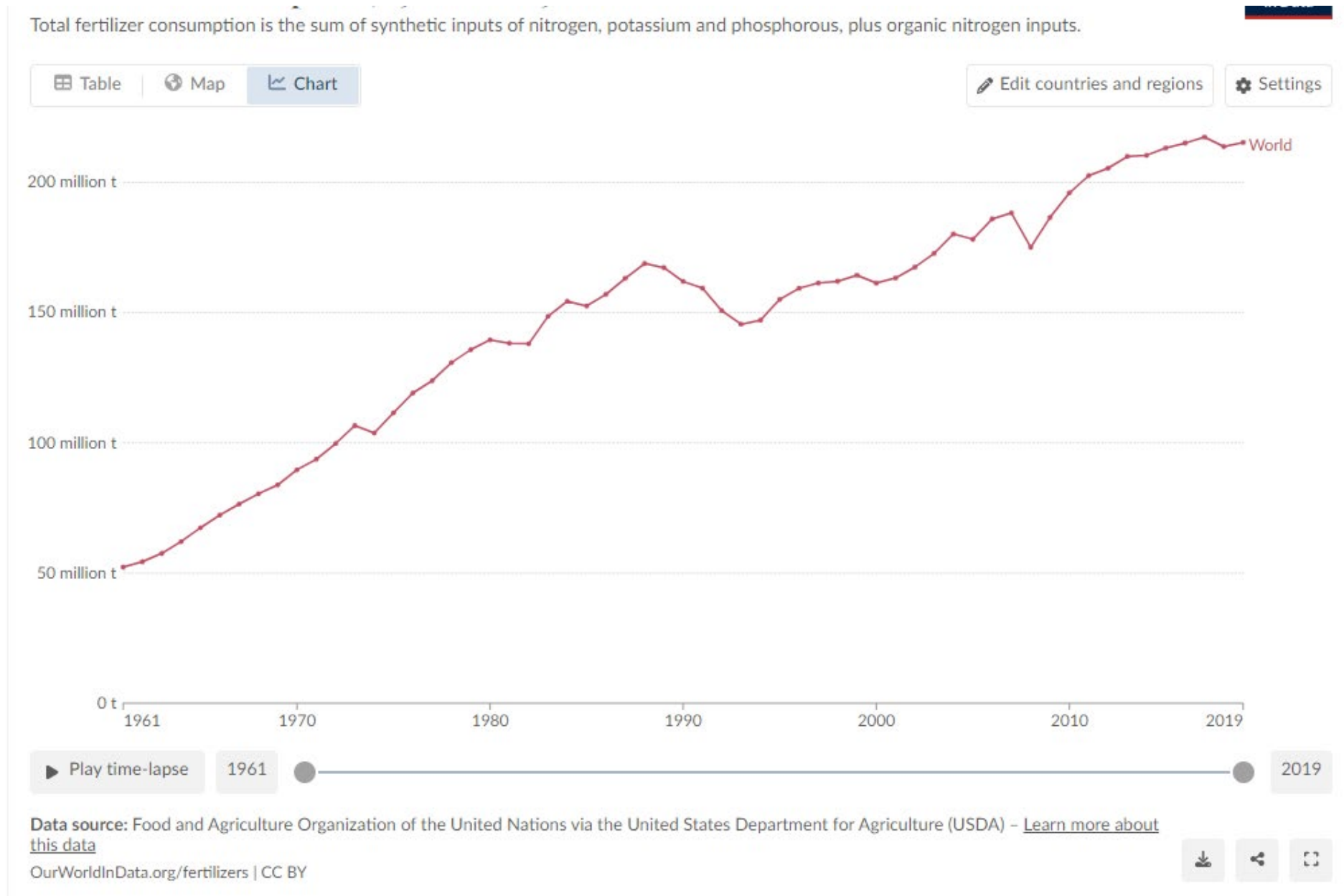
- 10 Nitrogen (N) man-made
- 20 Phosphate (P) mined
- 10 Potash (K) mined

These numbers represent the amount of nutrients being supplied.

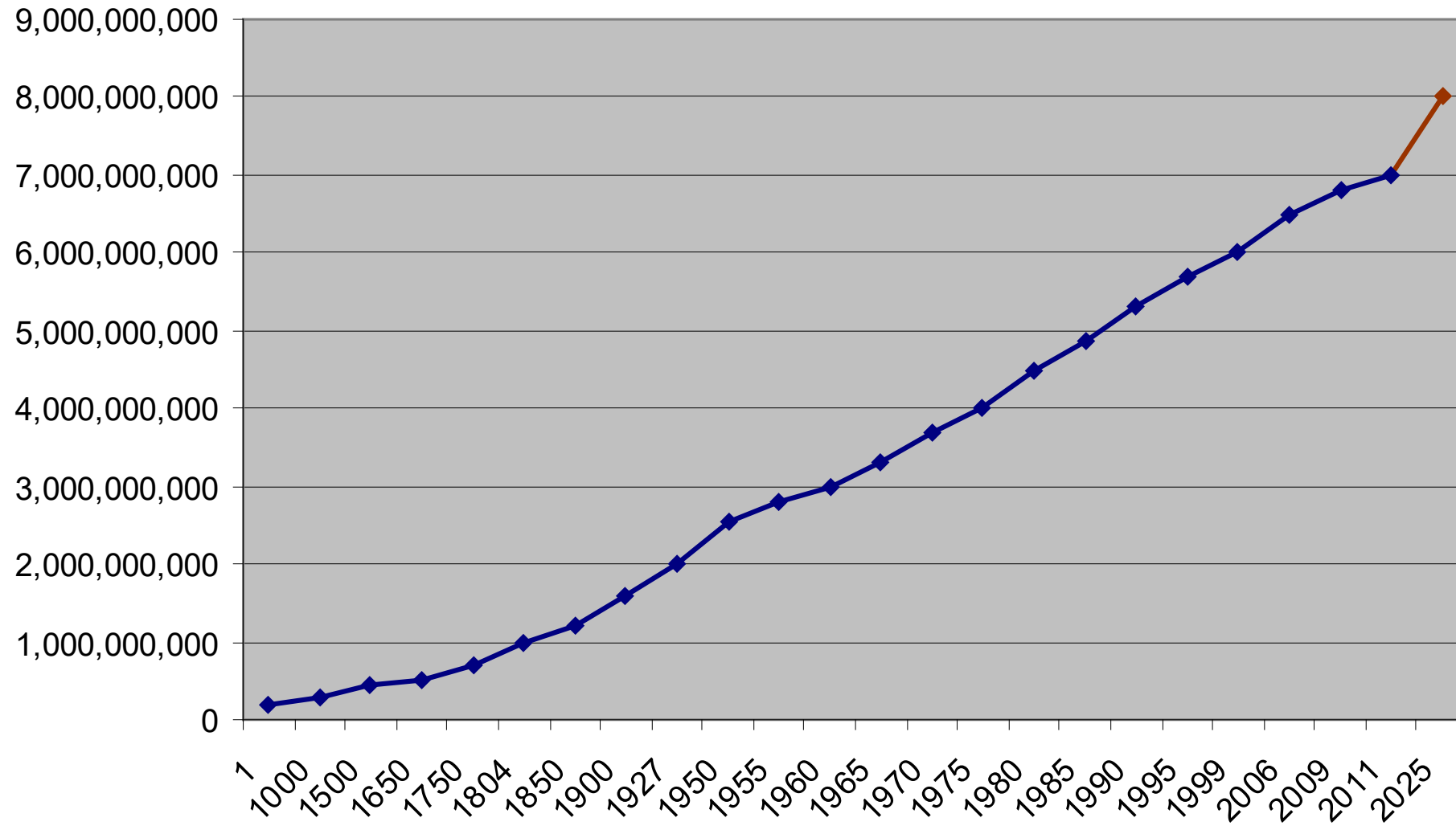


- The Haber-Bosch Process involves the synthesis of fossil fuels, primarily natural gas, into ammonia.
- Ammonia based fertilizers produce 40-60% of the food we eat by making plant nutrients more widely available.
- The expansion of the world's population from 1.6 billion people in 1900 to today's 8 billion would not have been possible without the synthesis of ammonia.

Fertilizer consumption, 1961 to 2019



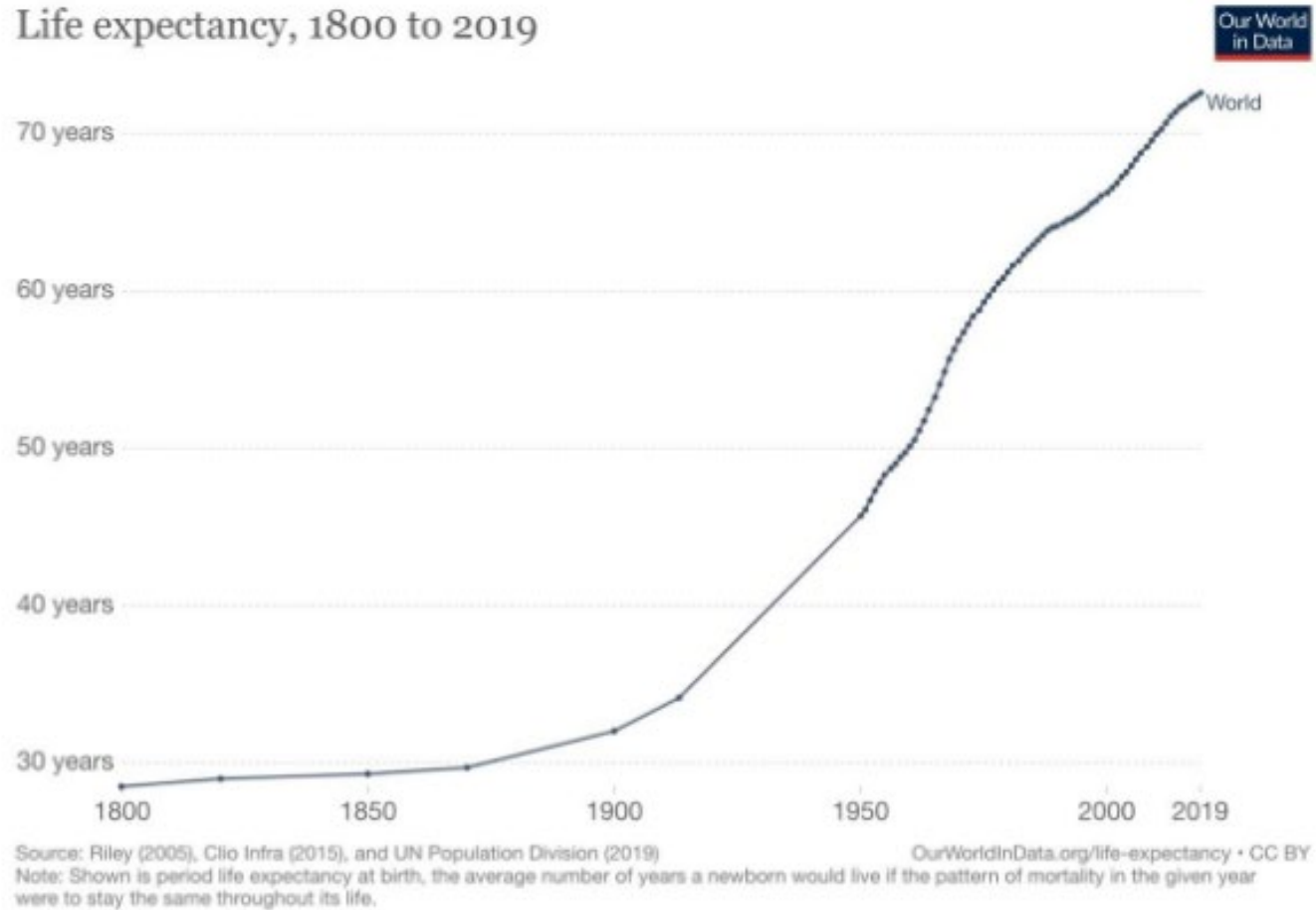
World Population Growth



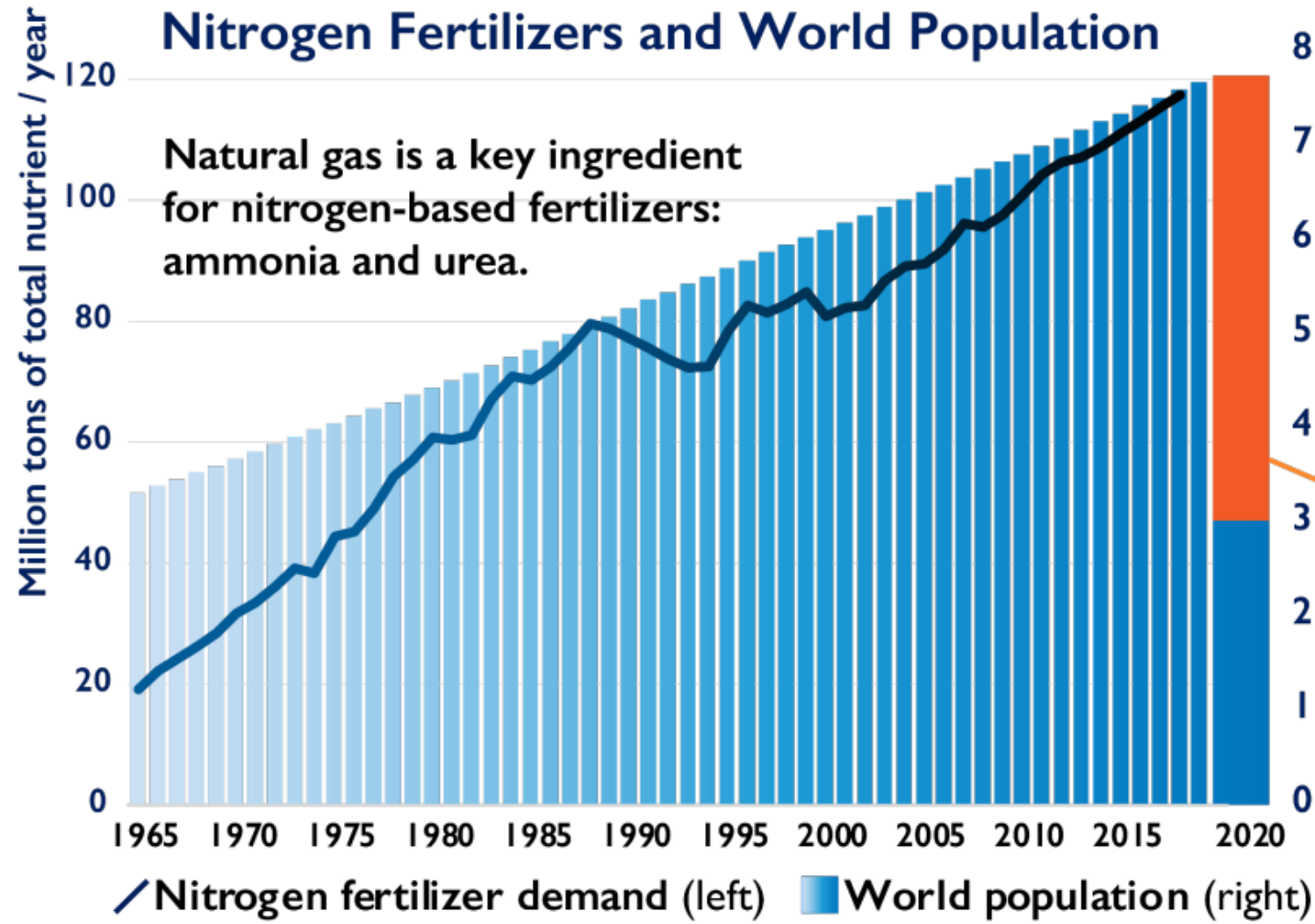
Source: About.com; <http://geography.about.com/od/obtainpopulationdata/a/worldpopulation.htm>

Urbanization,
industrialization,
and energy
consumption have
contributed to an
extension of life
expectancy of
over 40 years...

Life expectancy, 1800 to 2019



Source: Nikos Alexandratos and Jelle Bruinsma, "World Agriculture Towards 2030/2050: The 2012 Revision," ESA Working Paper no. 12-03, Agricultural Development Economics Division, Food and Agriculture Organization of the United Nations, June 2012, <http://www.fao.org/3/a-ap106e.pdf>.



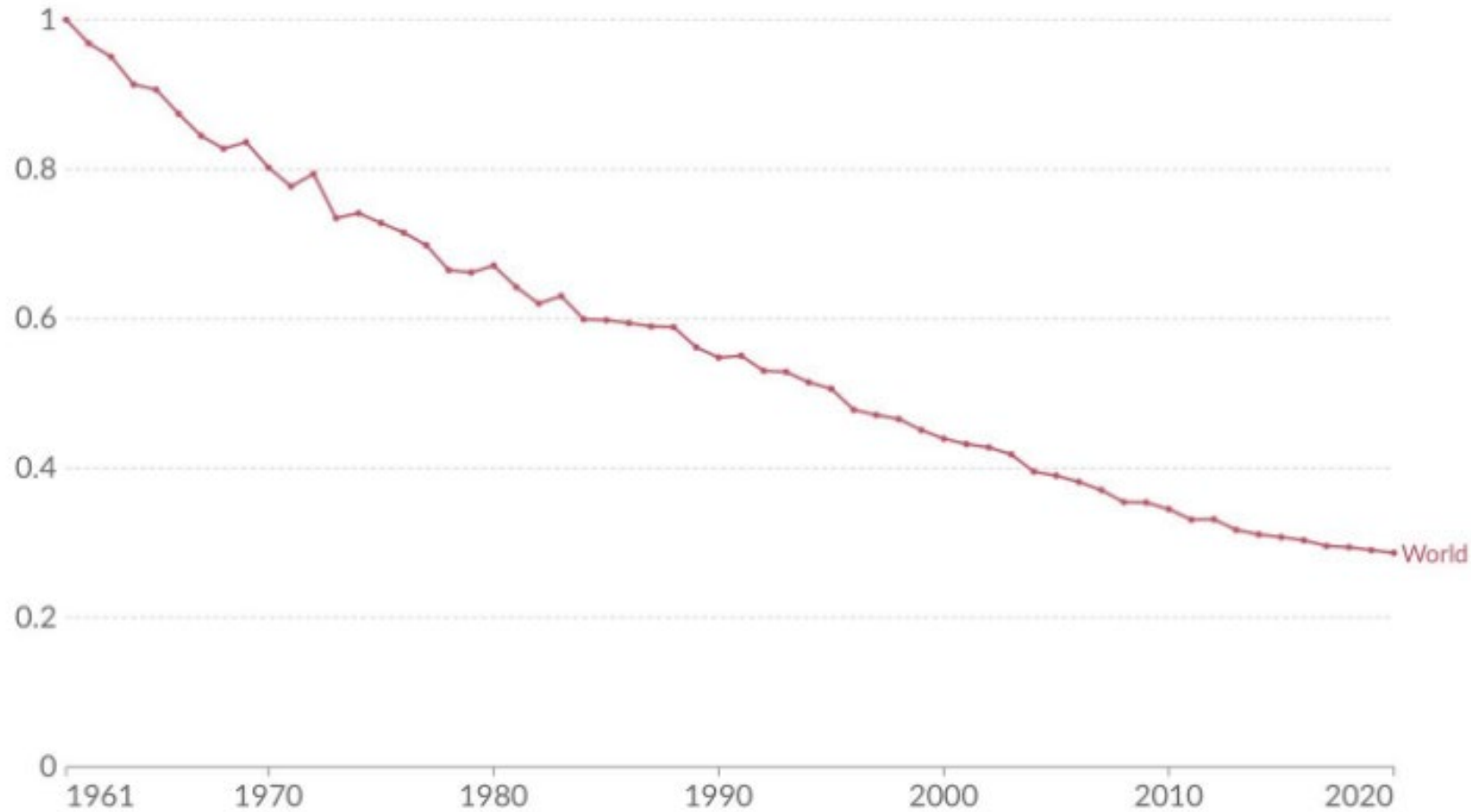
Without fossil fuel-based fertilizers, agriculture can support, at most, 3 billion people on plant-based diets, vs. today's 8 billion on mixed diets.

Sources: Vaclav Smil, FAO, World Bank, Statista,

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Arable land needed to produce a fixed quantity of crops, 1961 to 2020

Arable land needed to produce a fixed quantity of crops is calculated as arable land divided by the crop production index (PIN). The crop production index (PIN) here is the sum of crop commodities (minus crops used for animal feed), weighted by commodity prices. This is measured as an index relative to 1961 (where 1961 = 1).



Data source: Food and Agriculture Organization of the United Nations

OurWorldInData.org/land-use | CC BY



Source: "Nitrogen wars: the Dutch farmers' revolt that turned a nation upside-down," The Guardian, Paul Tullis, November 16, 2023

- Dutch farmers gathered to protest a governmental advisory committee's recommendation to take “drastic measures” to reduce emissions of nitrogen.
- The largest share of nitrogen deposited on Dutch land comes from agriculture.
- Committee recommended buying out and shutting down livestock farms

1970 Nobel laureate Norman Borlaug, “the Father of the Green Revolution,” and his colleagues developed wheat varieties that were resistant to a wider variety of insects and diseases

“This is a basic problem, to feed 6.6 billion people. Without fertilizer, forget it. The game is over.”

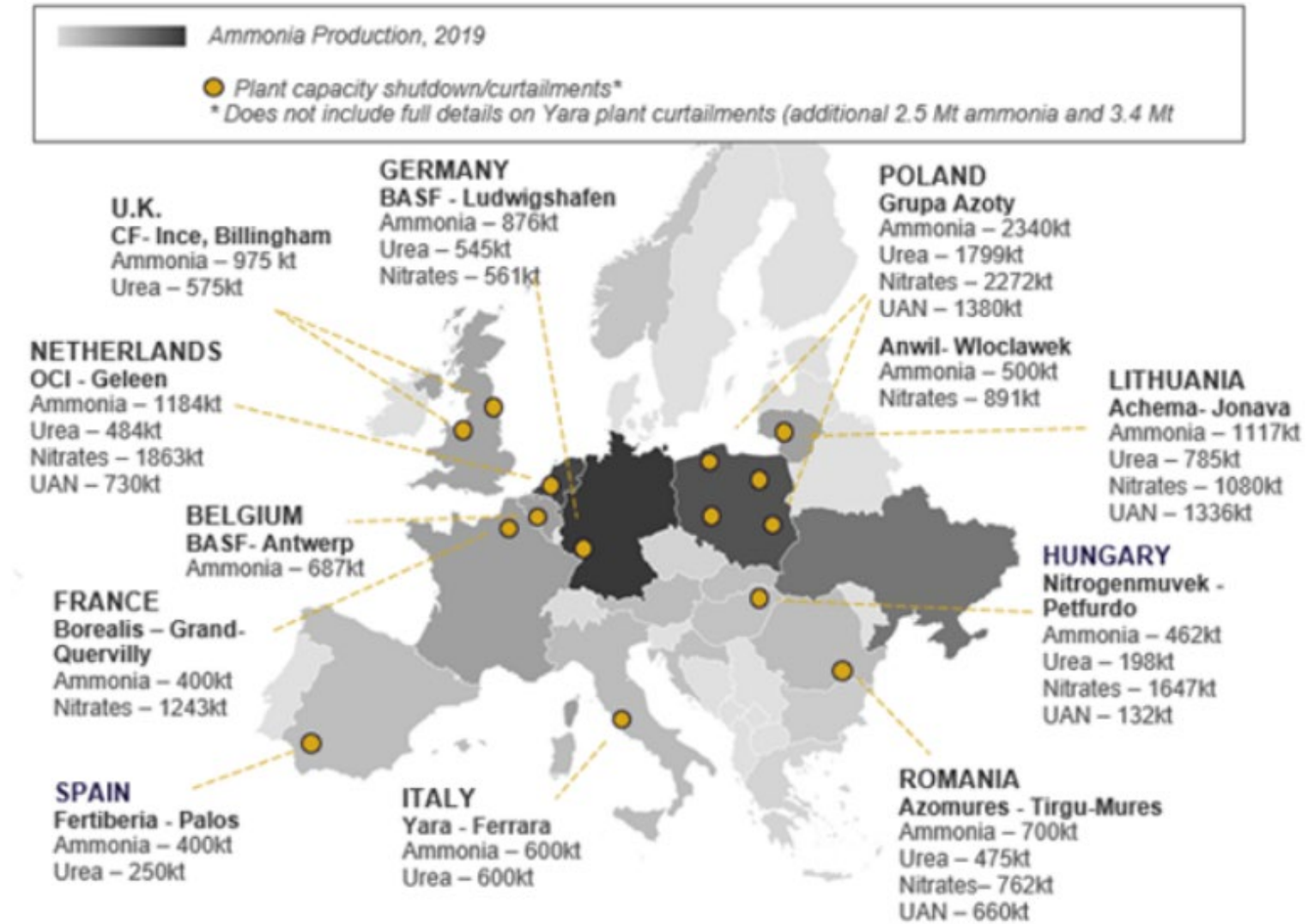
“In April 2021, Sri Lankan President Gotabaya Rajapaksa imposed a nationwide ban on the importation and use of natural gas-based, synthetic fertilizer and pesticides. This forced two million farmers to adapt to organic farming.”

- 20% decline in domestic rice production in the first 6 months
- 50% surge in domestic rice prices
- \$450 million paid by Sri Lanka for rice imports
- \$425 million loss in nation's tea crop
- \$40 billion foreign debt default by Sri Lanka

If you aggregate the world's daily demand for natural gas (**11 Bcf/day**) that is converted into fertilizer (through the Haber Bosch process) into one country, that country would rank 10th in the world for daily natural gas demand

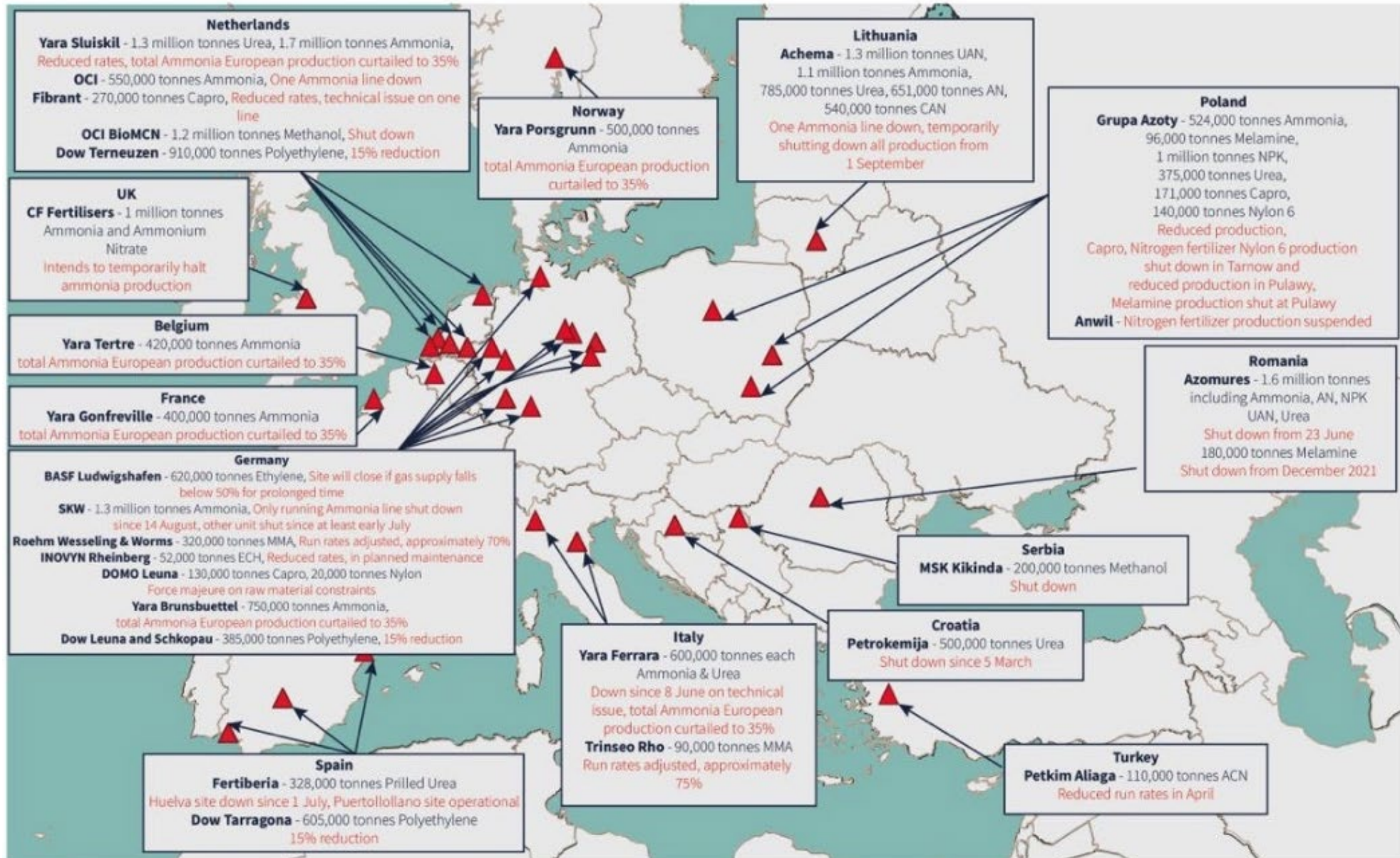
70% of Europe's nitrogen fertilizer plants closed during 2022

Figure 1: European nitrogen production shutdowns and curtailments

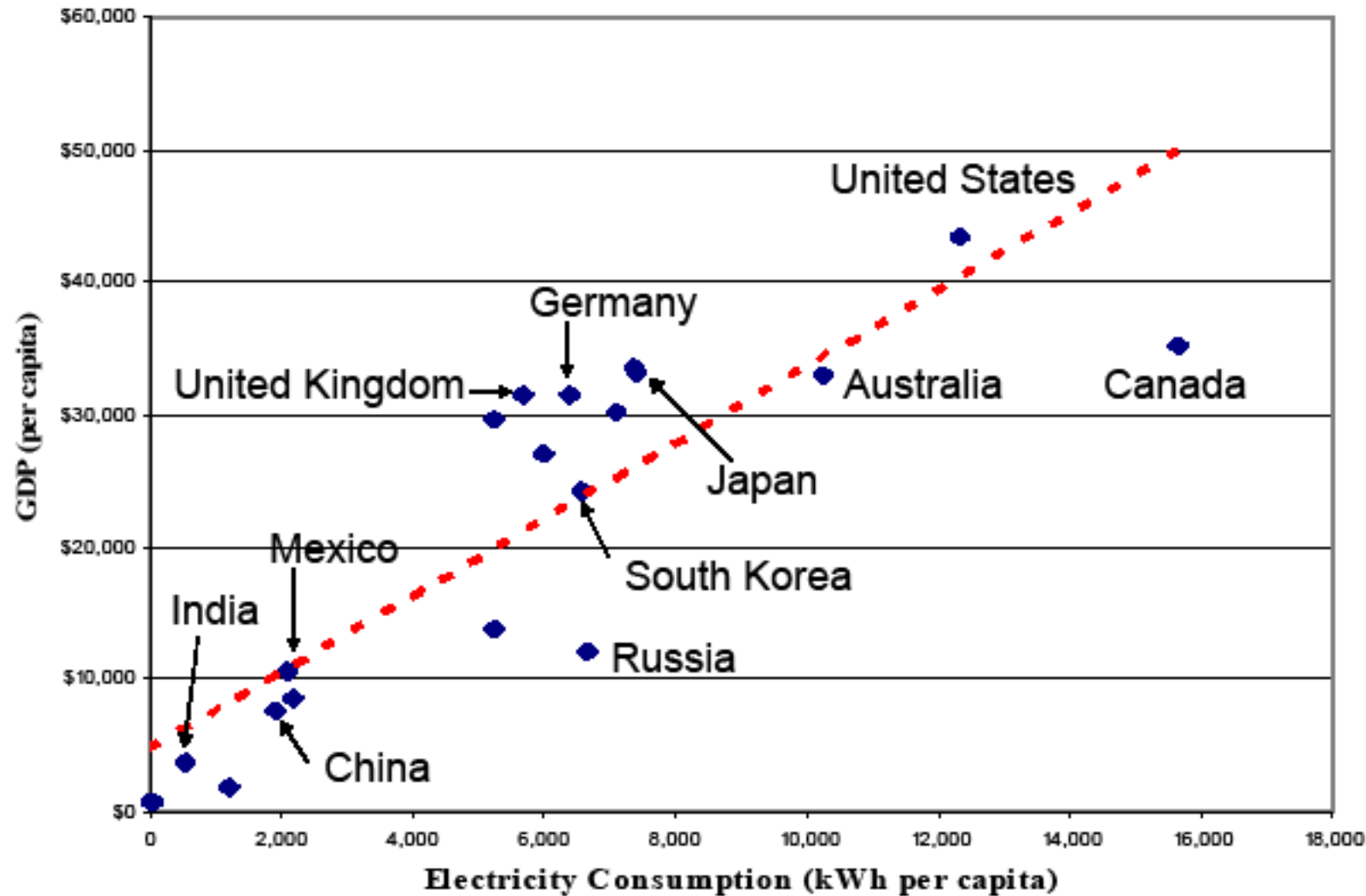


DATA: CRU, IFA

Soaring gas prices hit Europe fertilizers, chemicals



Quality of Life is Strongly Correlated with Electricity Consumption

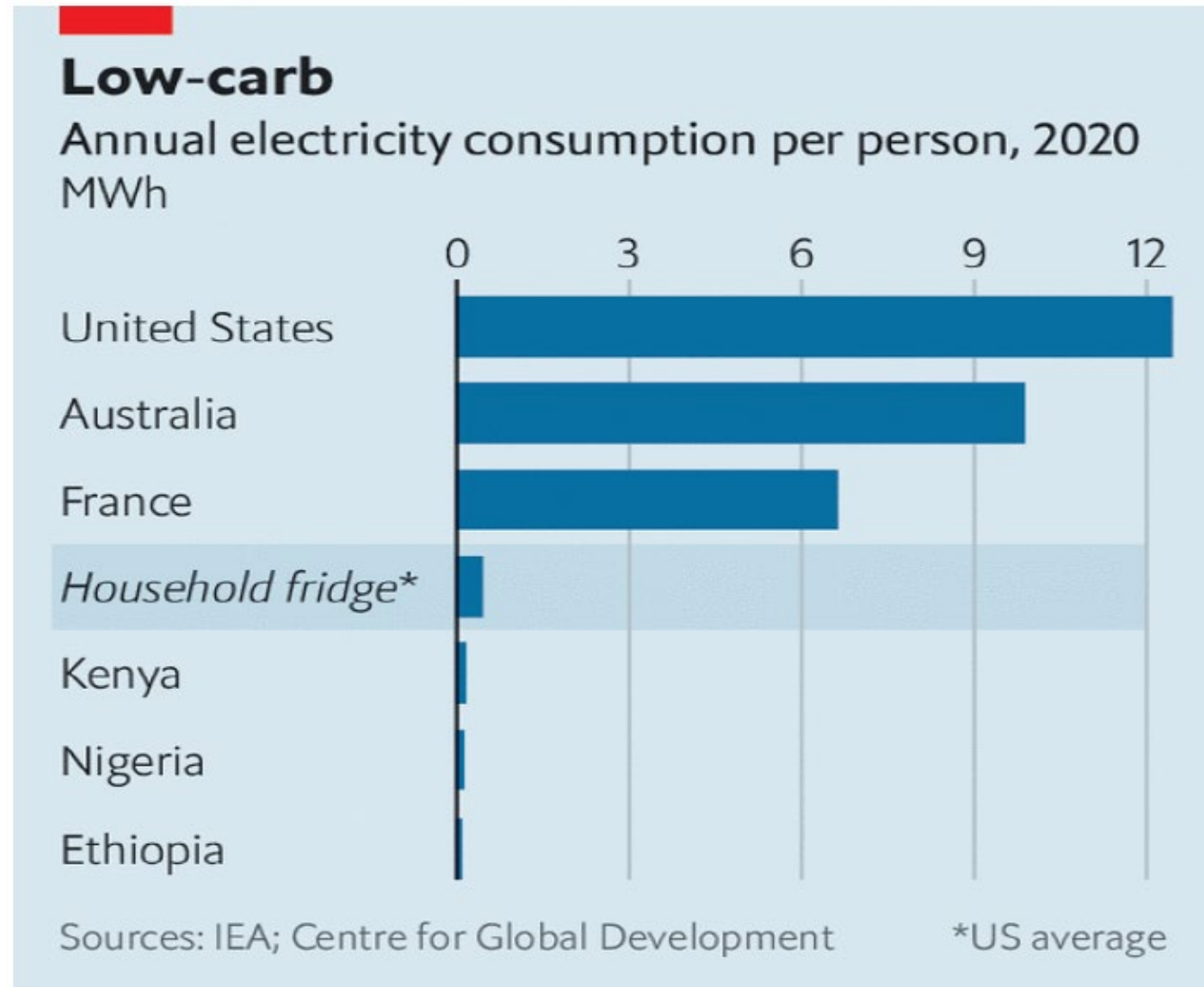


Source: CIA World Factbook, 2007

- In 2019, the world used a staggering 4.5 billion tons of cement, 1.8 billion tons of steel, 370 million tons of plastics, 200 million tons of fertilizer
- China produced more cement in 2020 and 2021 than the United States consumed in the entire 20th century
- 14% of worldwide oil demand and 8% of natural gas demand are used, not for energy, but as building blocks to make petrochemicals such as plastics and pharmaceuticals
- Steel alone accounts for 99% of metal consumption and is also 100% recyclable

3 Billion people in the world currently use less electricity than a typical American refrigerator

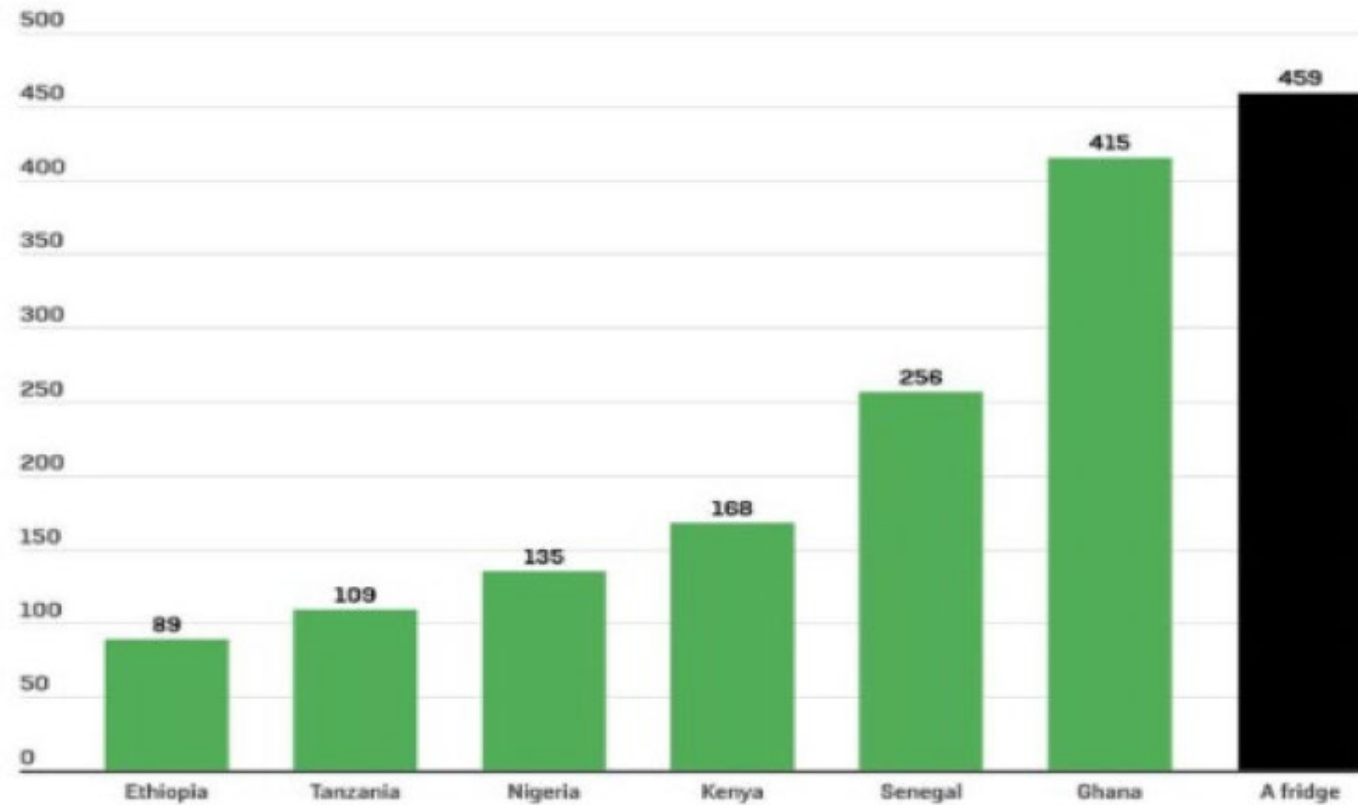




The Economist

Energy Use Per Person in Africa vs. a Typical American Refrigerator

Annual kilowatt-hours of electricity consumed per capita, 2017



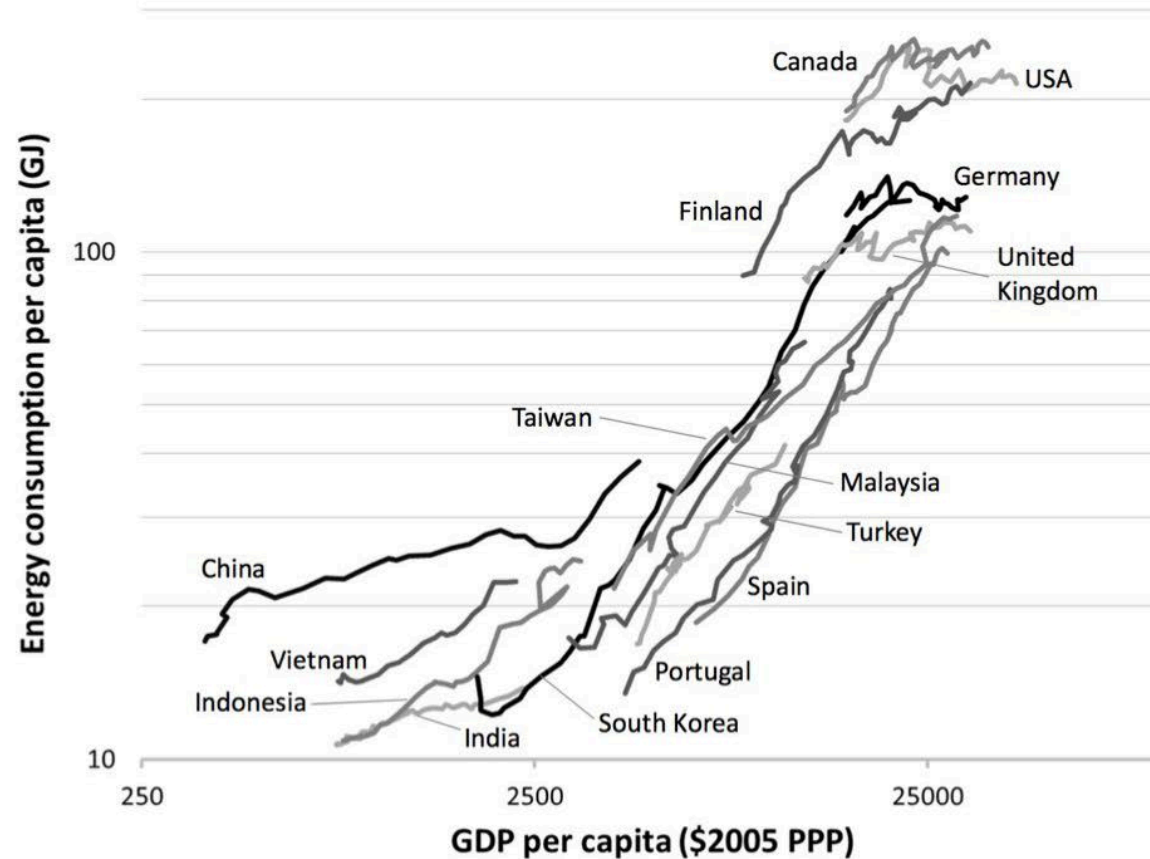
SOURCE: INTERNATIONAL ENERGY AGENCY AND ENERGY FOR GROWTH HUB

<https://toddmoss.substack.com/p/why-the-fridge-continues-to-resonate>

Over 1.2 billion people – 20% of the world's population – are still without access to electricity worldwide, almost all of whom live in developing countries. This includes about 550 million in Africa, and over 400 million in India.



Figure 1: The *Energy Ladder*: Per Capita Final Energy Consumption and GDP at PPP, 1960 – 2006

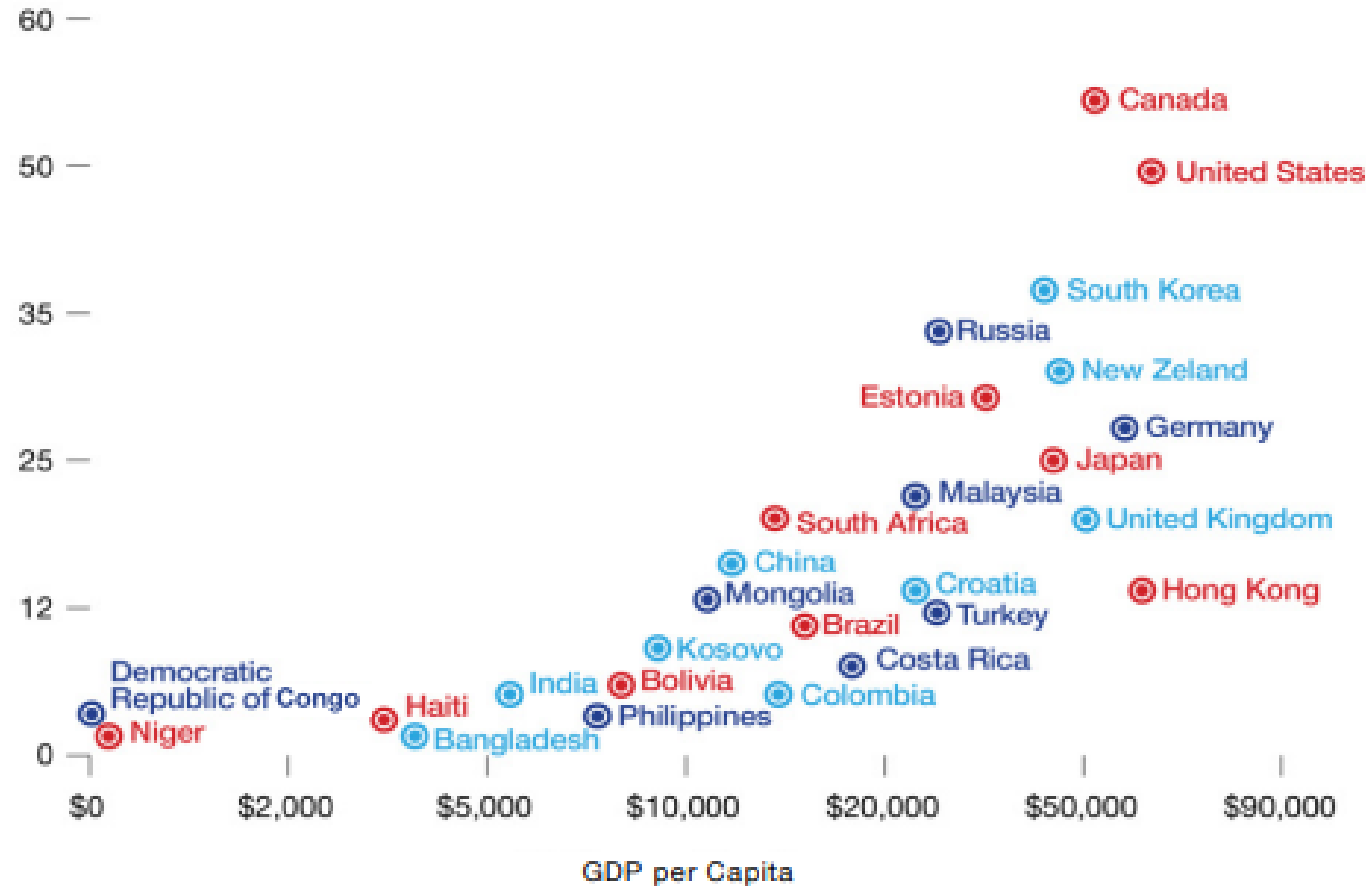


Notes: Both axes have a logarithmic scale. Energy consumption data are obtained from the International Energy Agency's Extended Energy Balances, GDP per capita from the World Bank's World Development Indicators.

Economic Growth Creates Demand for More Energy

Per Capita Wealth vs. per Capita Energy Use

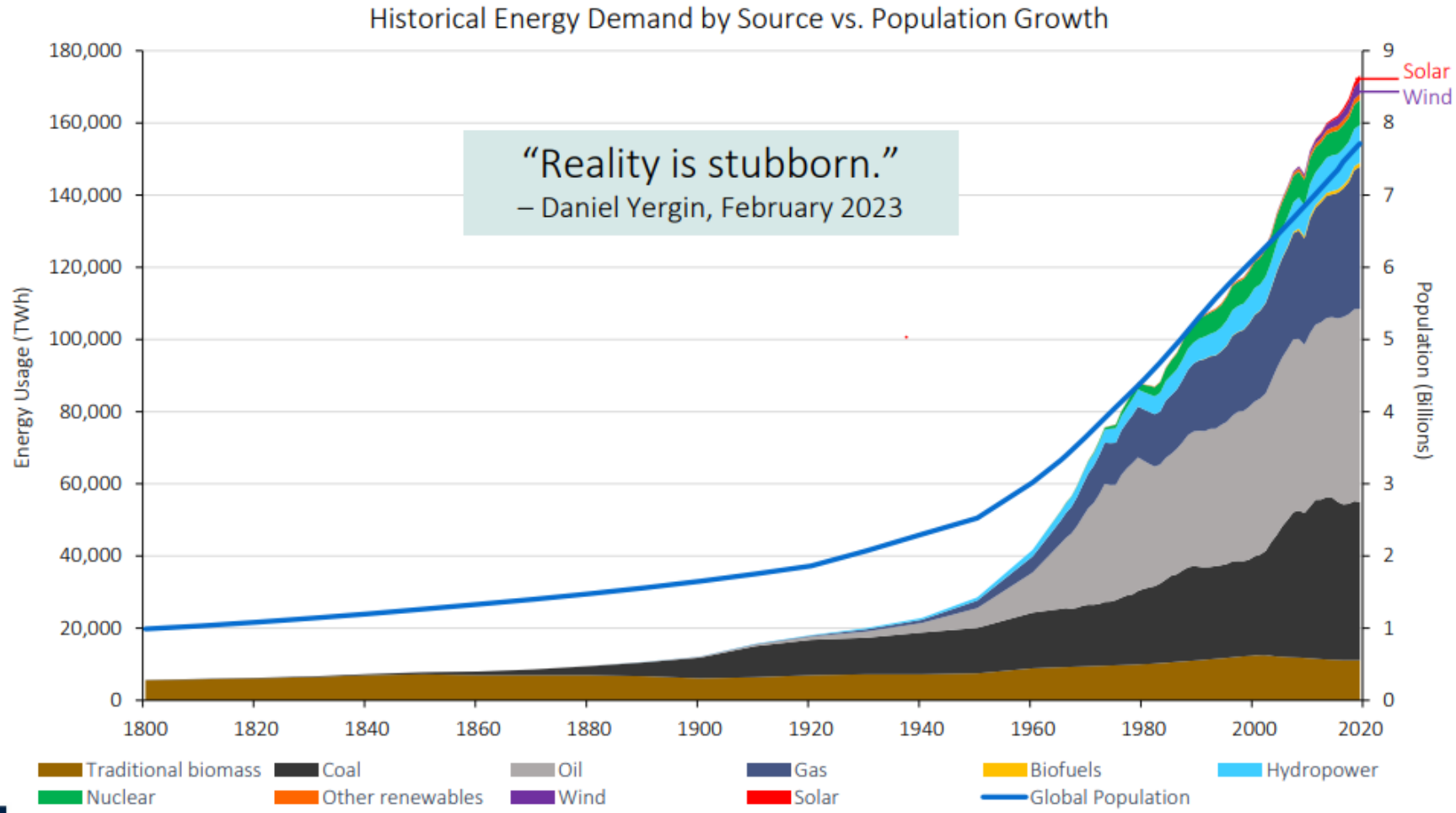
Energy per Capita (BOE/year)*



Note: Total energy measured as barrels-of-oil-equivalent (BOE). Thus, the average person in Japan, where GDP/capita is about \$50,000 uses about 25 BOE per year vs. about 5 BOE in India, where GDP per capita is around \$5,000

Global Population Growth Drives Energy “Addition”

Over the past century, global energy usage increased rapidly in connection with industrialization and rising global population. Further, from 1965 to 2021, per capita energy consumption grew 61%.

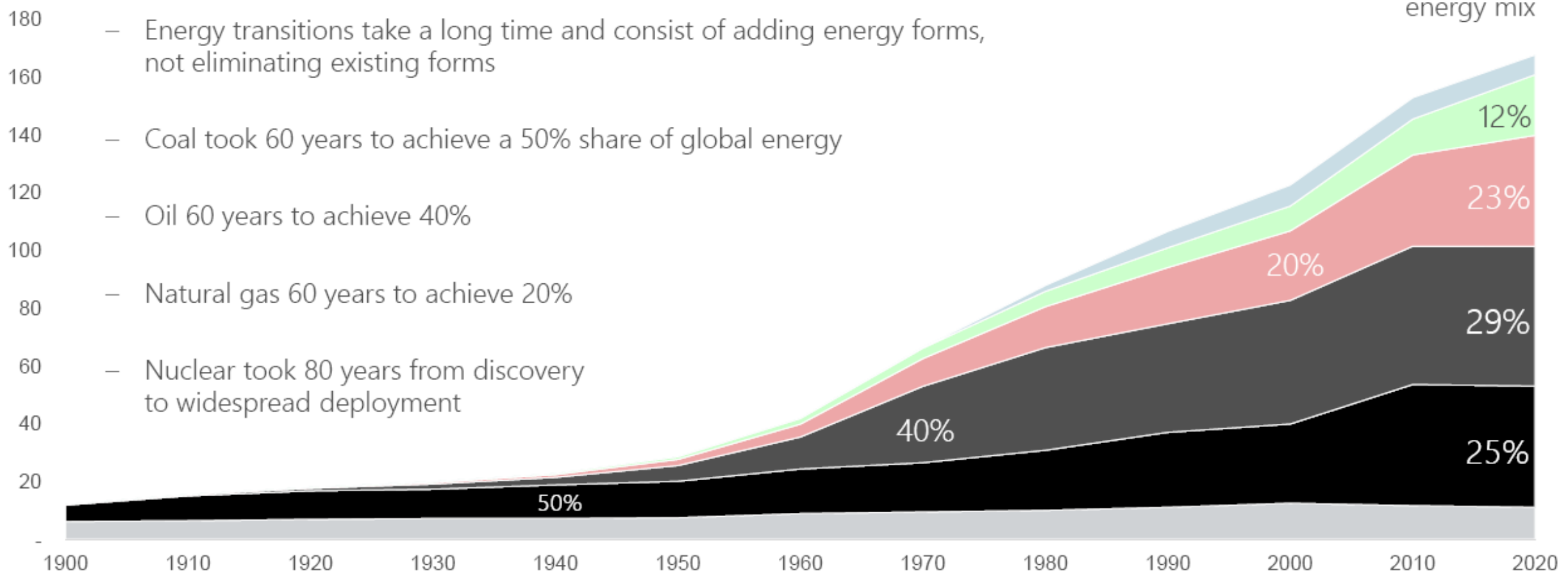


Energy Transitions Take Time

Our assets and services will be needed for a very long time

GLOBAL ENERGY MIX BY FUEL PWh

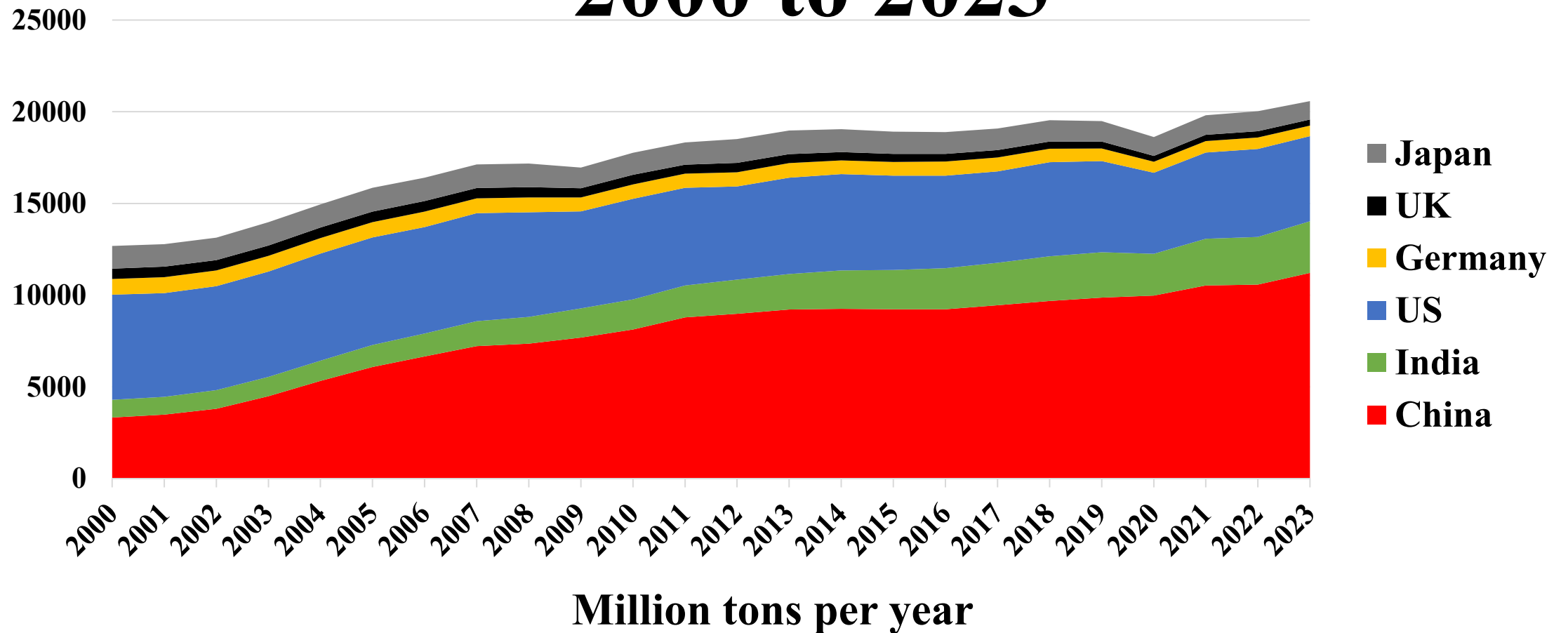
■ Biomass ■ Coal ■ Oil ■ Natural gas ■ Renewables ■ Nuclear



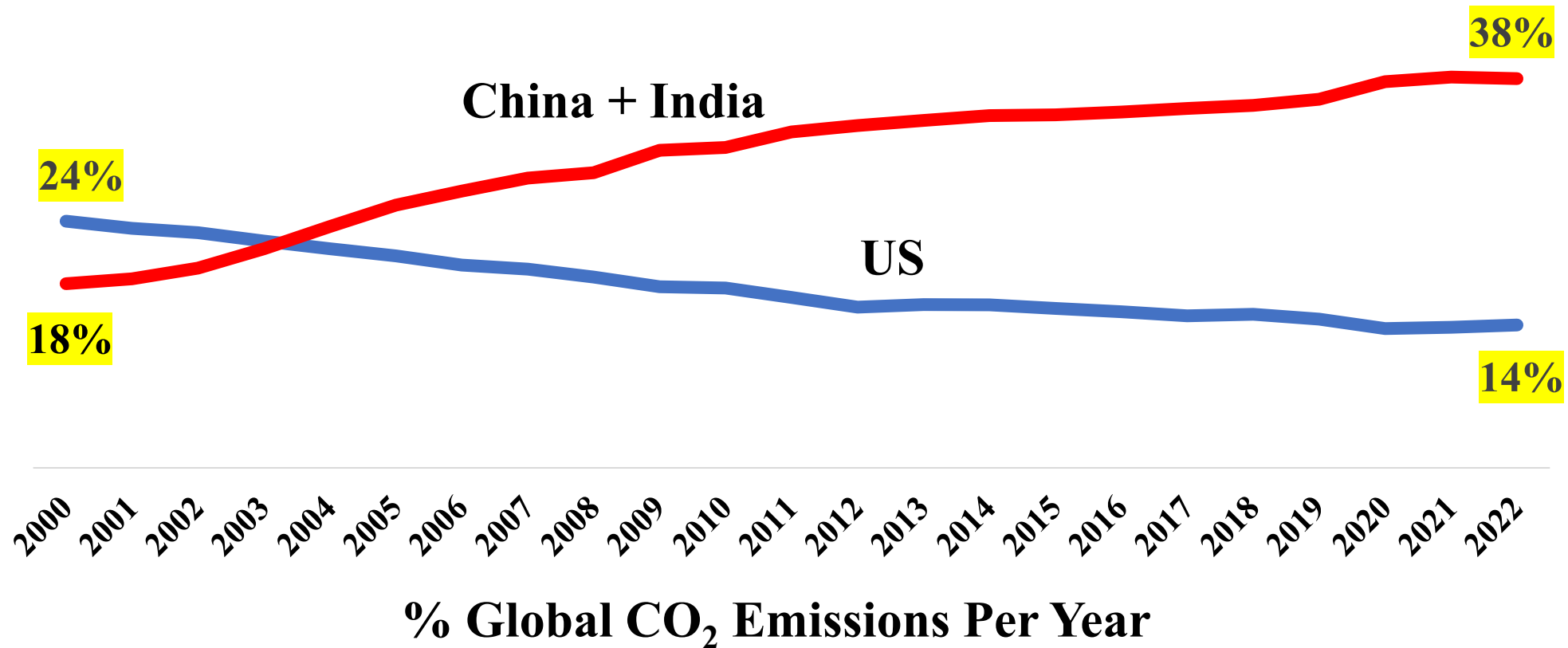
Source: Pre-1965 from *Energy Transitions: Global and National Perspectives*; 1965 and beyond from BP's Statistical Review of World Energy.

What Energy Transition?

CO₂ Emissions In Six Largest Economies, 2000 to 2023



Share Of Global CO₂ Emissions, US Versus China + India, 2000 to 2022



In 2021, US Hydrocarbon Use Grew ***5.7x Faster*** Than Wind + Solar Combined

Wind + Solar



**Net W+S:
+ 0.7 EJ**

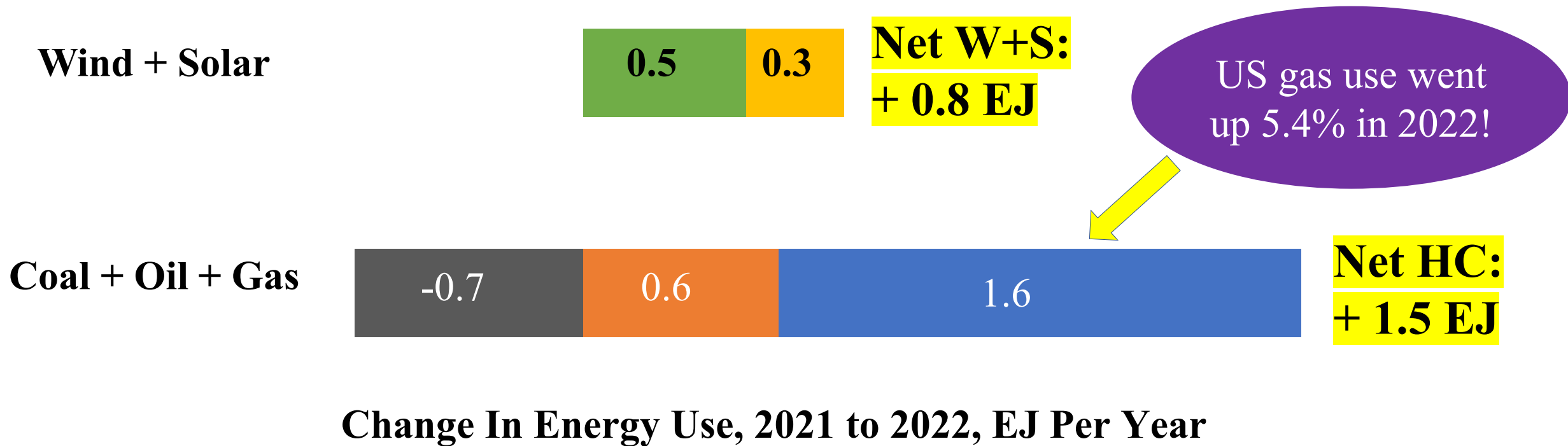
Gas + Oil + Coal



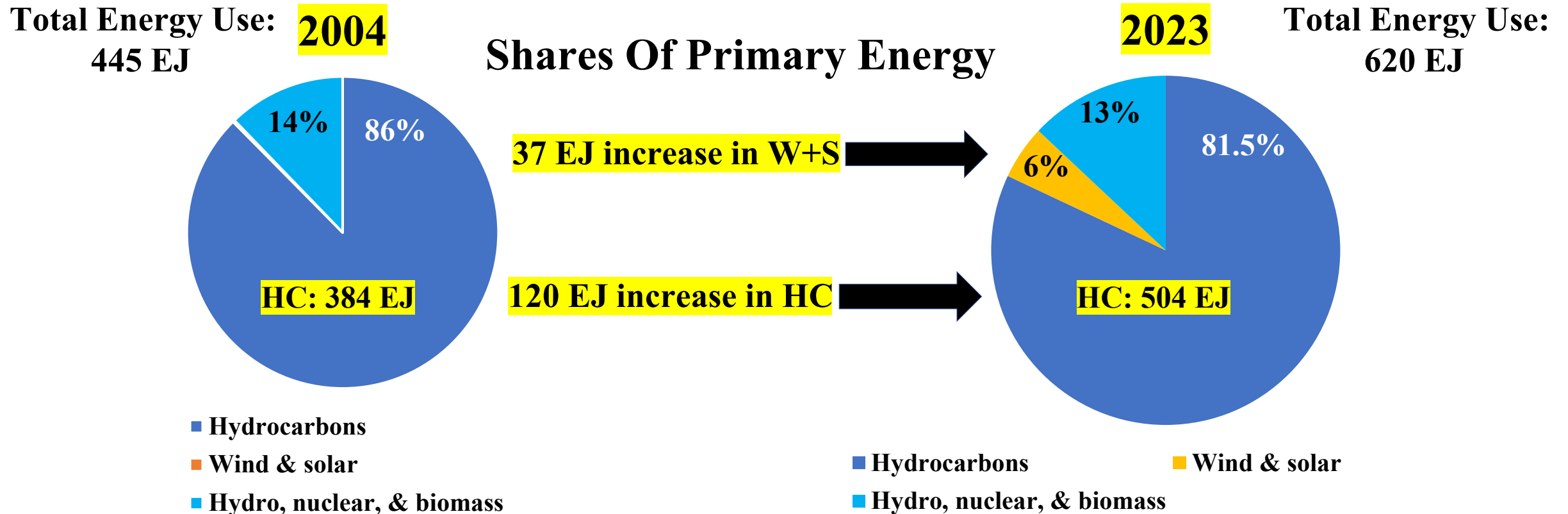
**Net HC:
+ 4.0 EJ**

Change, EJ per year

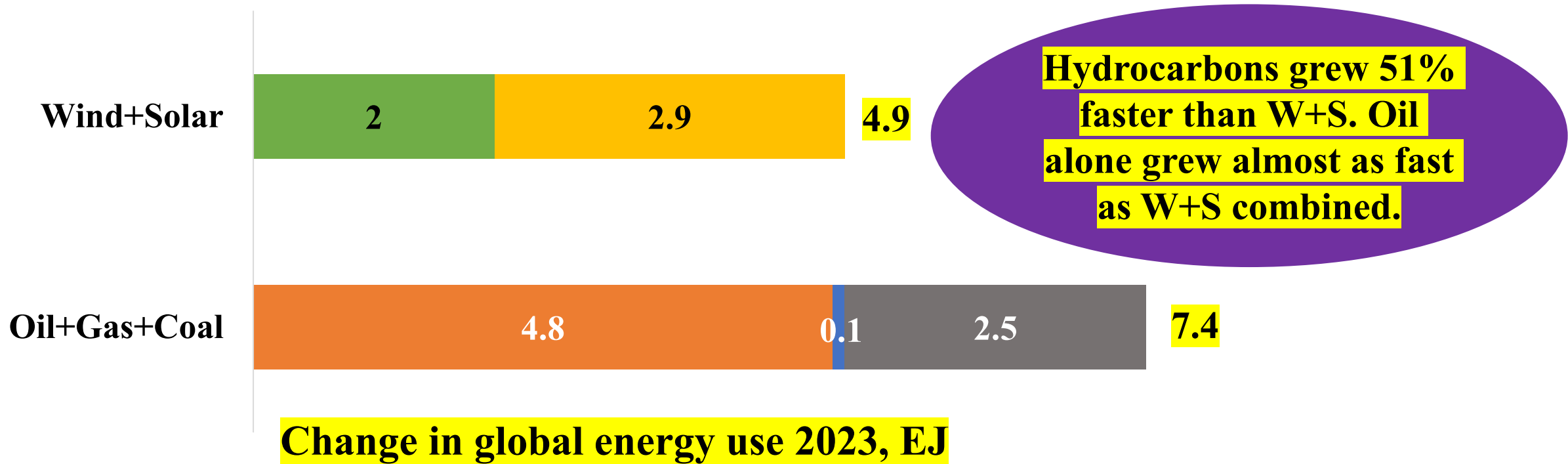
In 2022, US Natural Gas Use Grew 2x Faster Than W + S Combined



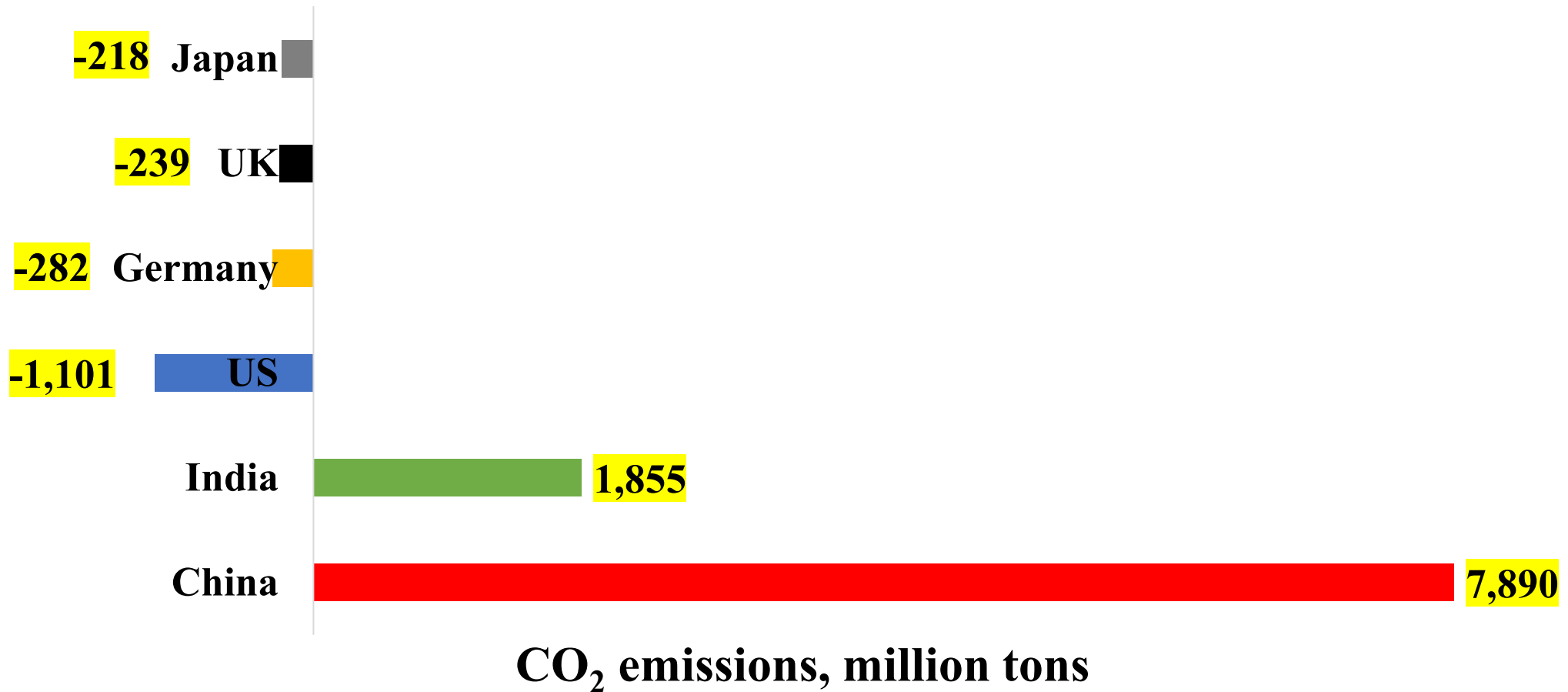
What Energy Transition? From 2004 to 2023, Global Spending On Wind + Solar Totaled \$4.7 Trillion **Yet Hydrocarbon Use Increased 3.2x Faster**



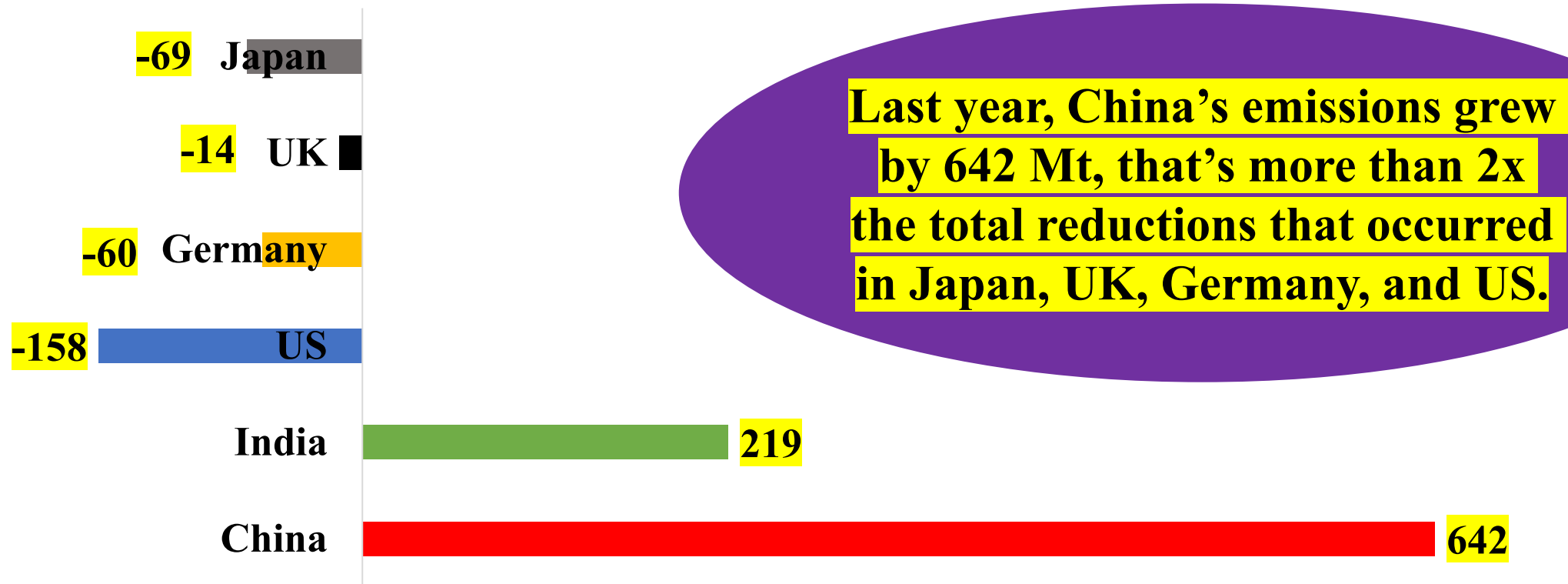
Hydrocarbons Grew Faster Than Wind + Solar Again In 2023



Change In CO₂ Emissions In The Six Largest Economies, 2000 to 2023



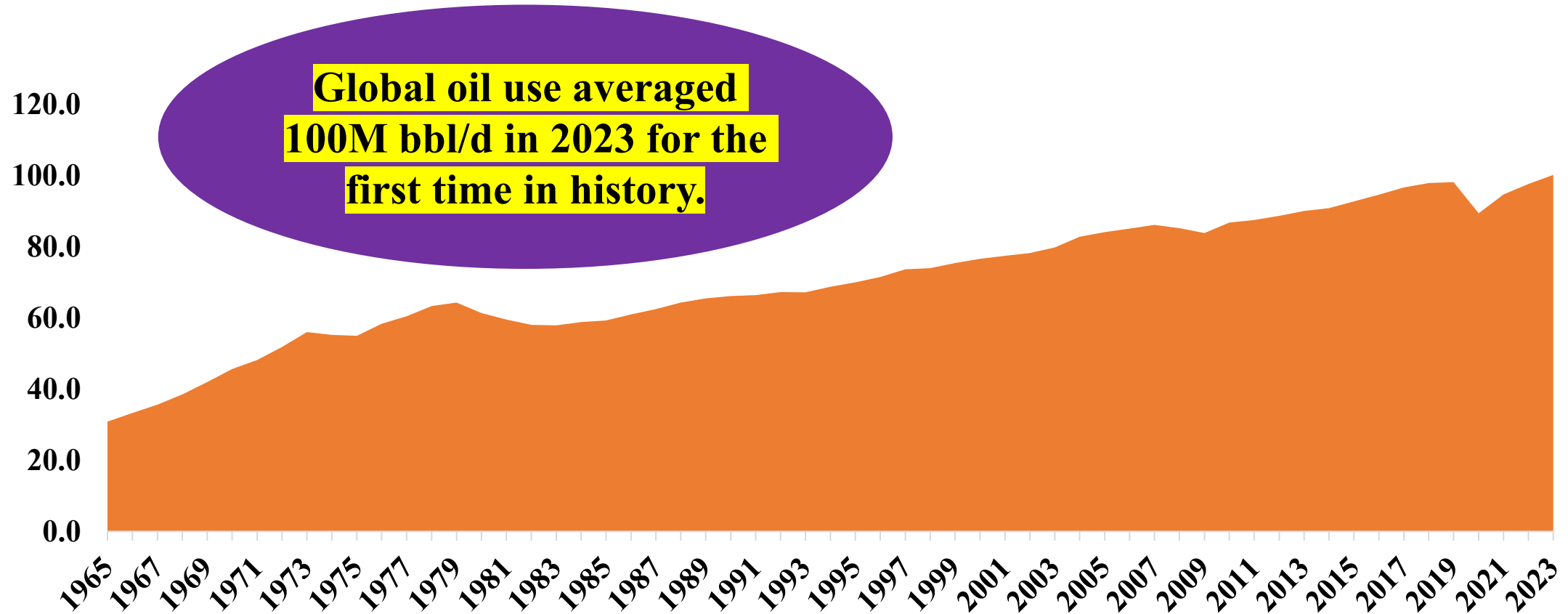
Change In CO₂ Emissions In The Six Largest Economies, 2023



CO₂ Emissions, Million Tons

Just Stop Oil?

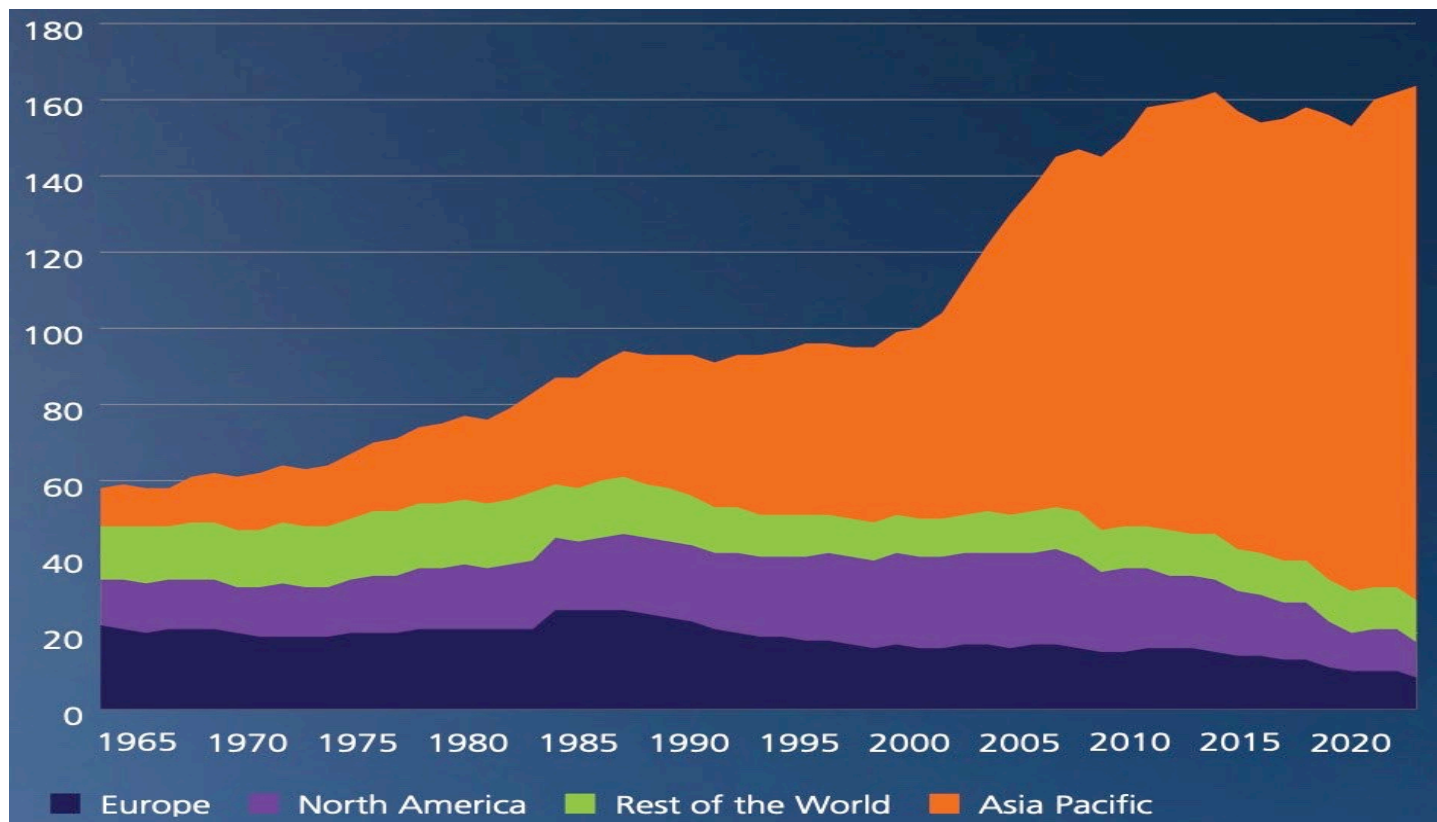
Global Oil Demand Is Going One Direction: Up



Oil demand 1965 to 2023, million barrels per day

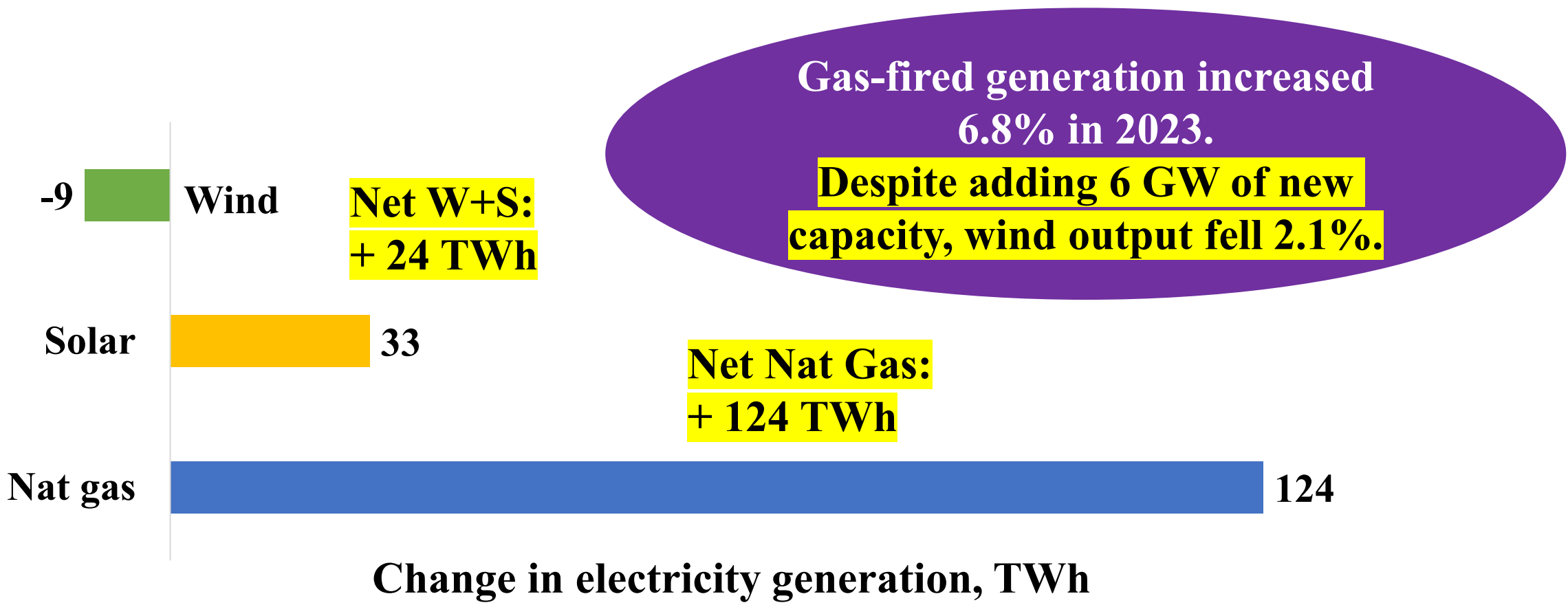
Just Stop Coal?

Coal use jumped 1.6% to set a new record, & India's use exceeded the combined consumption of Europe & N. America for first time.



Global coal use by region, 1965 to 2023, EJ/year

In 2023, U.S. Gas-Fired Generation Grew 5x Faster Than W + S Combined



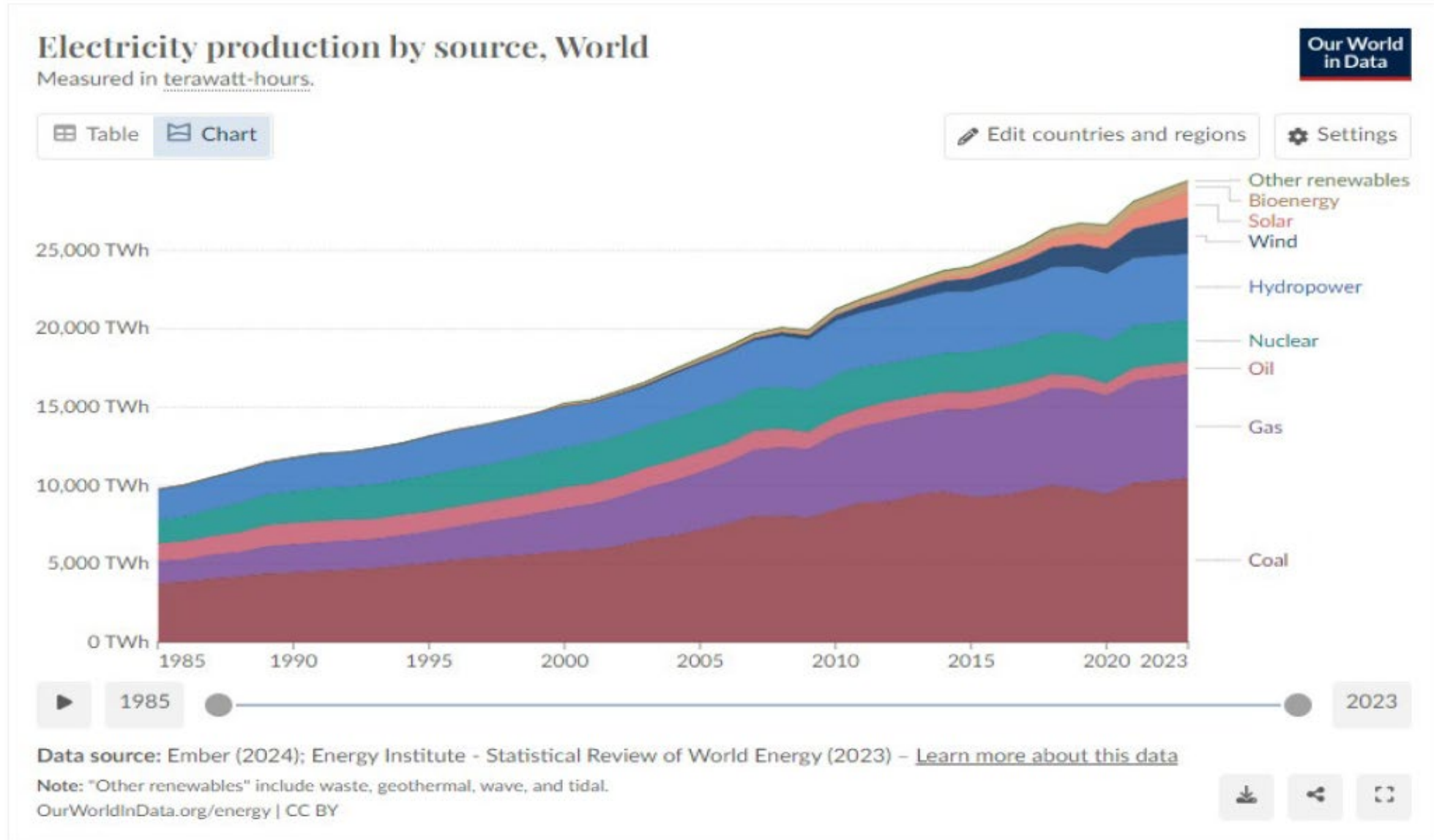
Source: Statistical Review of World Energy 2024

Again, It's All About Scale

It would require **15,280** storage centers the size of Escondido, the largest in California, to provide just **4 hours** of backup power for the U.S. grid — at an estimated cost of **\$764 billion**



Electricity production by source, World



One-Year Forward Strip

NYMEX Henry Hub	\$ 7.725
LNG Delivered Price to Europe	\$97.993

Comparative Forward Strips as of July 29, 2024

One-Year Forward Strip

NYMEX Henry Hub	\$ 2.898
LNG Delivered Price to Asia	\$13.060
LNG Delivered Price to Europe	\$37.500

Three-Year Forward Strip

NYMEX Henry Hub	\$ 3.665
LNG Delivered Price to Asia	\$12.258
LNG Delivered Price to Europe	\$34.888

* Settled price as of July 29, 2024



... be intellectually curious.

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[AlexEpstein.substack.com](https://alexepstein.substack.com)

“Energy and Civilization A History,” Vaclav Smil

“Bettering Human Lives,” Chris Wright, Liberty Energy

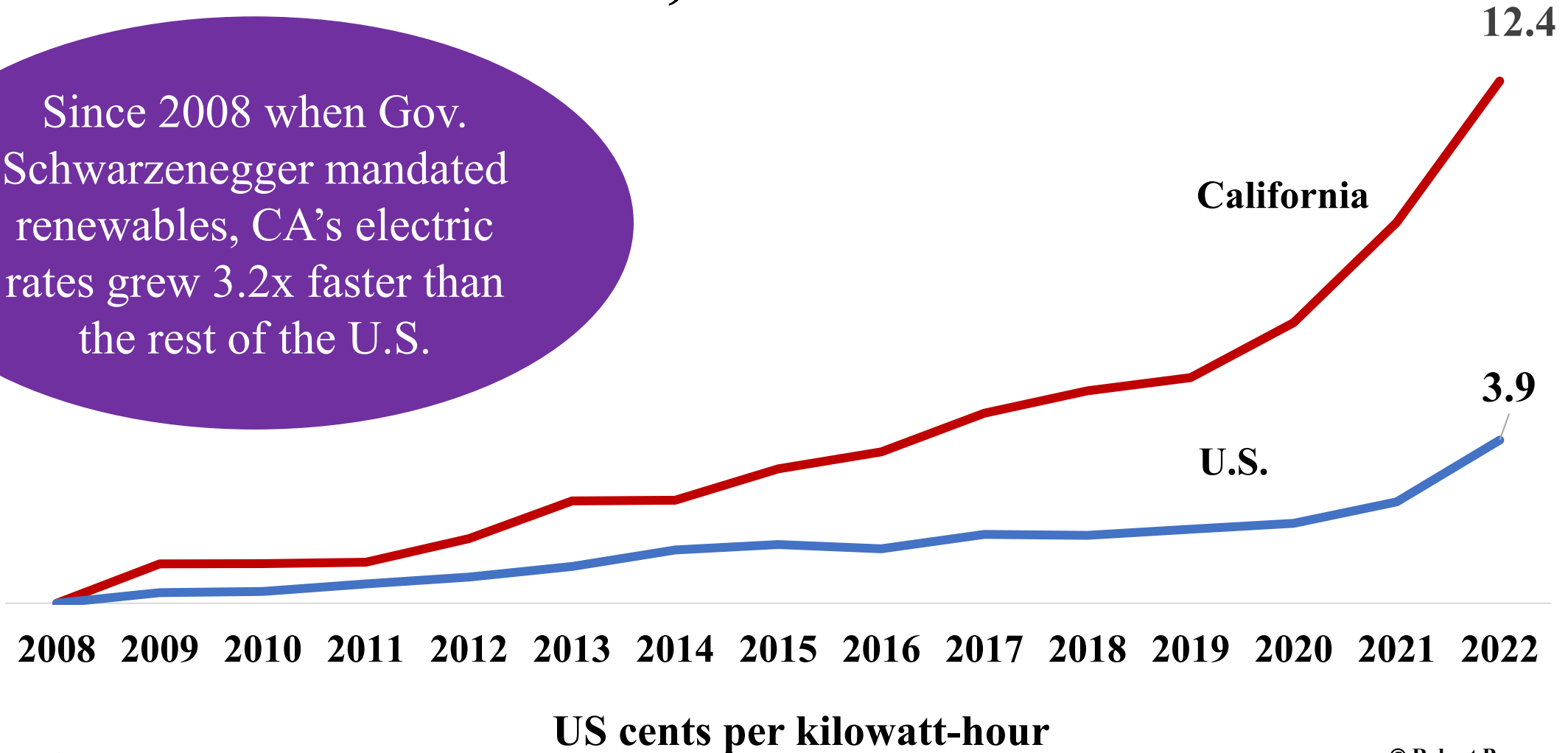
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[Unreportedstory.com](https://unreportedstory.com)

[Committeetounleashprosperity.com](https://committeetounleashprosperity.com)

Change In California Residential Electricity Prices, 2008 to 2022

Since 2008 when Gov. Schwarzenegger mandated renewables, CA's electric rates grew 3.2x faster than the rest of the U.S.



- The average per unit fuel cost for natural gas was roughly one-third the cost of electricity for the same on-site energy uses.
- Conversely, transitioning to an all-electric home would imply a two-fold increase to energy bills on average, increasing the financial burden on residential consumers as energy costs would amount to roughly 6.5% of the average household income.