

Energy Transitions: Understanding the Scale Challenge

Slides for Discussion

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“All Models are Wrong, but Some are Useful”

George G.P. Box

British Statistician, 1919-2013

**....Or Exactly How Hard is Net Zero When
Balancing Energy Security, Affordability
and Decarbonization?**



<https://youtu.be/1il-xk8JLns>

Scale Problem: LNG

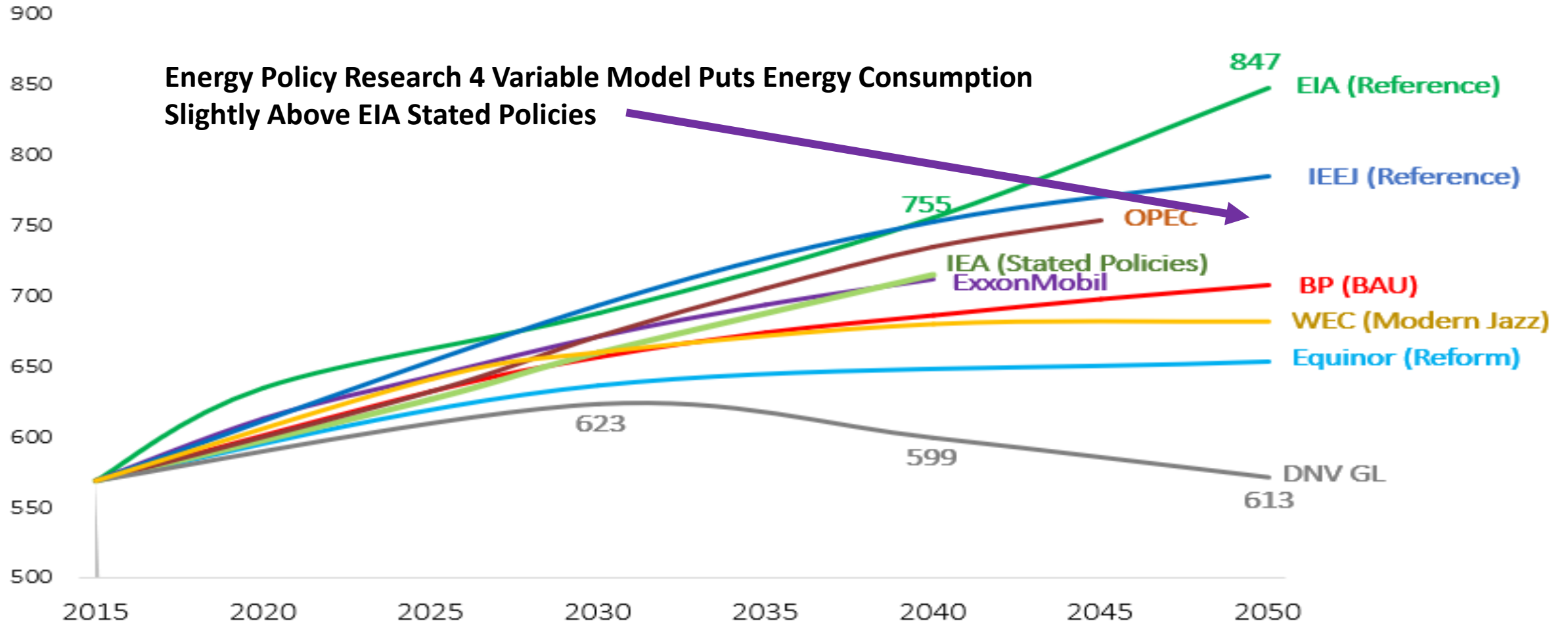
<https://www.youtube.com/watch?v=-MEtLfu4u-4>

Scale Problem: Coal Fired Power Plants Worldwide

From Dr. Francis Collins, Head of National Institutes of Health (Dr. Fauci's boss) upon his retirement earlier this year (2024).

“So you attach infinite value to stopping the disease and saving a life. You attach a zero value to whether this actually totally disrupts people’s lives, ruins the economy, and has many kids kept out of school in a way that they never quite recovered.” This, he explained, ***“is a public-health mindset,”*** which was ***“another mistake we made.”***

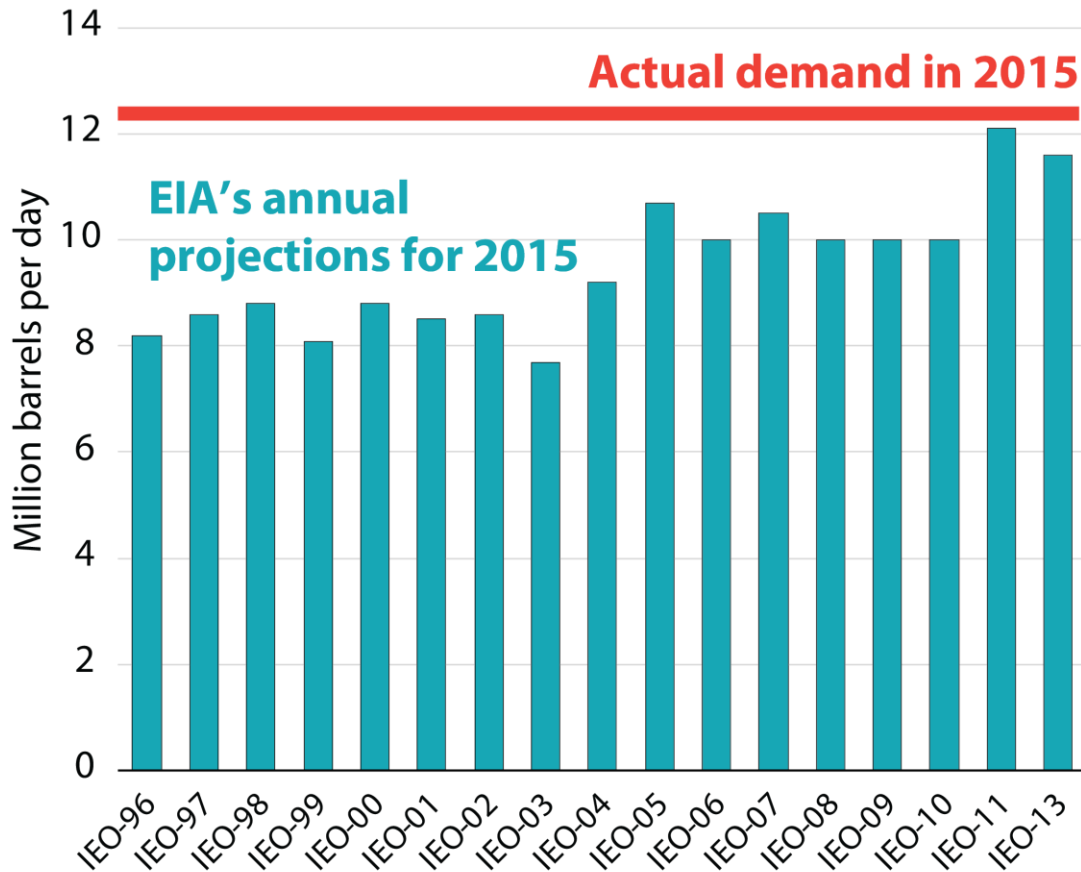
Uncertainty Dominates Model Projections



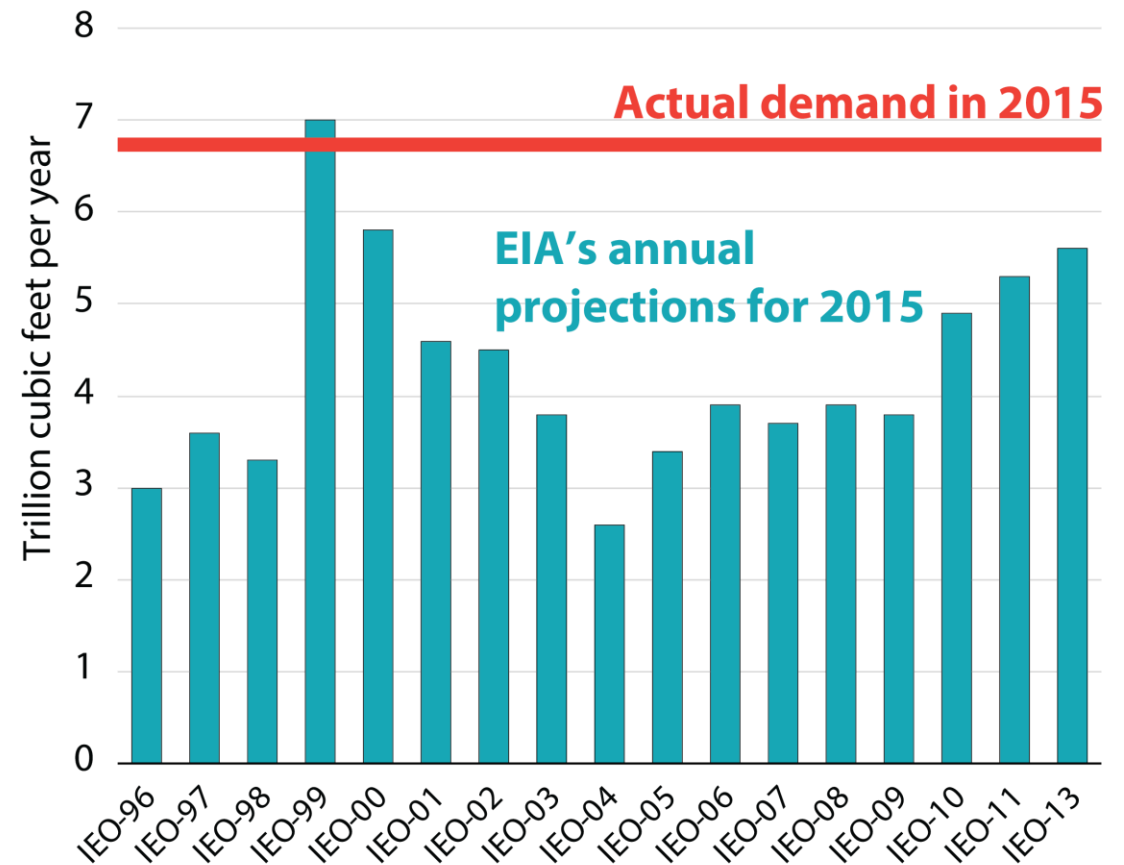
Data: IEA WEB, IEA WEO 2020, EIA IEO 2019, IEEJ Outlook 2020, OPEC WOO 2020, ExxonMobil OE 2019, BP EO 2020, Equinor EP 2020, WEC Scenarios 2019, DNV-GL ETO 2020

It's Hard to Predict Non-OECD Demand: China Case

China's Liquids Demand in 2015: Projected vs. Actual



China's Gas Demand in 2015: Projected vs. Actual

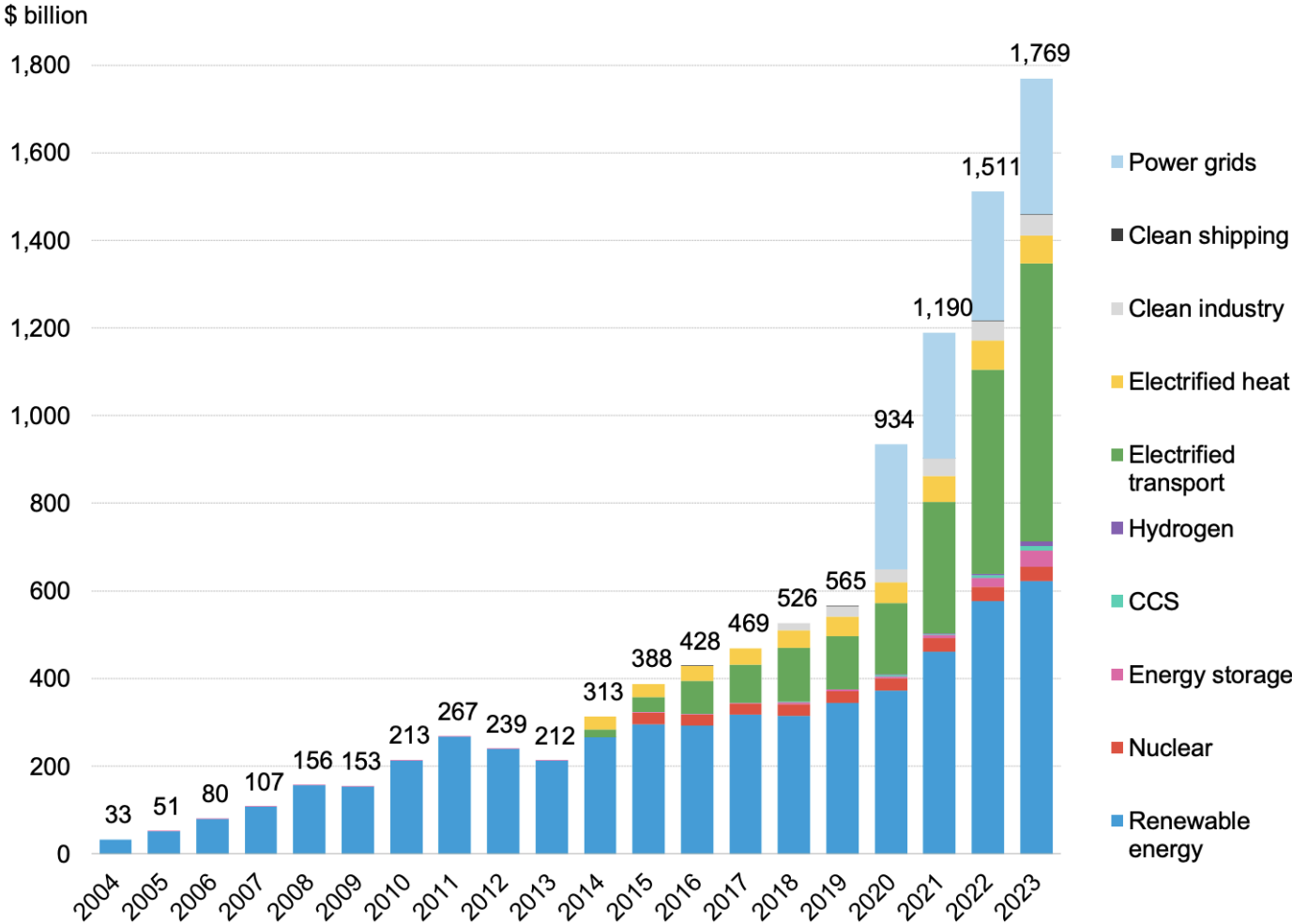


Source: U.S. EIA's International Energy Outlooks (IEO) 1996-2013, 2016, EPRINC.

Note: On March 27, 2023, CNPC announced that 2023 petroleum demand would be 756 million metric tons (mt). Earlier forecasts for 2023 were 690mt (2018), 705mt (2019) and 740mt (2020), all by Bloomberg

World Has Spent \$9.6 Trillion on Energy Transition

Global investment in energy transition, by sector



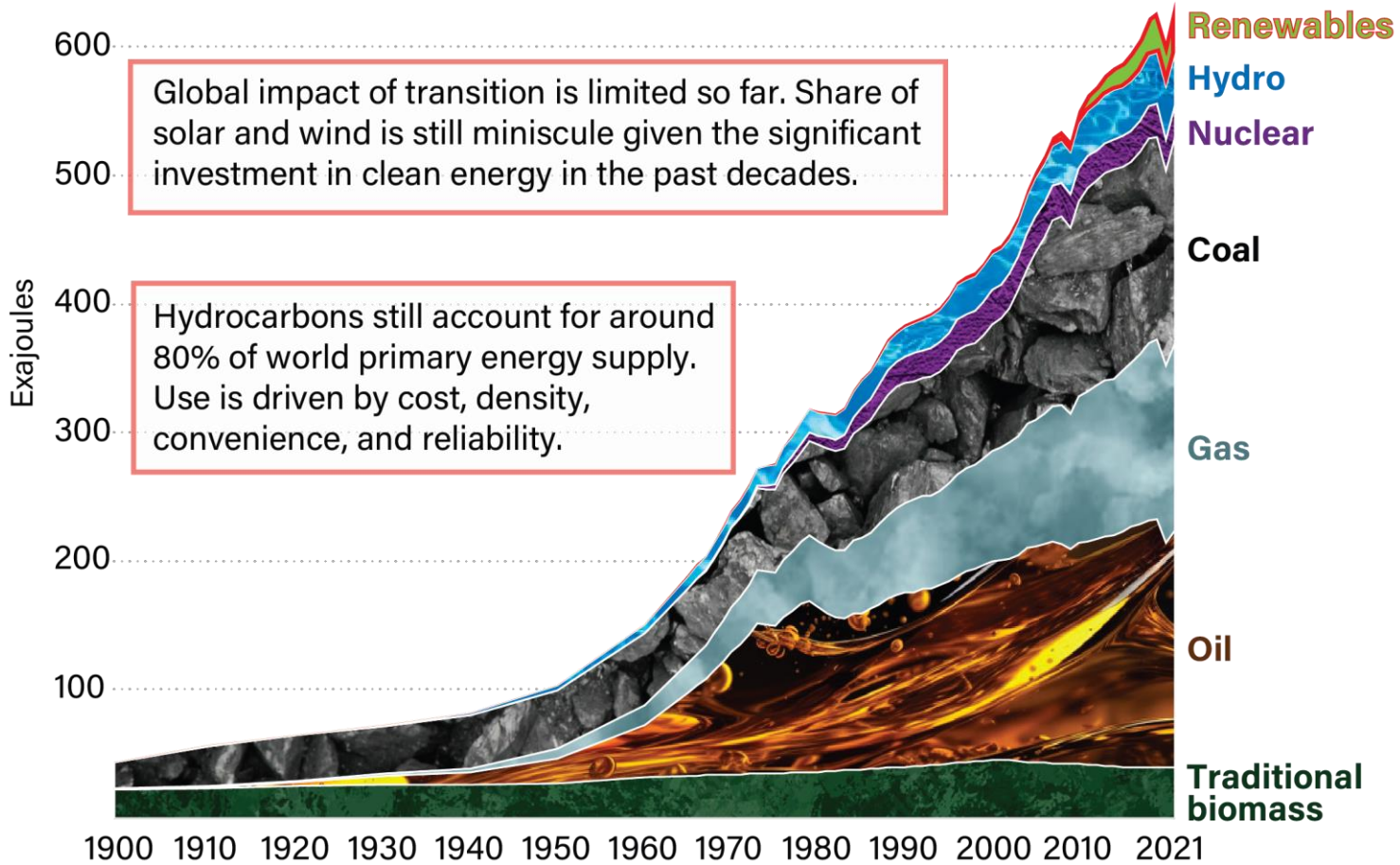
Global investments in energy transition have reached \$9.6 trillion over the past 20 years, according to a BloombergNEF analysis.

Most of these investments have been directed toward renewable energy and electrified transport.

Source: BloombergNEF. Note: Start years differ by sector but all sectors are present from 2020 onwards; see [Methodology](#) for more detail. Most notably, nuclear figures start in 2015 and power grids in 2020. CCS refers to carbon capture and storage.

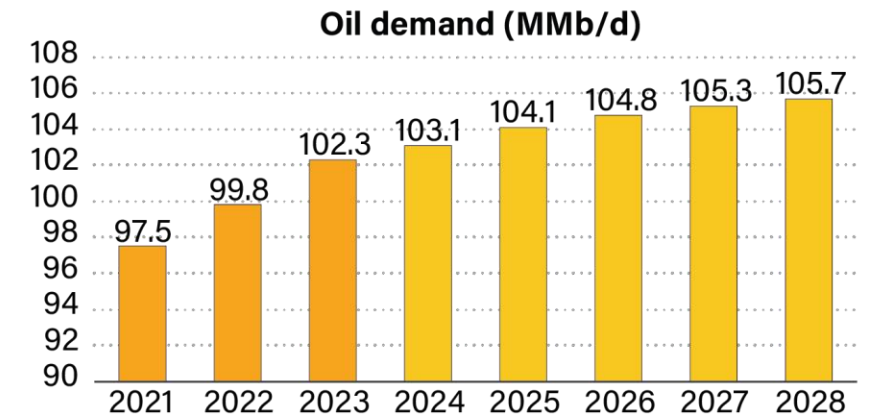
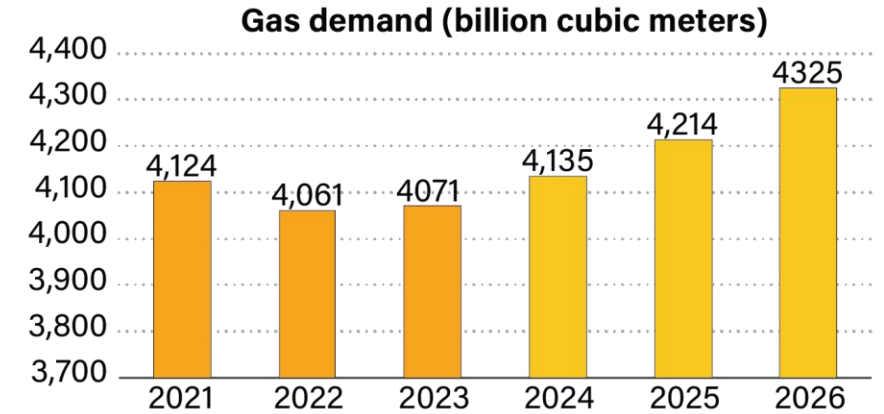
But Share of Fossil Energy Remains High

World Primary Energy Consumption (1900-2021)



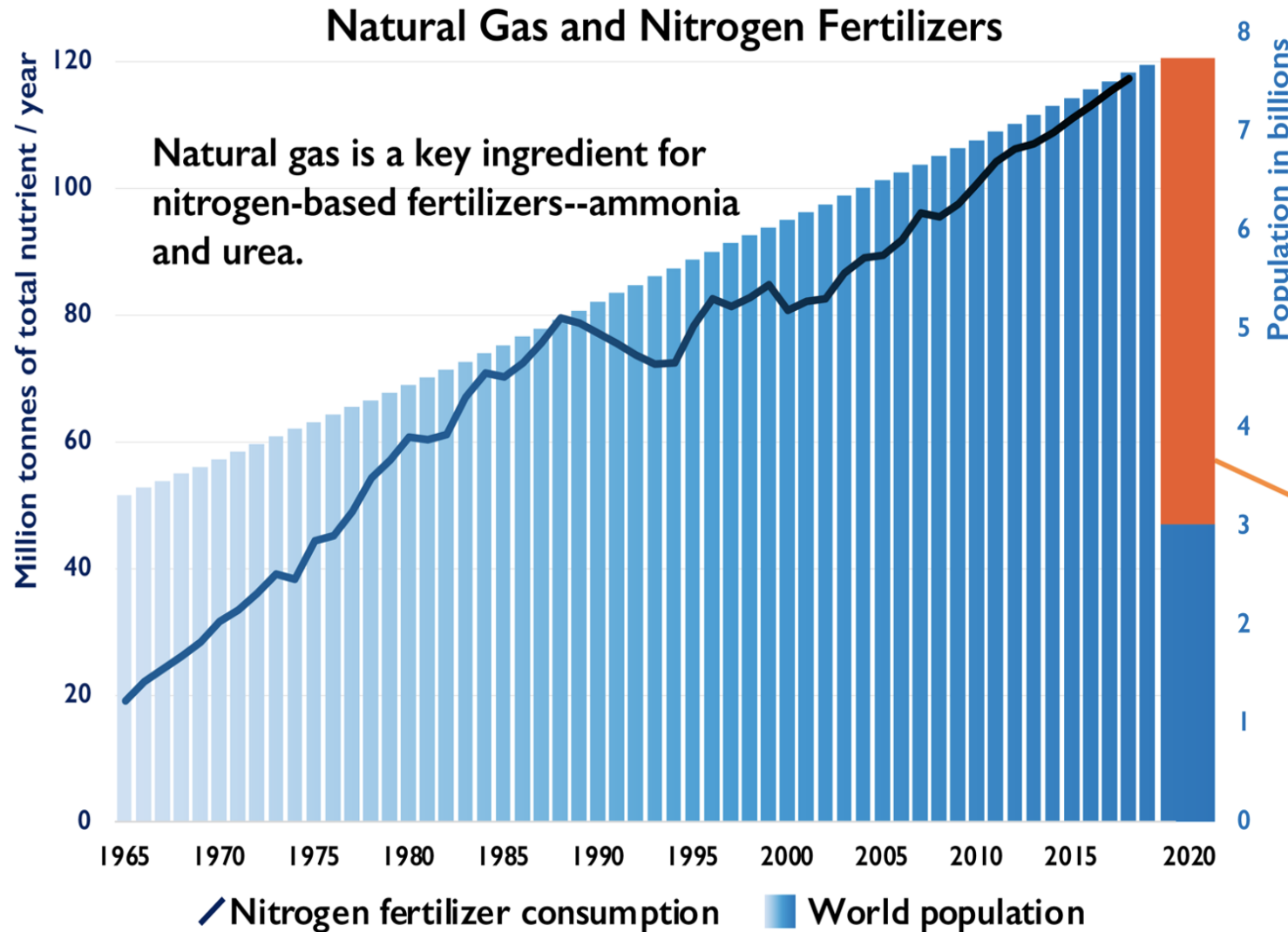
Source: Energy Policy Research, BP, Vaclav Smil

IEA forecast shows growing oil and gas demand:



Source: Energy Policy Research, IEA

World Food Production Depends on Fossil-based Fertilizers



“[Nitrogen fertilizer] has been called one of the greatest inventions of the 20th Century, and without it almost half the world's population would not be alive today.” - BBC

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,

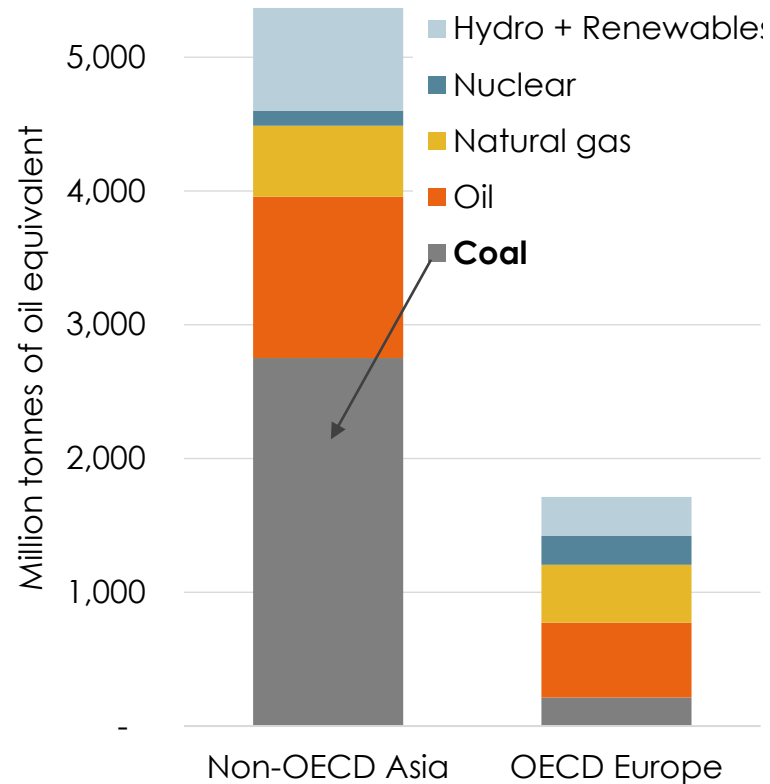
Different Pictures in Europe and Asia

Primary coal supply in non-OECD Asia (incl. China and India) was 2,751 Mtoe, 60% higher than the entire primary energy supply of OECD Europe.

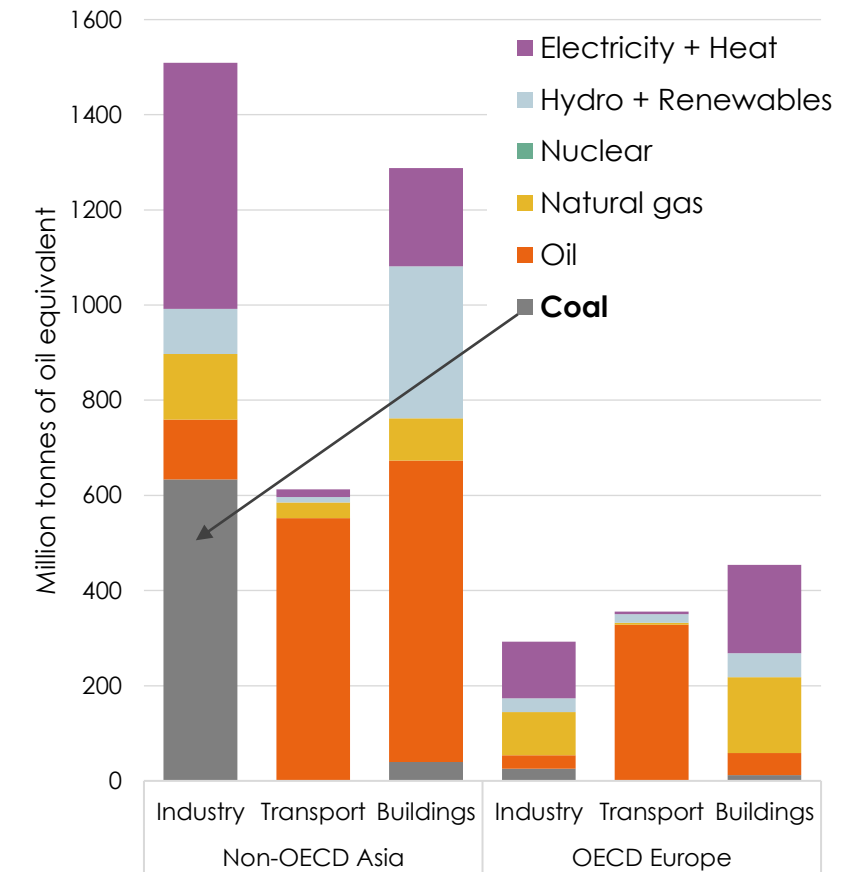
In final consumption, 94% of non-OECD Asia coal use is consumed in industry, incl. “harder-to-abate” sectors like cement and steel.

Fuel Mix in Non-OECD Asia (incl. China) and OECD Europe

Primary Energy Supply, 2019



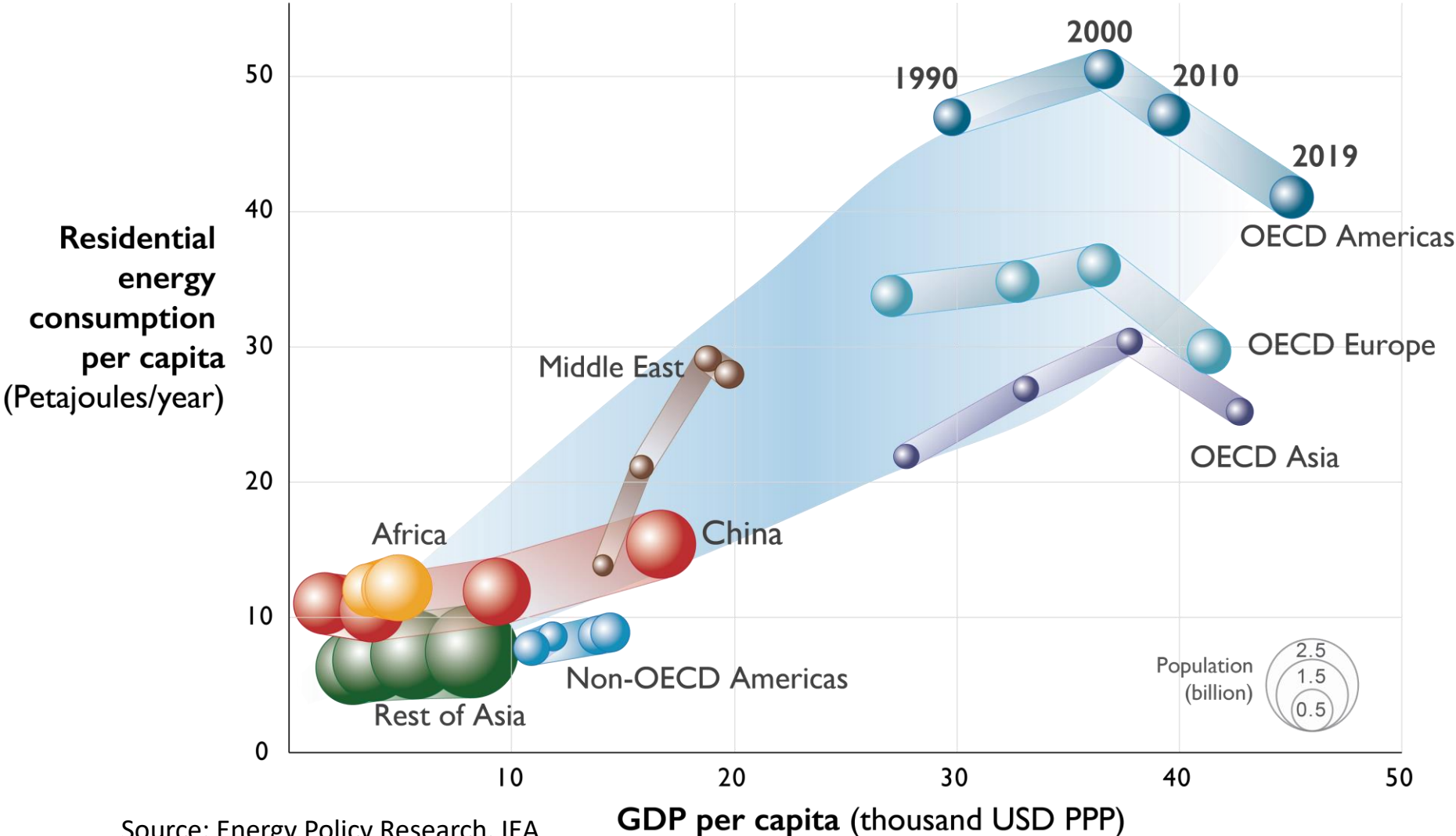
Final Consumption, 2019



Source: EPRINC figures based on IEA data

Non-OECD: Energy Must Grow to Meet Economic Progress

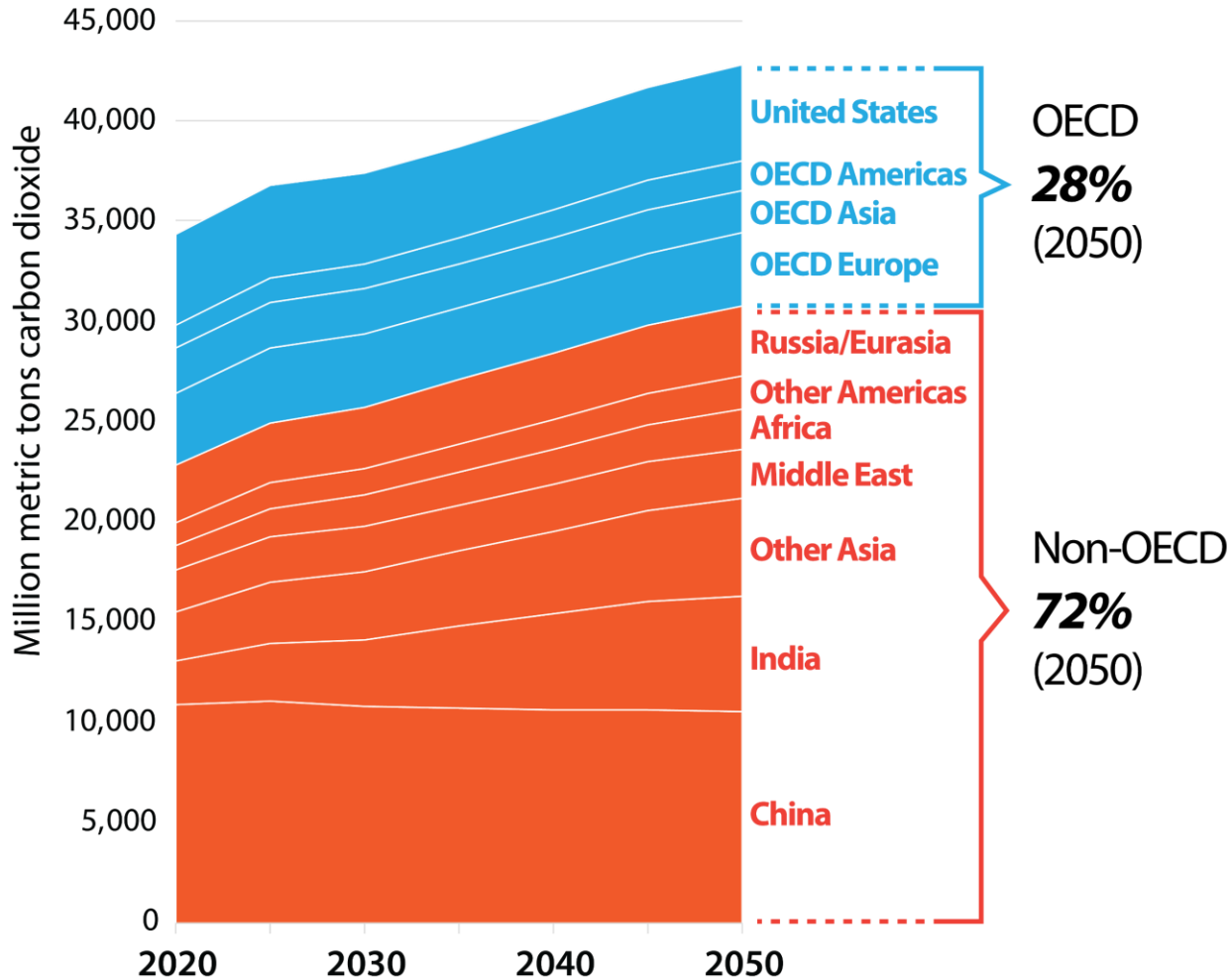
Primary Energy Requirements for Residential Consumption & GDP per Capita (1990-2019)



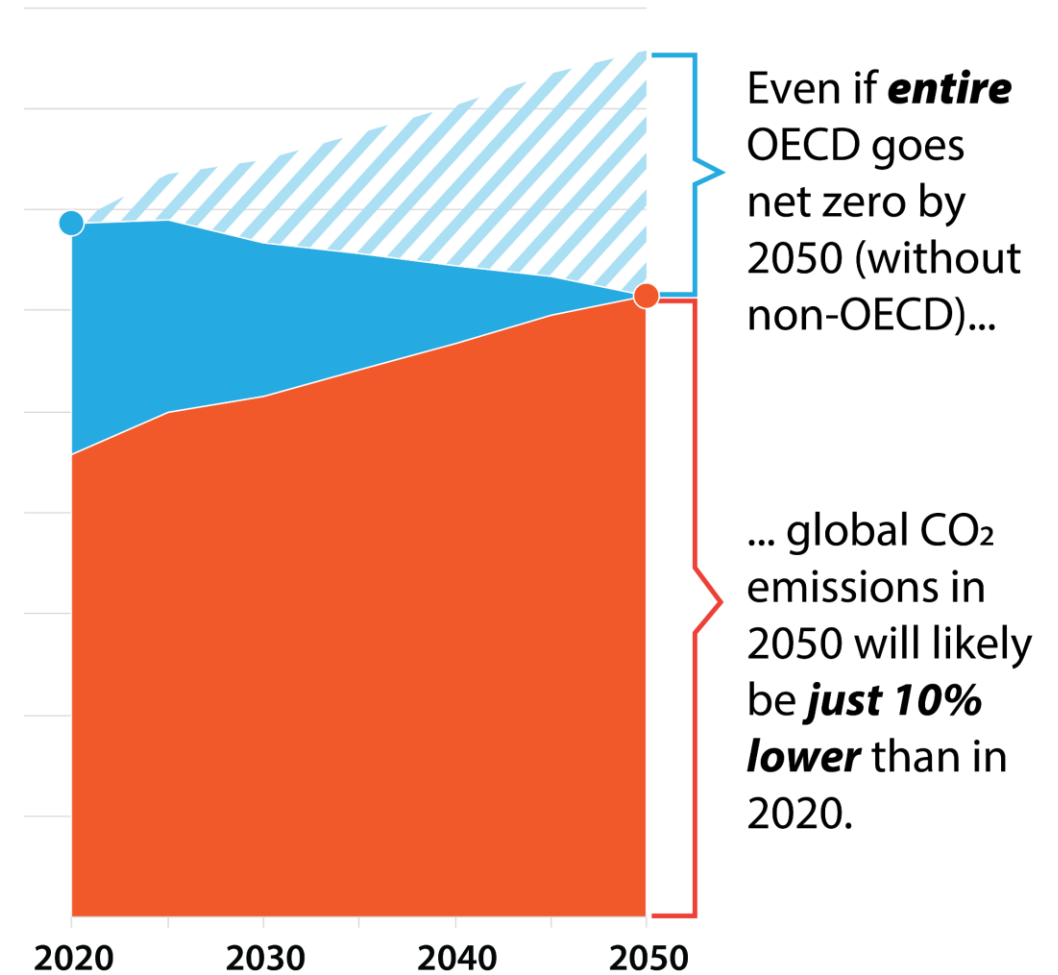
Source: Energy Policy Research, IEA

Problem with OECD-Centered Worldview

EIA Reference Case: *Projected CO₂ Emissions*

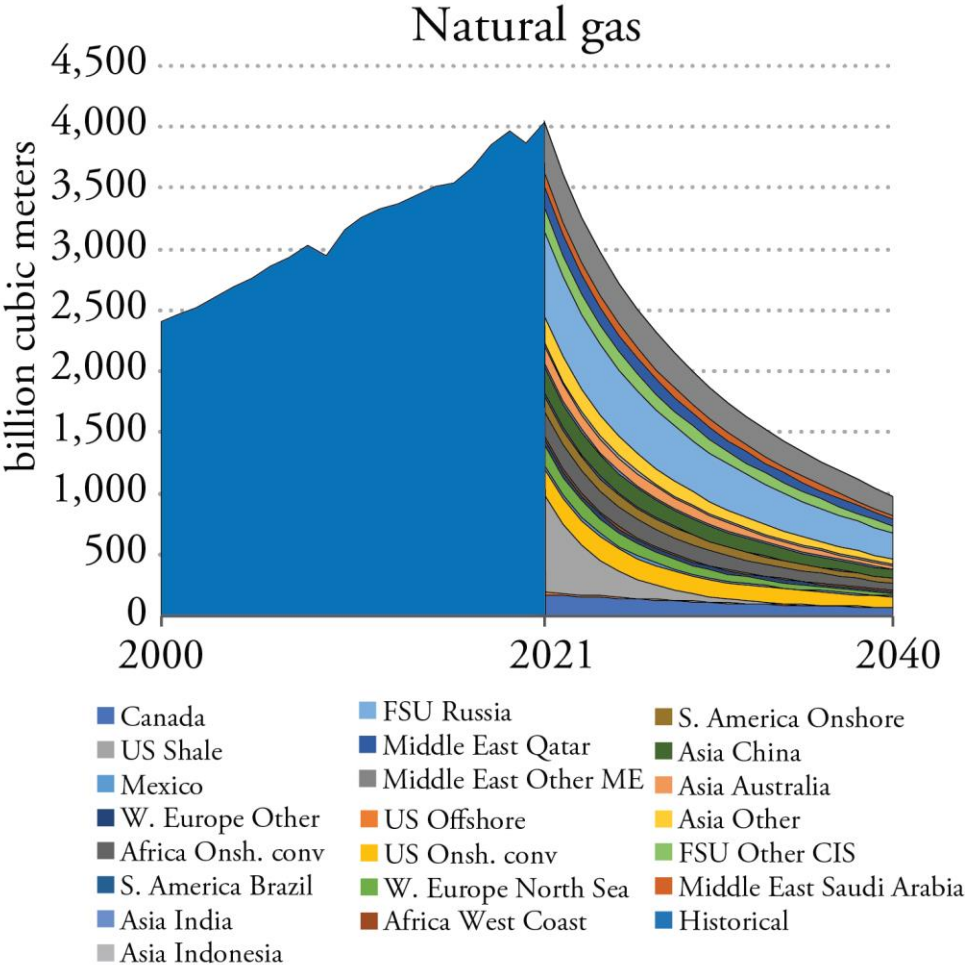
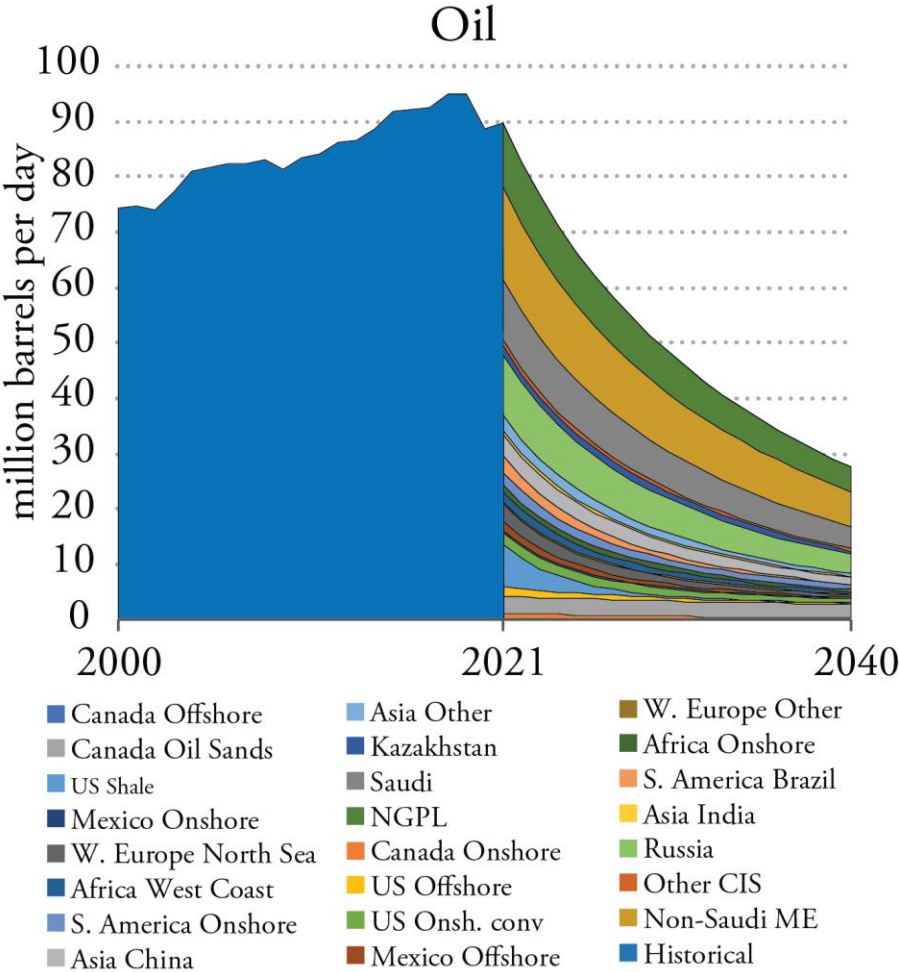


Will *OECD Net Zero* Matter?



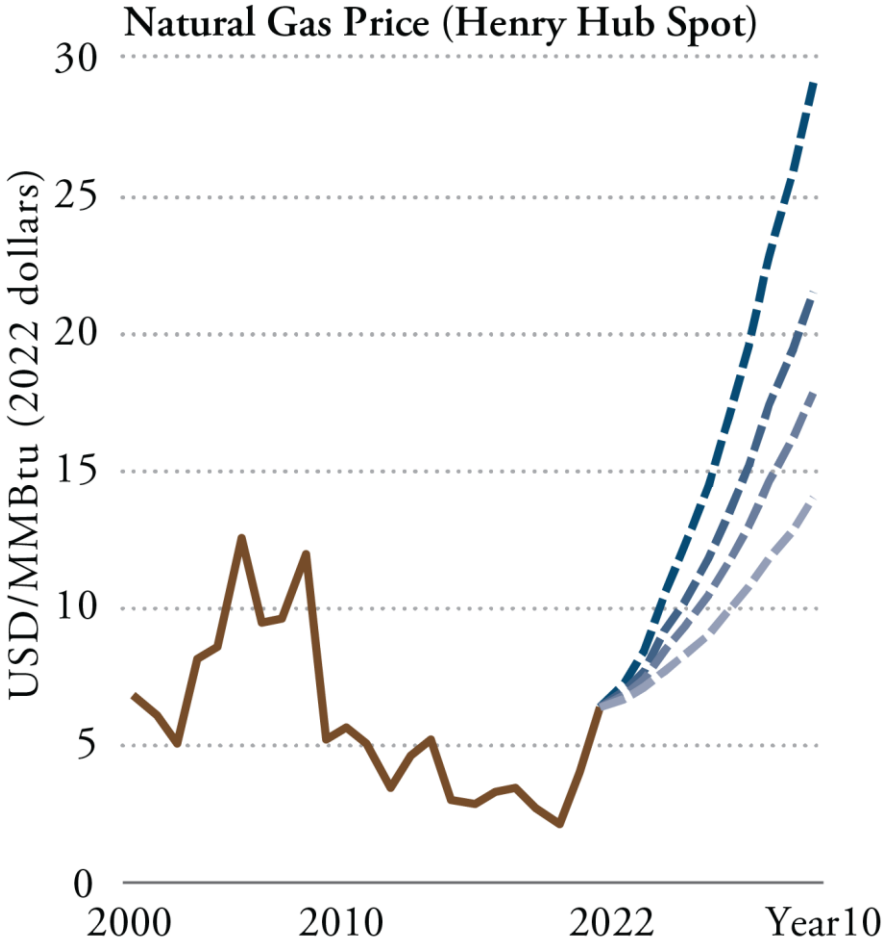
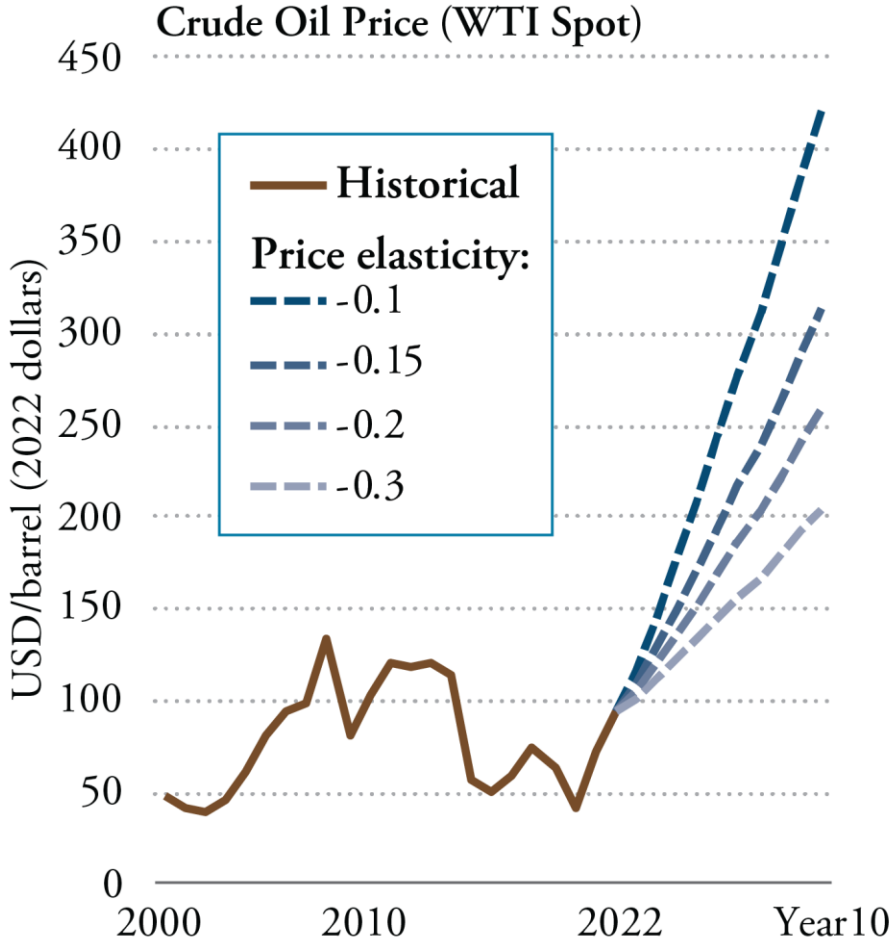
EPRINC analysis based on EIA's International Energy Outlook 2021 (most recent)

What Happens if Investment is Halted Worldwide for New Oil and Gas Development?



Source: Energy Policy Research, Michael Lynch

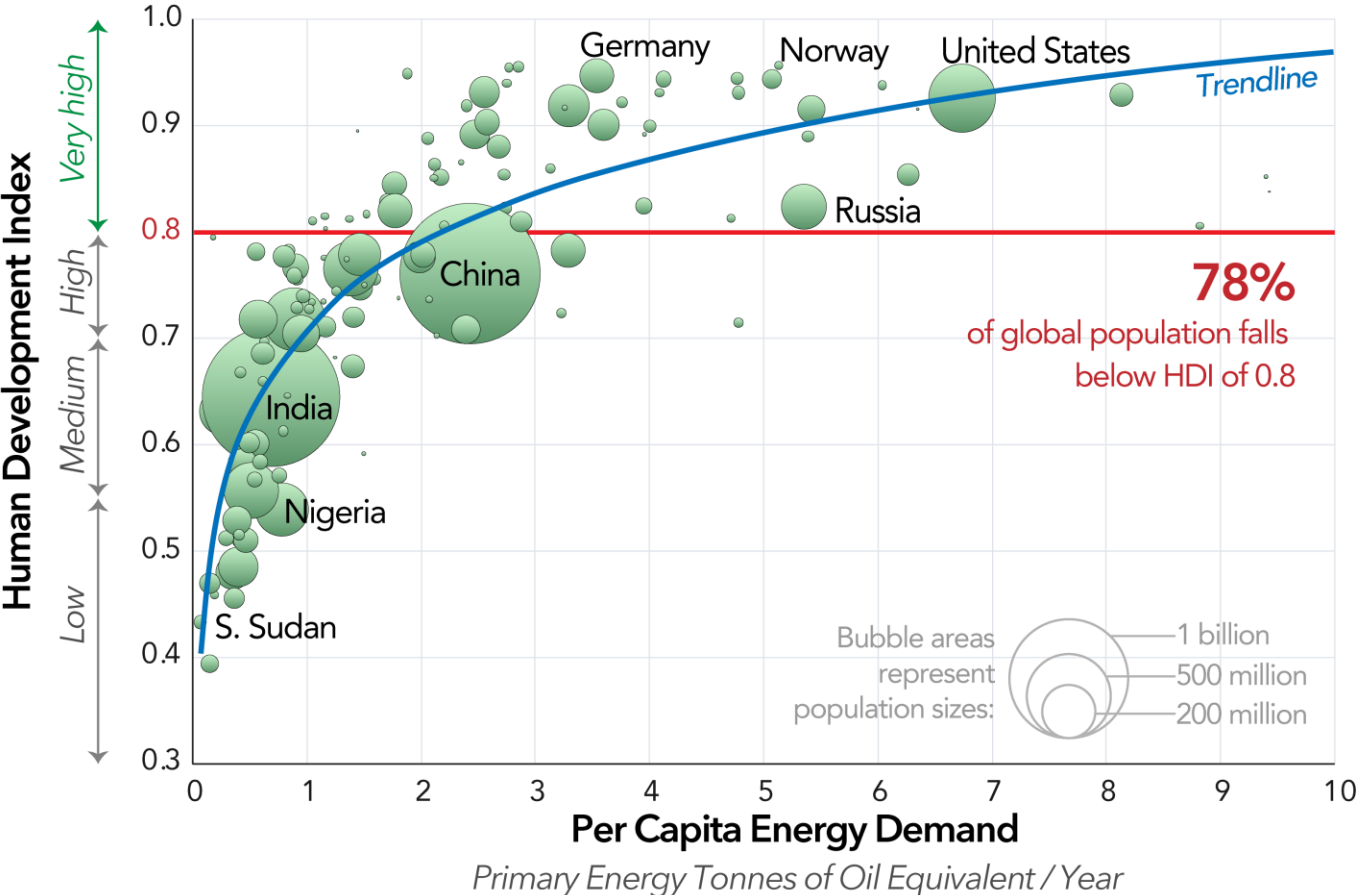
Oil and Gas Prices Under No New Investment Scenario (IEA-NZE) Based on Historic Price Elasticities of Demand



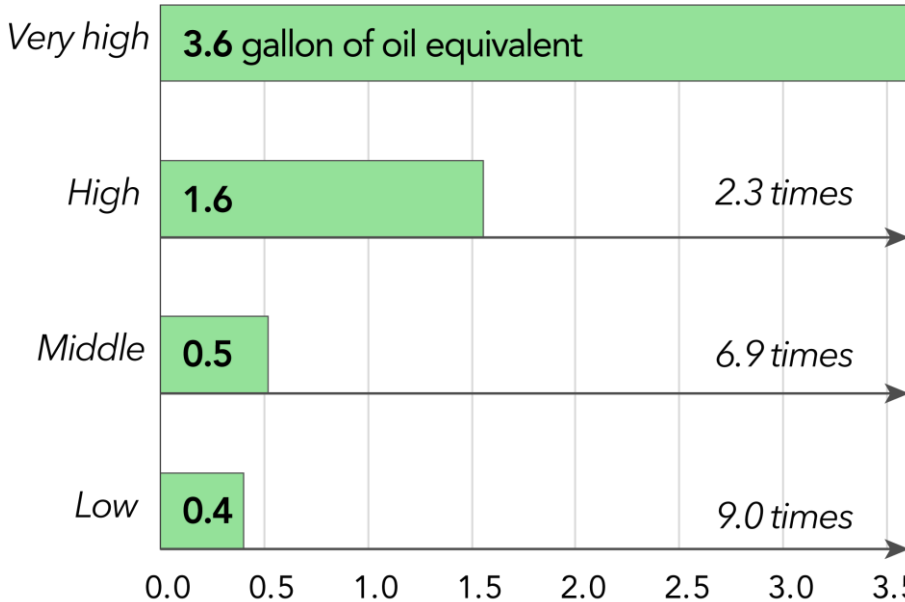
Source: Energy Policy Research

Energy Supply and Human Development Index

Per Capita Energy Demand and Human Development Index (2019)



Daily per Capita Energy Demand by Human Development Index (2019)



Source: Energy Policy Research

NET ADDITIONAL COAL PLANT CAPACITY SINCE 2015 PARIS AGREEMENT

Cumulative net worldwide coal power plant capacity additions (2016-2023H1): 206.3 GW

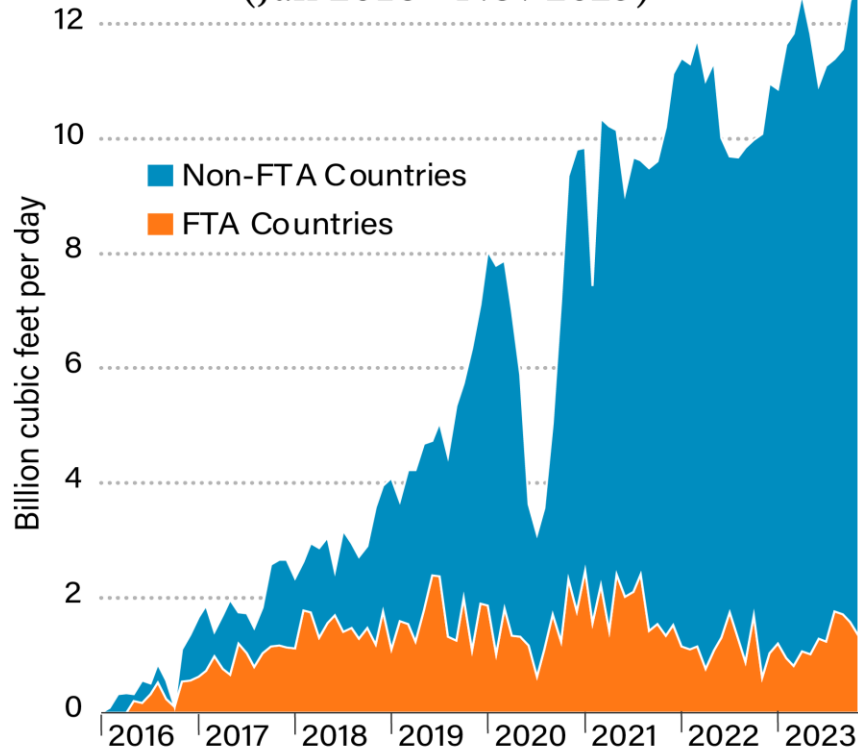
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animation

Data: Global Energy Monitor



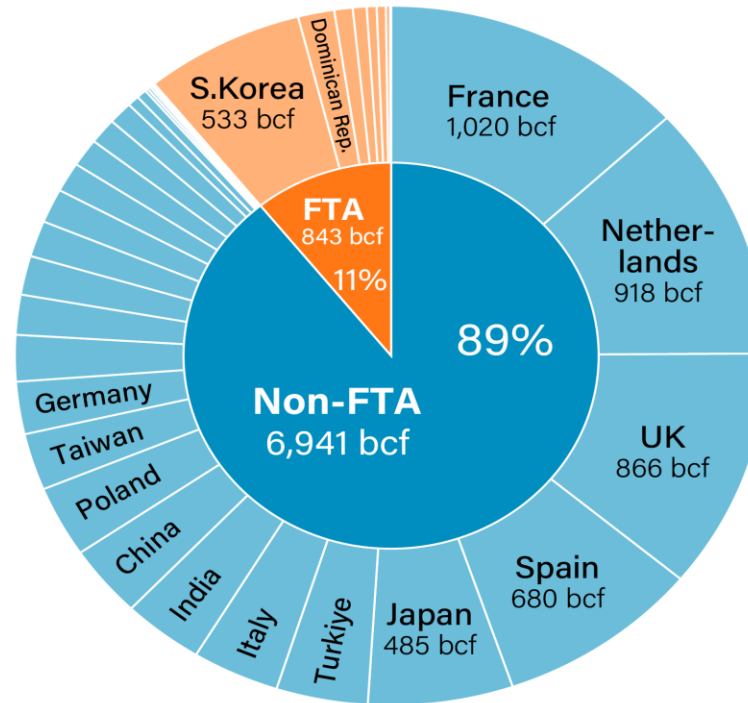
FTA vs. Non-FTA Destinations for U.S. LNG

U.S. LNG Exports to the World
(Jan 2016 - Nov 2023)



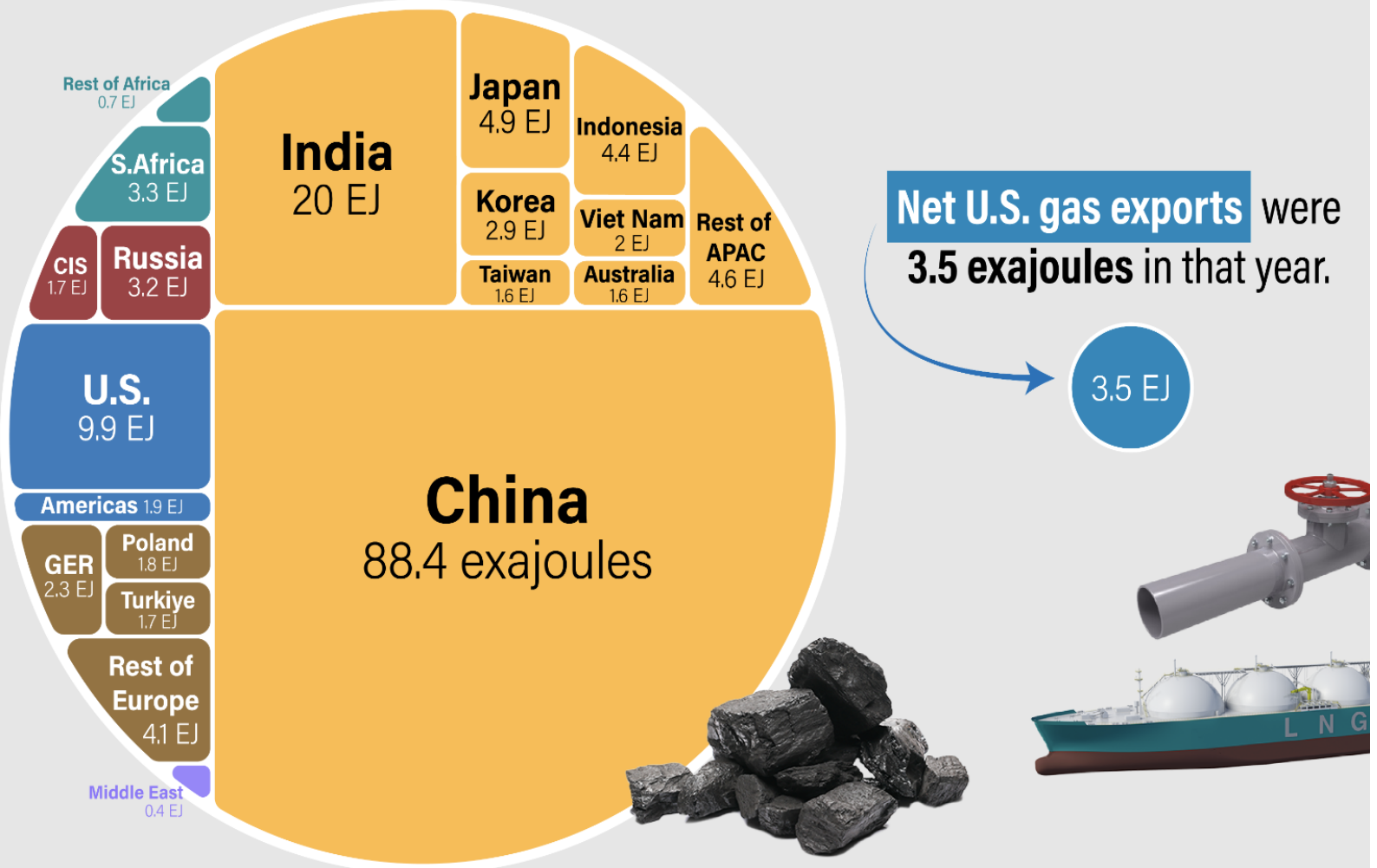
Source: Energy Policy Research, U.S. EIA Monthly Data

Cumulative U.S. LNG Exports
(Jan 2022 - Nov 2023)



Global Coal Consumption vs. U.S. Net Gas Exports (2022)

Global coal consumption was 161.5 exajoules (EJ) in 2022.



Net U.S. gas exports were 3.5 exajoules in that year.

3.5 EJ



- 1 exajoule is roughly equivalent to BTUs in 500,000 barrels/day for one year
- Coal is a dense, low-cost, resilient supply of energy. Replacement for coal in the developing economies needs to be cost-effective
- Best near-term strategy for cost-effective reductions in carbon emissions is massive use of natural gas.

Total world energy demand (all fuel types) was 604 EJ in 2022.
 Source: Energy Policy Research, Energy Institute's Statistical Review of World Energy

Implications of High Oil and Gas Prices Under No Investment Scenario

