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Global Energy and Climate: Aspiration versus Reality

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Reality is a binding constraint!

Supply chains matter, and every region is different!

- Comparative advantage, natural resource endowment, human capital endowment, economic development, policy, market design, and cost, among other things, will dictate outcomes.
- What about new tech? The widget parable…🤔… Engines of change: innovation and growth
- Value must be generated because capital always chases returns.

The evolving energy landscape: The last 53 years

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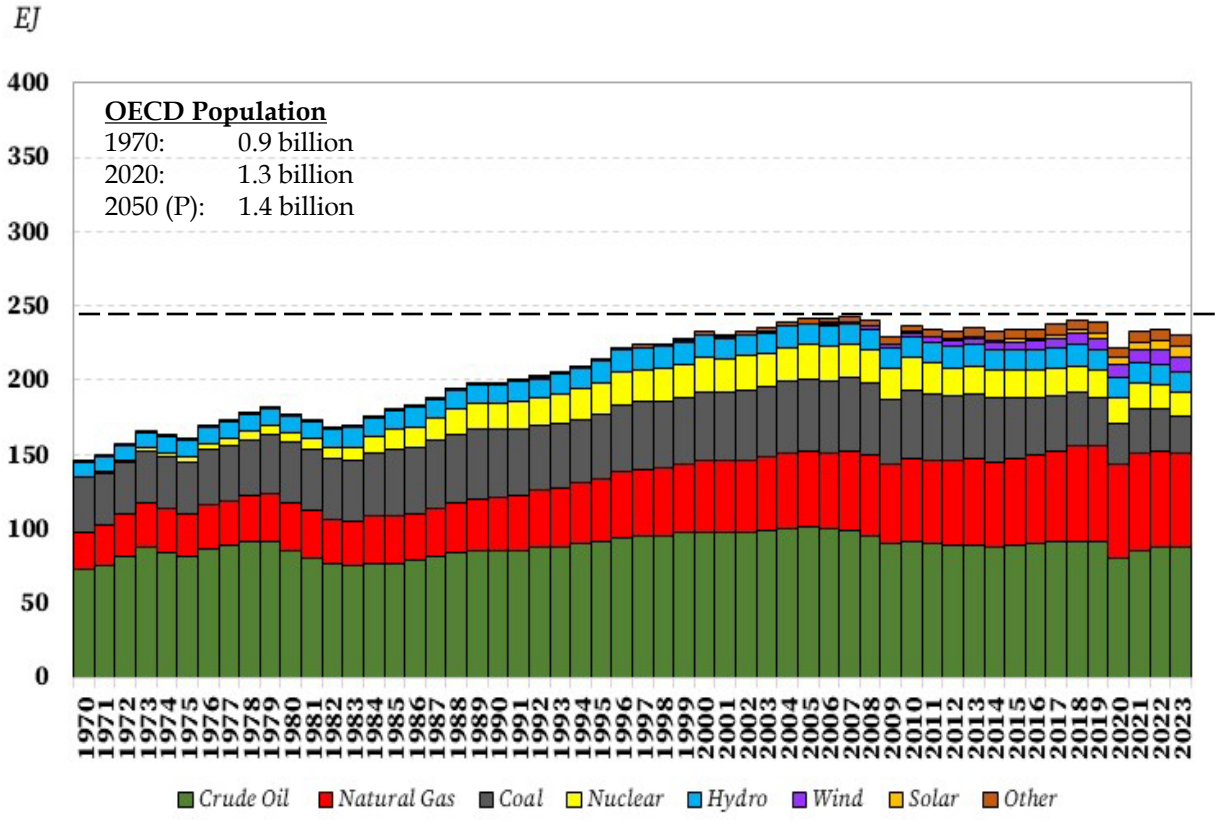
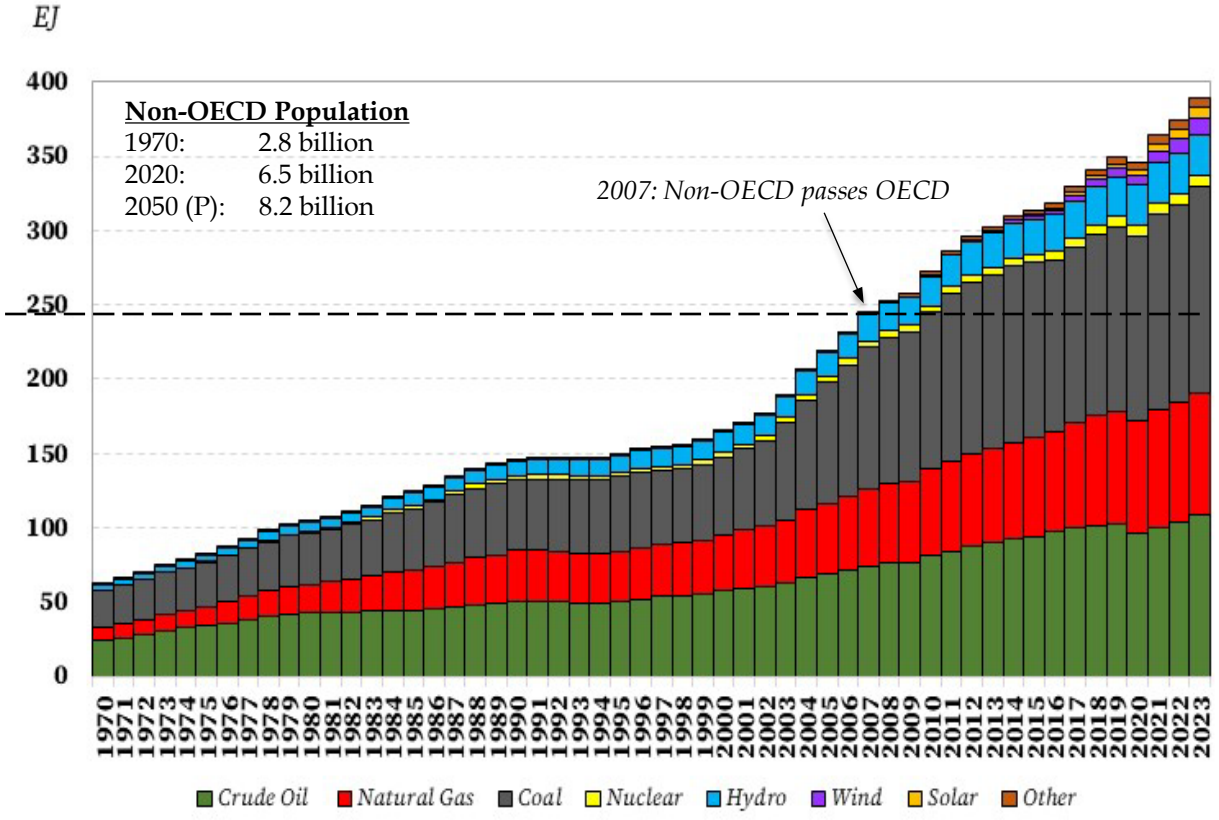
- Energy demand is rising fastest in the developing world, largely driven by hydrocarbon fuels.
  - EU is 9.1% of global demand; N. America is 18.8% of global demand; developing Asia is 39.7% of global demand.
- Projections for population and economic growth indicate this trend will likely continue.





Data Sources: EI Statistical Review of World Energy, 2024; OECD.stat

Focus on the last 20 years: Global energy demand

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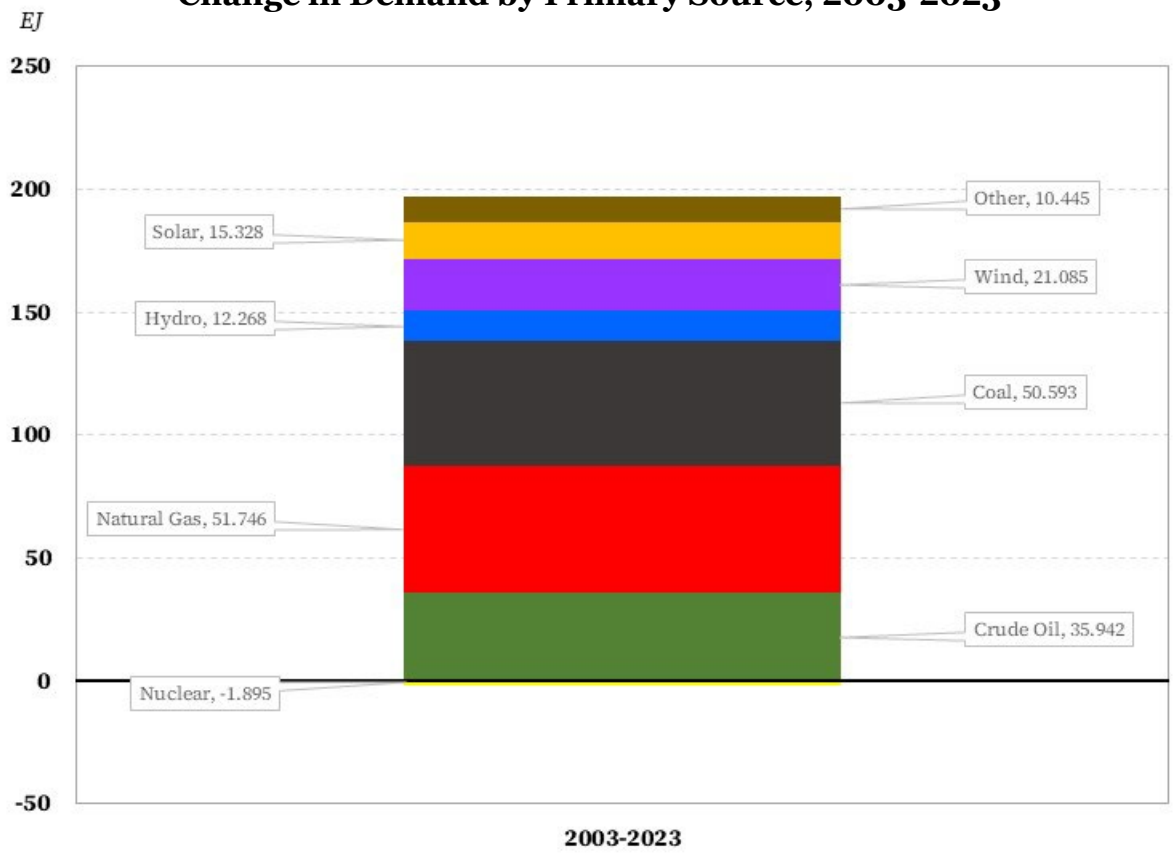
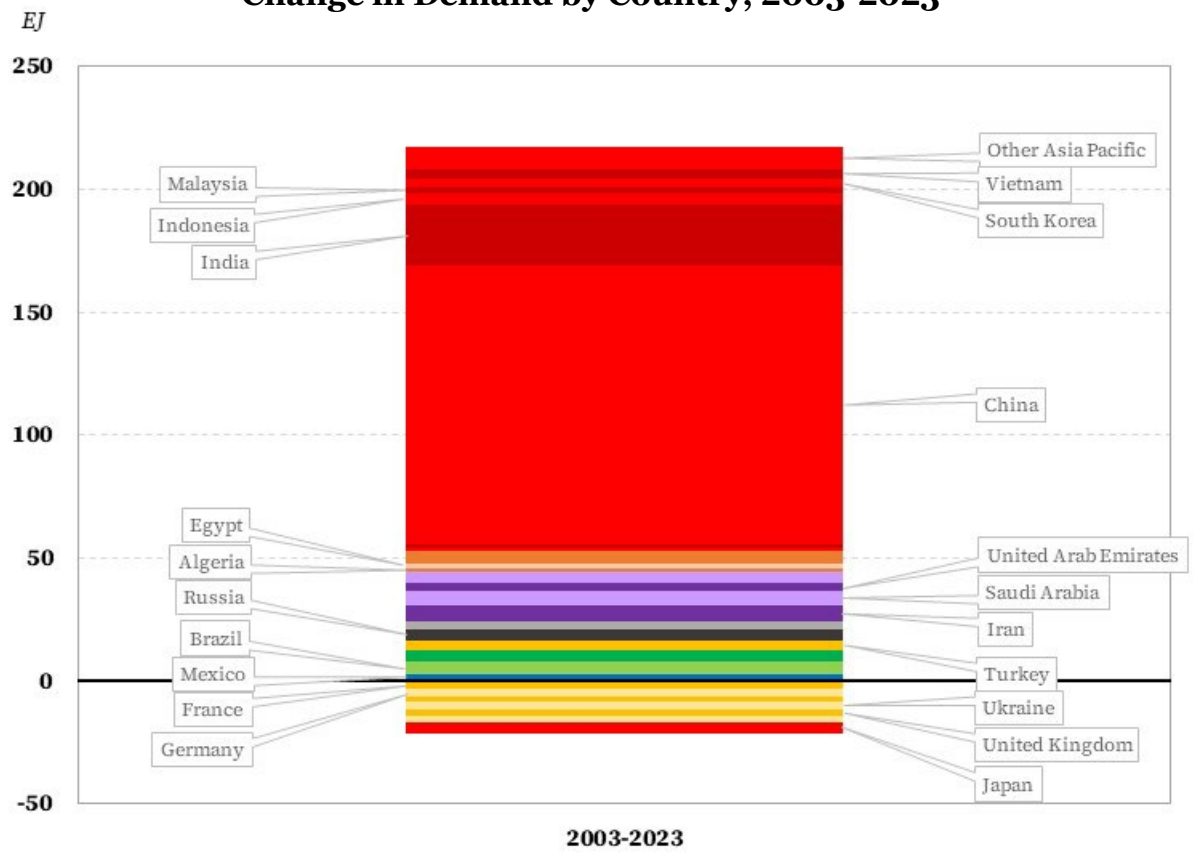
- Demand has grown almost everywhere. Exceptions include most of OECD Europe, Japan, New Zealand, and the US.
- Demand by primary source has increased for energy source, except nuclear.
  - Wind and solar have increased at the highest average annual rate – 19.1% p.a. and 38.3% p.a., respectively.
  - But total demand has increased most for natural gas, coal, and crude oil.
- Developing Asia has driven increases across the energy landscape, with significant ramifications for international trade.

Change in Demand by Primary Source, 2003-2023



Change in Demand by Country, 2003-2023

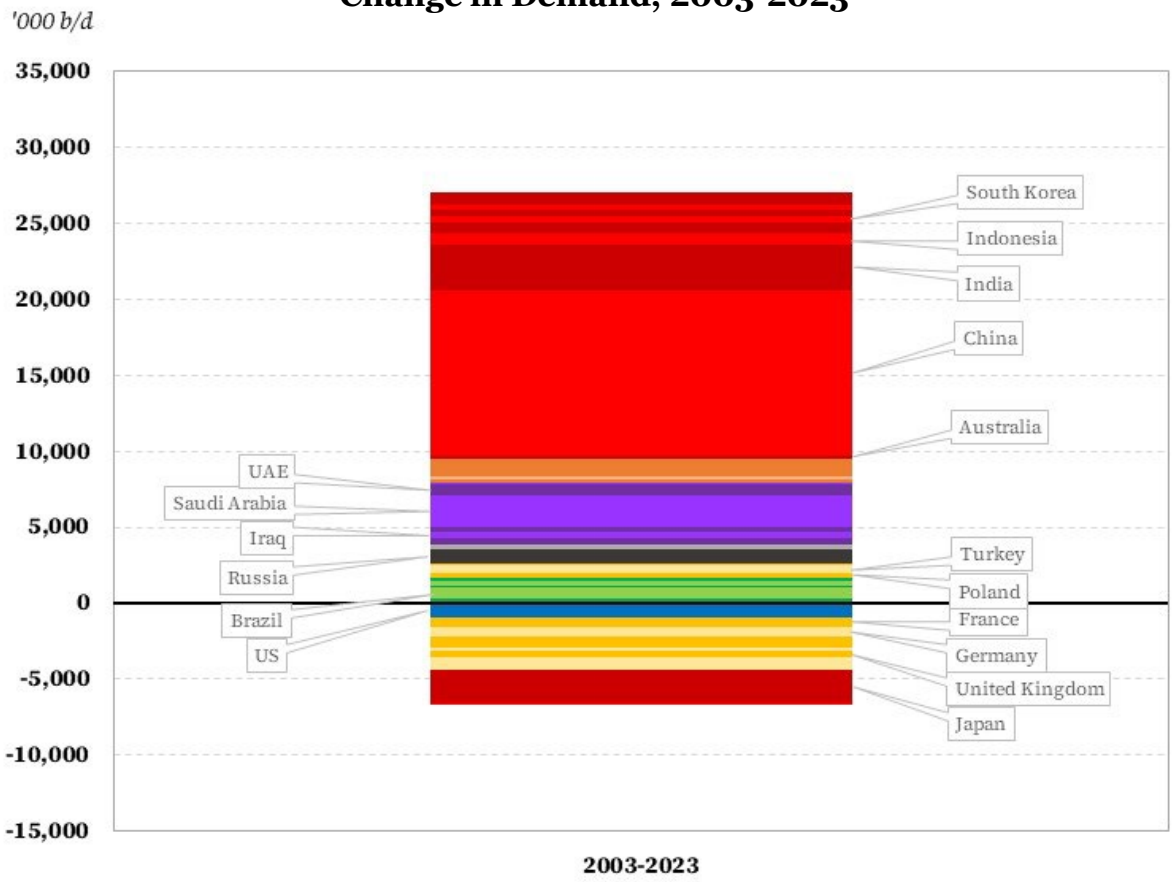


Data Source: EI Statistical Review of World Energy, 2024

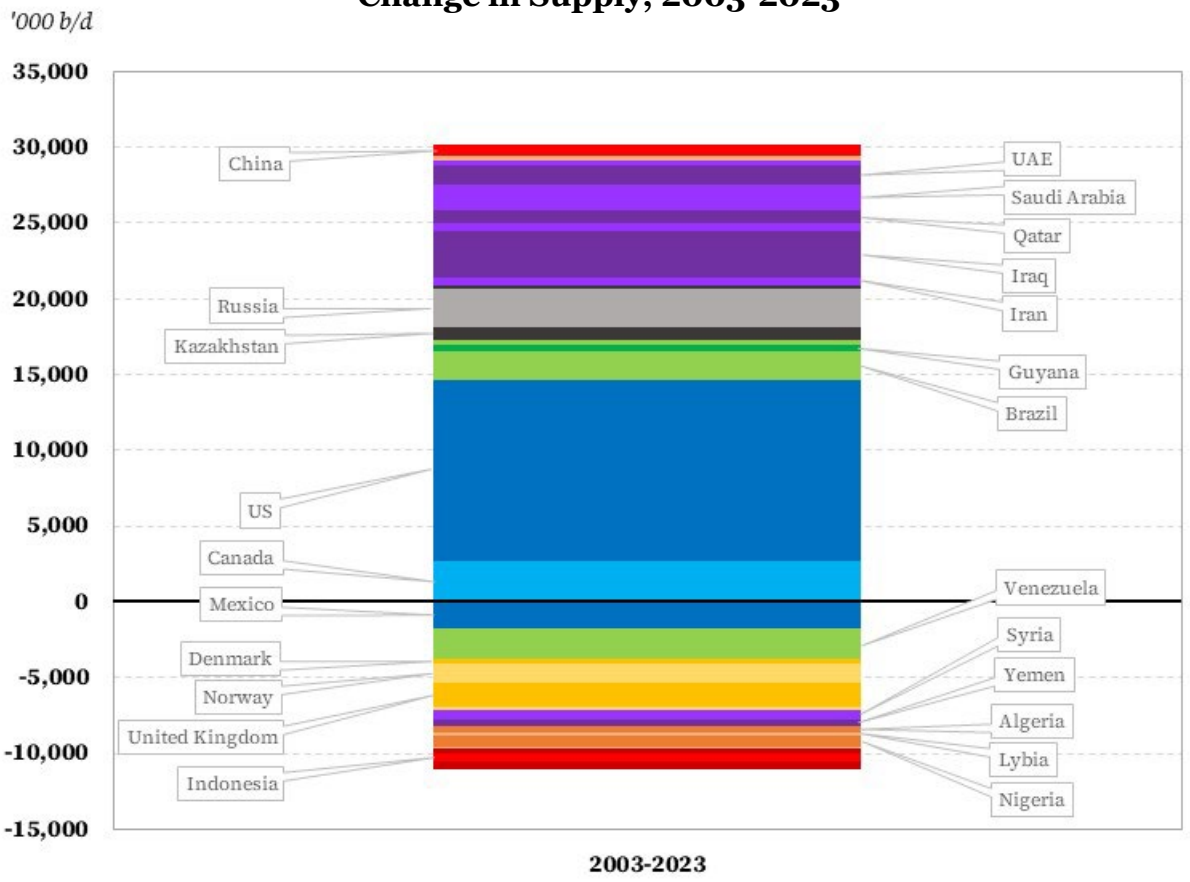
Focus on the last 20 years: Oil – a growth story

- Demand has grown in the developing world, but it has declined in the developed world.
- Supply growth has been from "incumbent" producers, plus the emergence of the US, Canada, and Brazil.
- Above-ground issues lead supply decreases.
- Net growth over the last 20 years was 20.4 million b/d, and that includes 2020! Net growth from 1983 to 2003 was 21.9 million b/d. The average annual increase only changed from 1.09 to 1.02 million b/d.

Change in Demand, 2003-2023



Change in Supply, 2003-2023

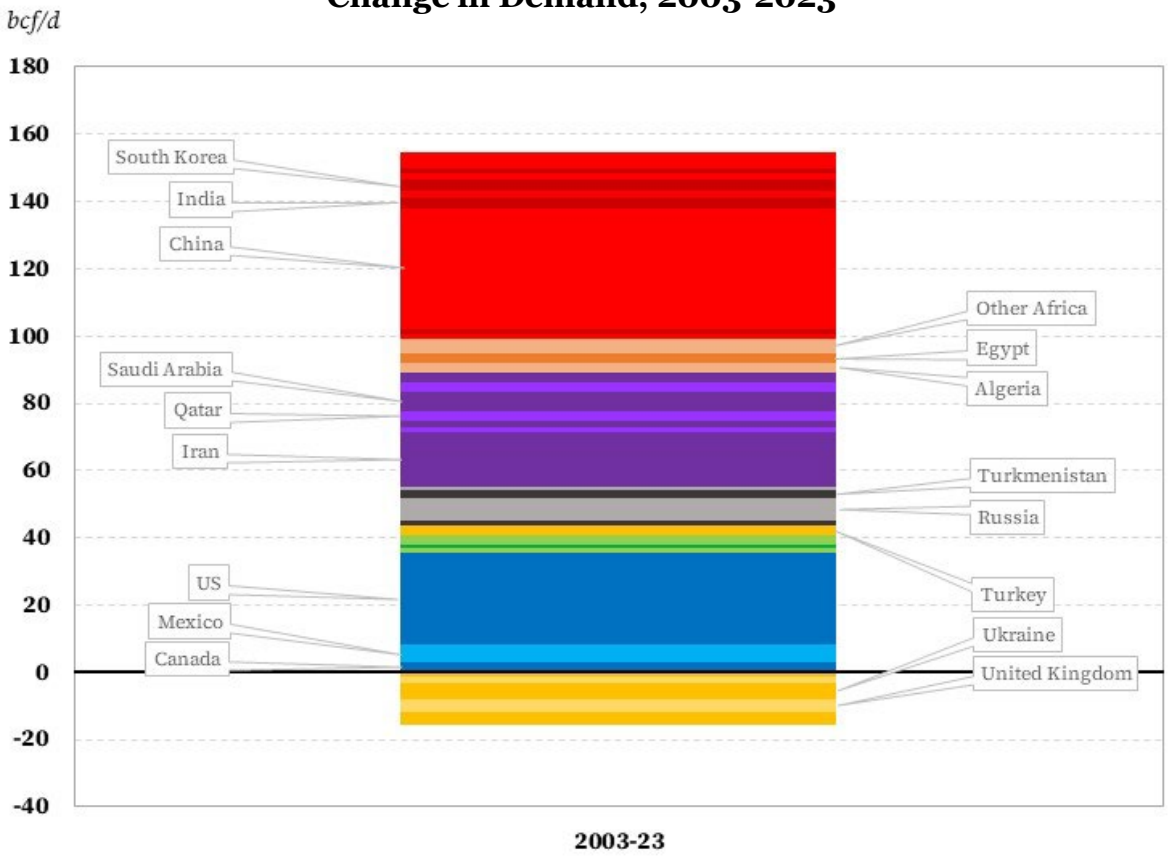


Data Source: EI Statistical Review of World Energy, 2024

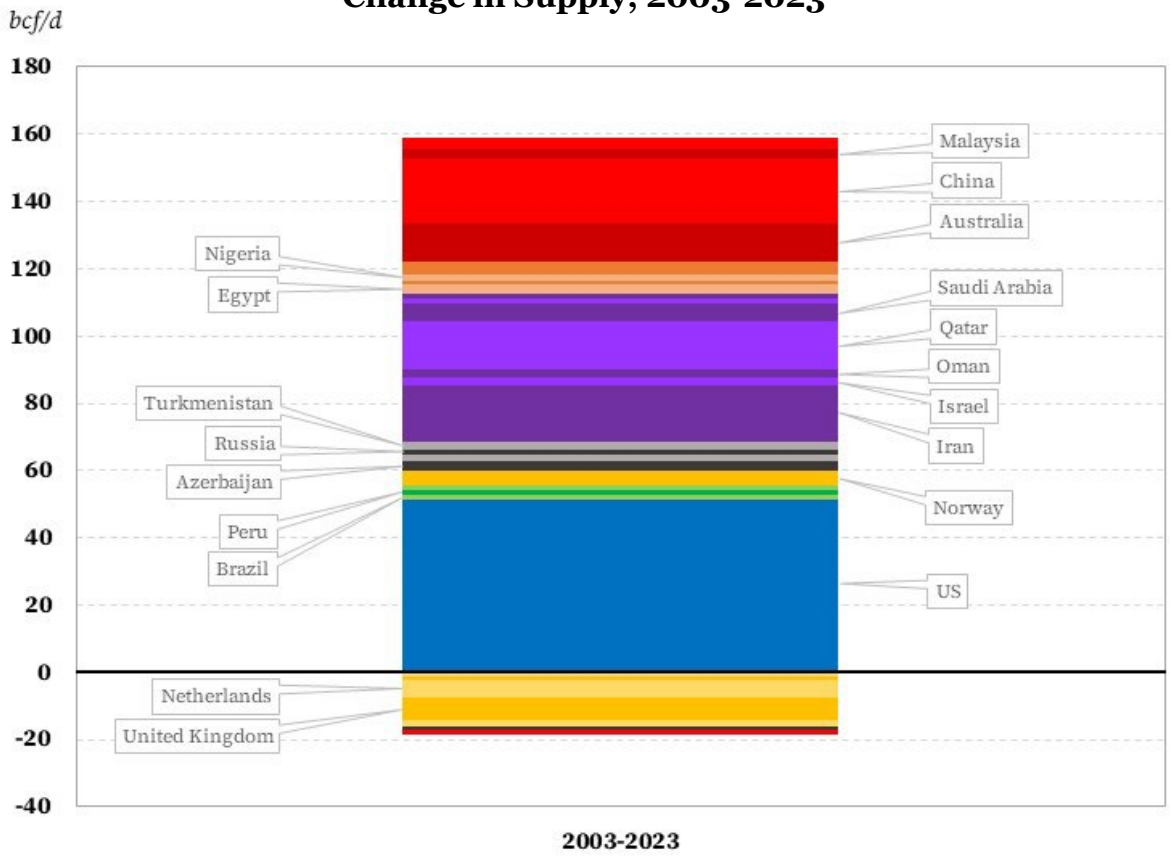
Focus on the last 20 years: Natural gas – another growth story

- Demand has grown everywhere, except in Europe.
- Supply declines are also led by Europe.
- Supply growth has largely been to meet local demand. Notable exceptions: US, Qatar, Australia.
- Net growth over the last 20 years has been 139 bcf/d, or a 56% increase! Net growth from 1983 to 2003 was 107 bcf/d, so although the growth rate has slowed, the net increase was larger.

Change in Demand, 2003-2023



Change in Supply, 2003-2023

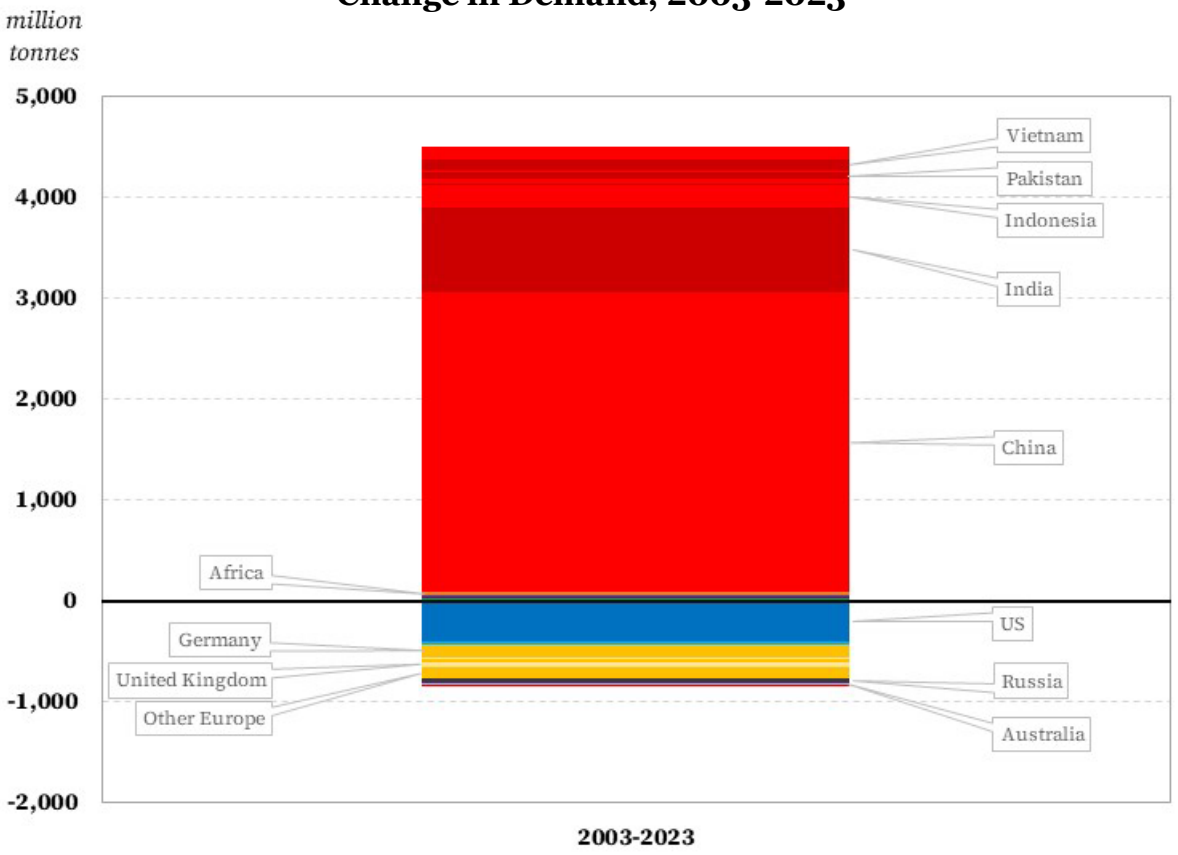


Data Source: EI Statistical Review of World Energy, 2024

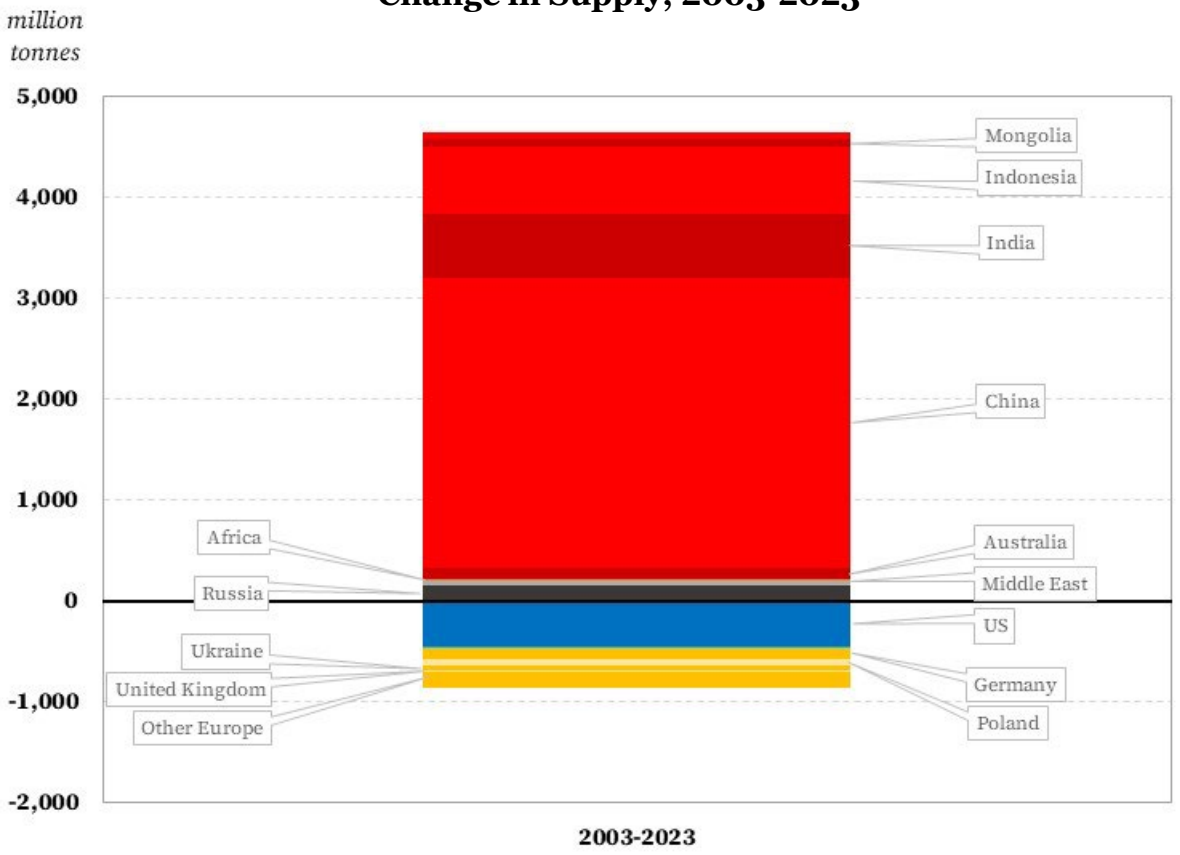
Focus on the last 20 years: Coal – yet another growth story

- Growth in demand in Asia has driven the "global" increase.
- Both supply and demand have decline in Europe and North America.
- Supply growth has largely been to meet local demand, but regional trade in Asia has proven important for market balance.
- Coal demand in 2023 was 9.10 billion tonnes, the highest it has ever been. Net growth over the last 20 years has been 3.77 billion tonnes, up from 1.26 billion tonnes over 1983-2003. Growth in Asia has dramatically changed the coal landscape.

Change in Demand, 2003-2023



Change in Supply, 2003-2023



Data Source: EI Statistical Review of World Energy, 2024

Geopolitics loom large. Consider crude oil.

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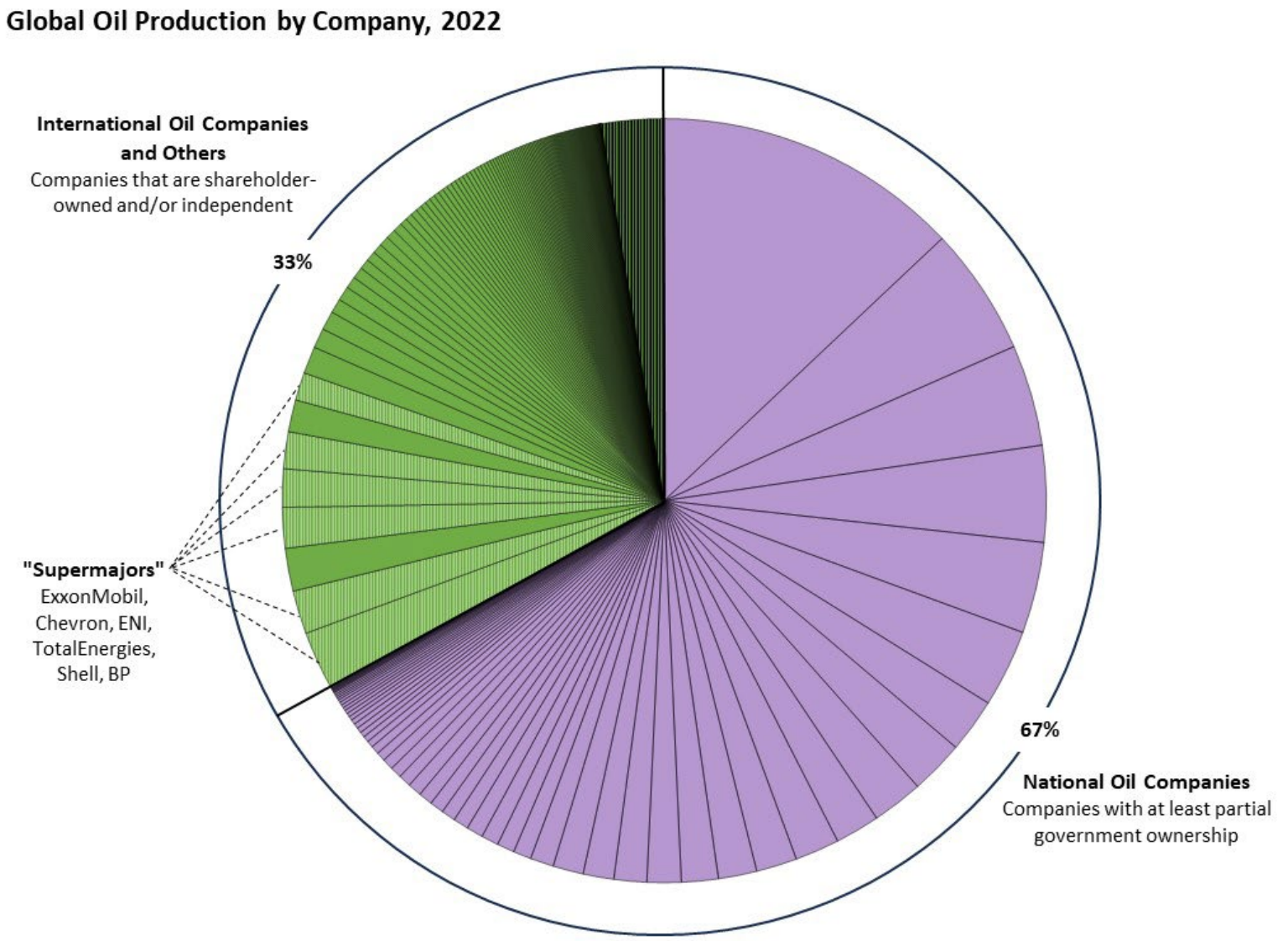
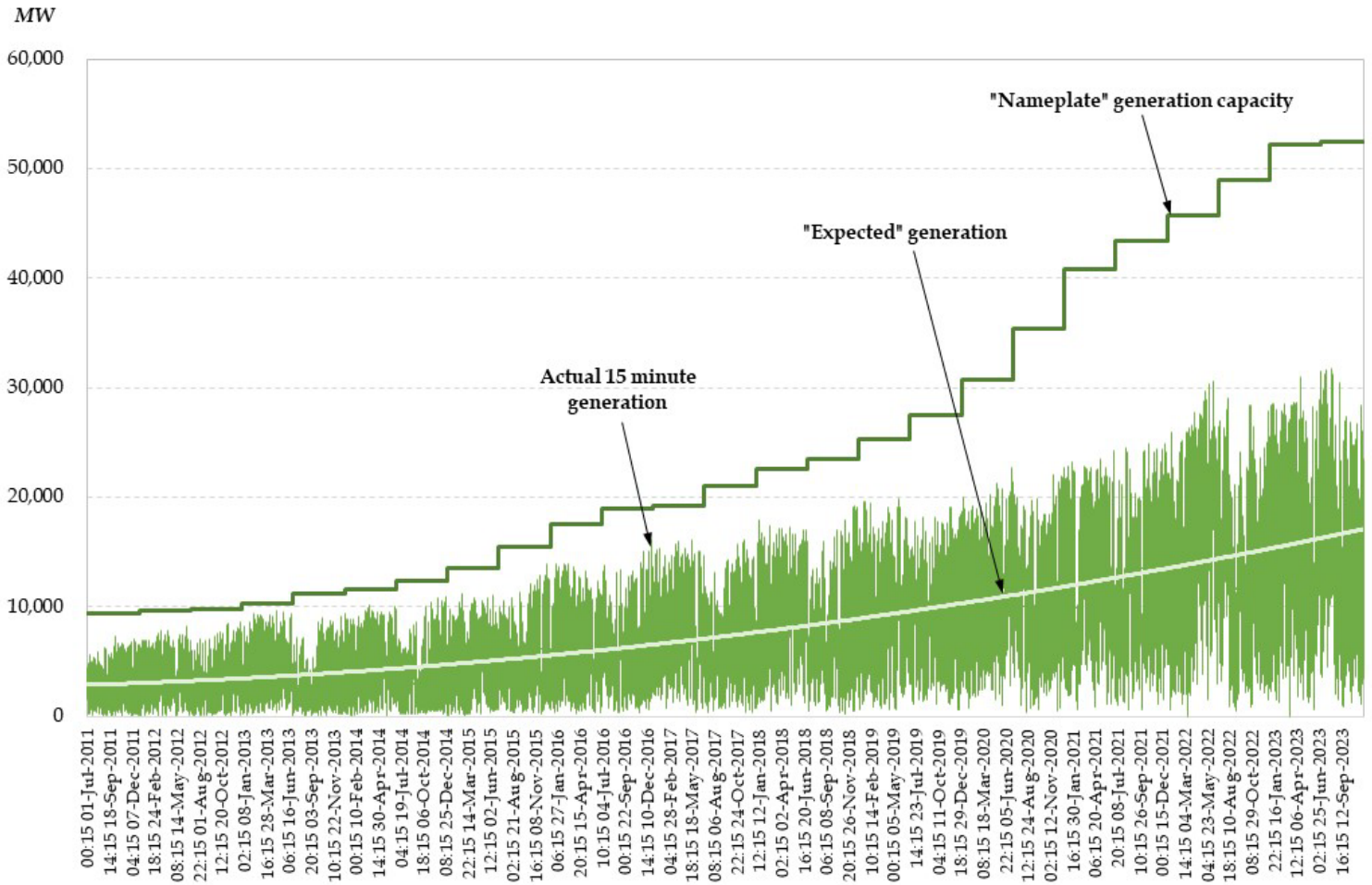
- The oil market is highly diverse, but NOCs deliver most production.
- Competition in the "green" makes production resilient to targeted interventions.
- The importance of oil revenues for governments makes production resilient to external pressures.
- In 2022, "supermajors" accounted for less crude oil output than the world's largest NOC.
- Why raise this? Because market structure matters and government stake matters. It has implications for price, capital allocation, geopolitics, energy security, and energy transitions.



Data Source: Company annual reports, compiled by author

What about renewables? Complexity! Consider ERCOT.

- As wind and solar generation *capacity* grows, <u>average</u> generation grows, and emissions intensity falls.
- But averages are irrelevant for **reliability**. Extremes matter.
- Therefore, sufficient *dispatchable* capacity is required.
- But this raises the capital intensity of each MWh delivered, which presents an economic cost.
- So, who pays?
- **Reliability matters. It must be priced to ensure sufficient redundancy for the grid.**
  - This is nothing new! Grids have always needed sufficient "insurance" against unexpected outages.



Source: Data compiled from ERCOT. "Expected" generation is the best fit over time to the actual 15-minute generation and is only for illustration. Resource planning utilizes seasonally rated capacity, which is different by season.

Infrastructure is critical. It defines legacy and opportunity.

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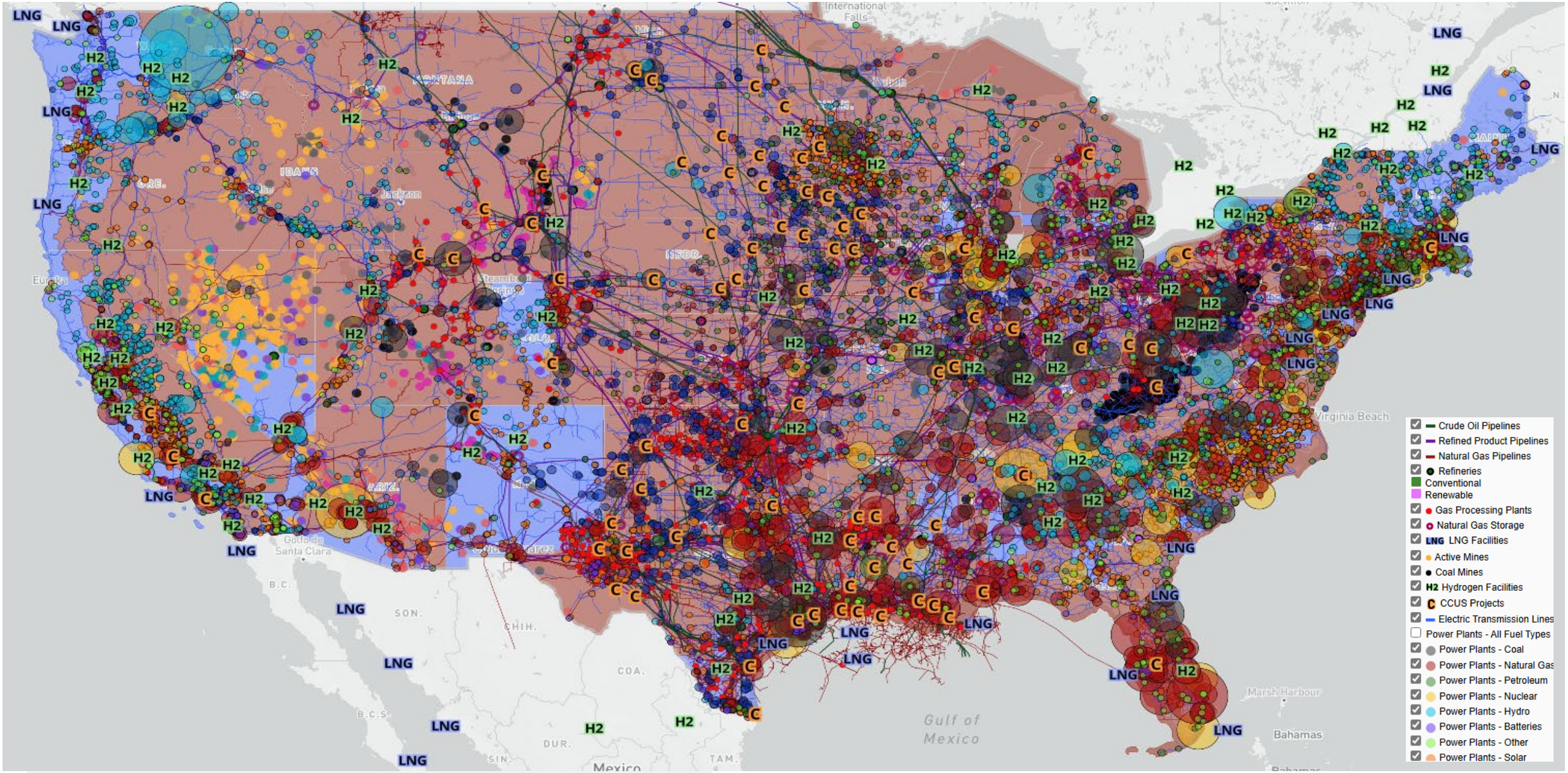

Source: [Map: Energy, Environment, and Policy in the US | Baker Institute]

Forecasting is inexact; consensus is a dangerous place to be.

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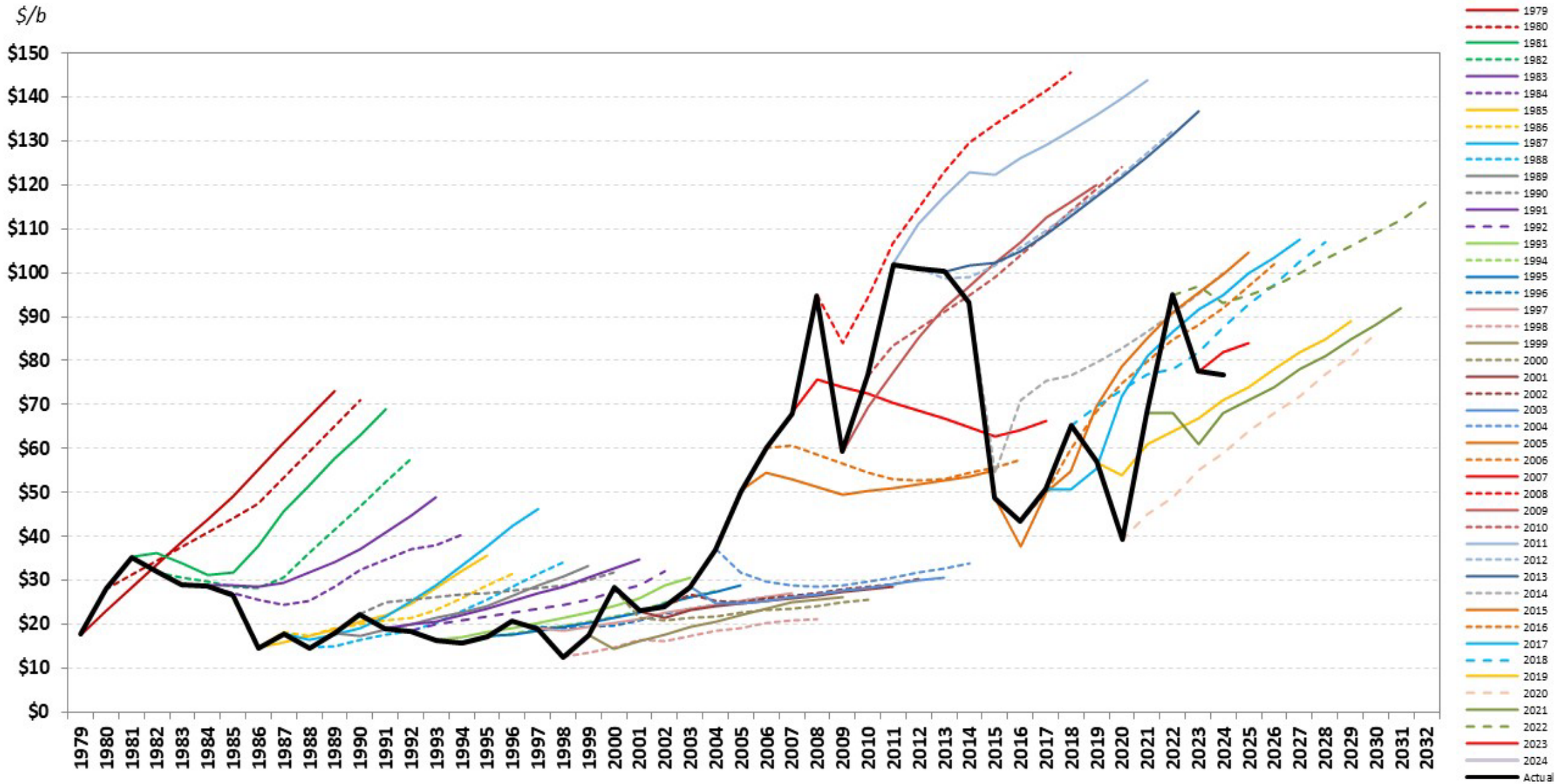

Data Source: EIA Annual Energy Outlook, www.eia.gov

Despite our best efforts, we have no idea what will happen…

… but we do know there will be trade-offs…

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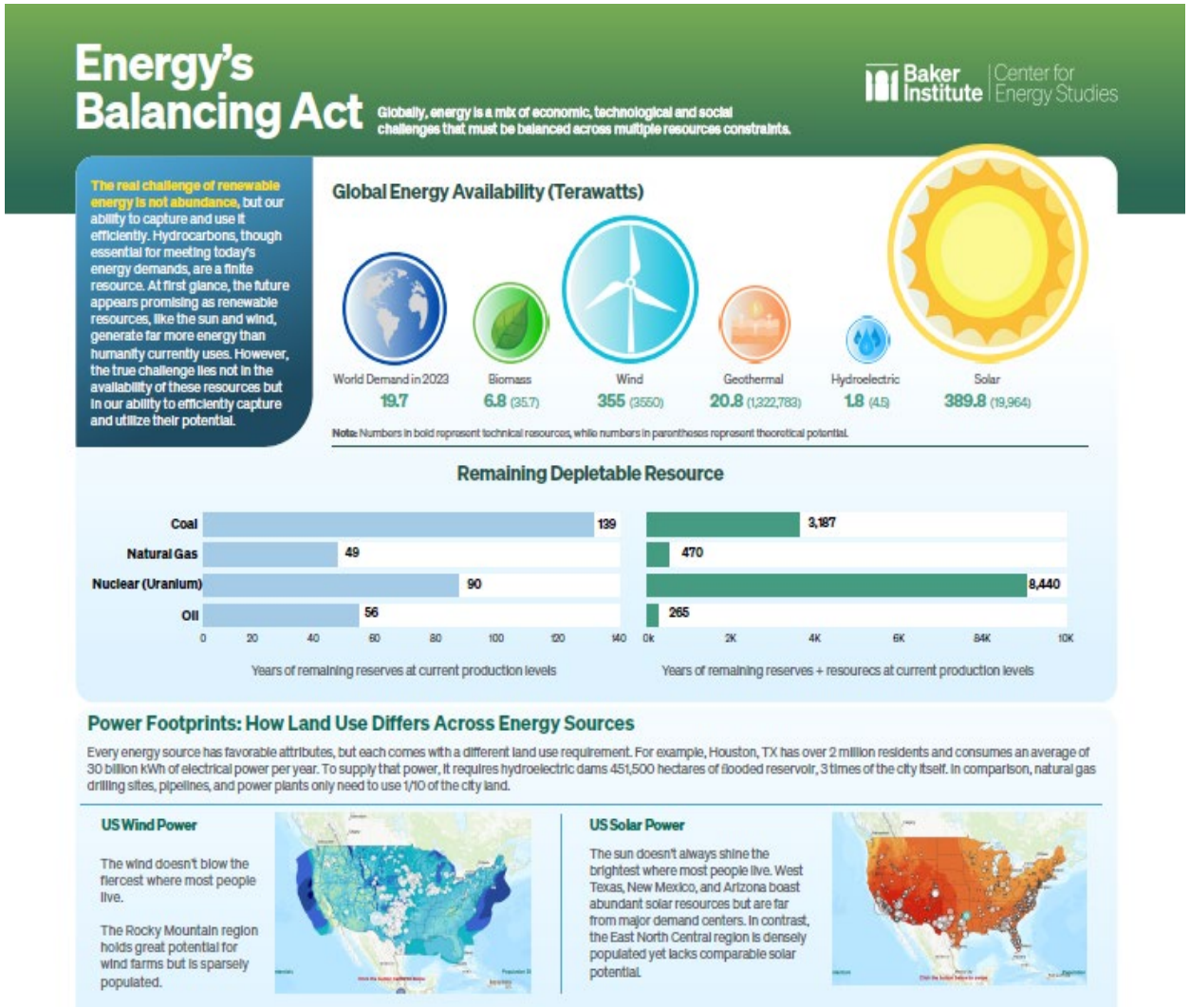

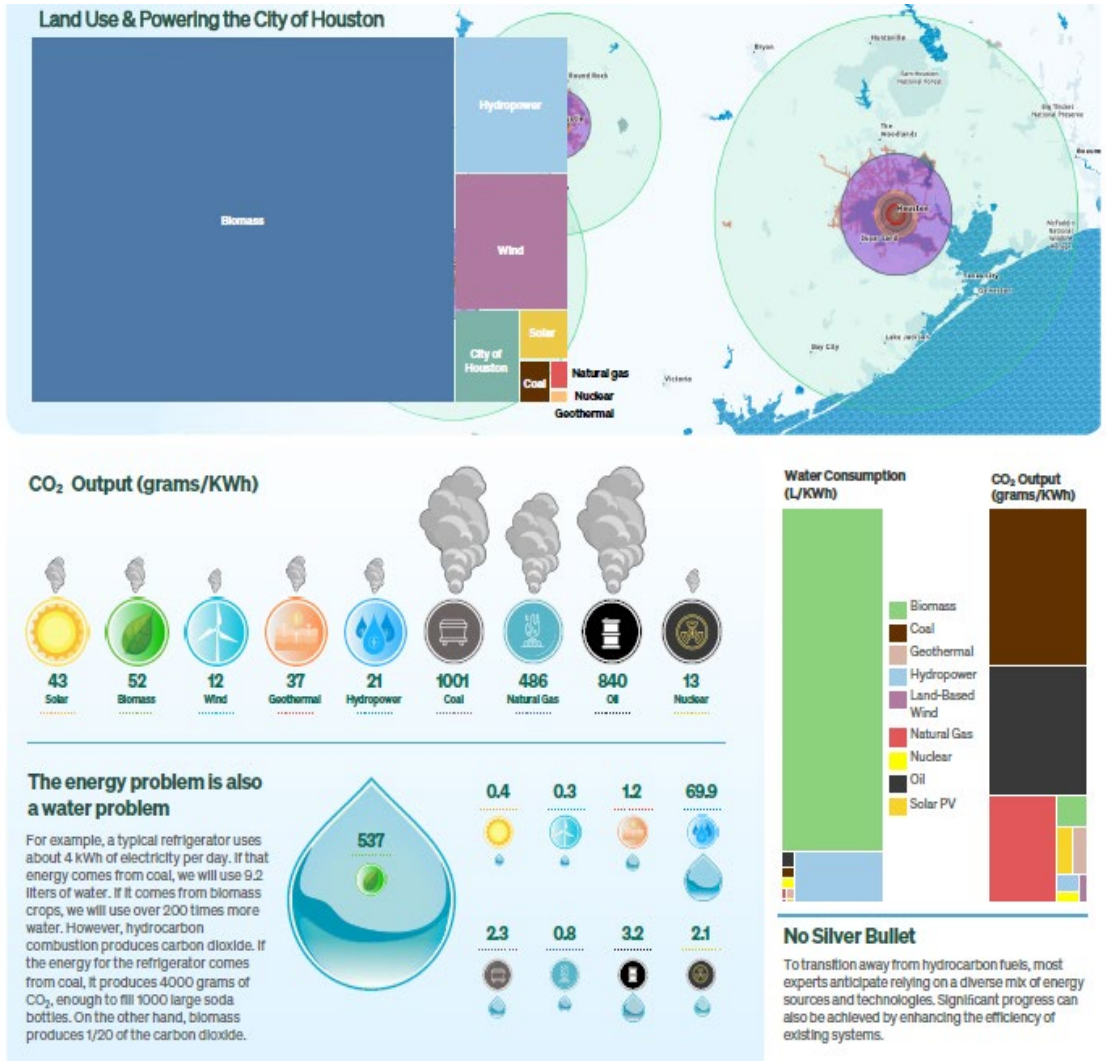

See: https://www.bakerinstitute.org/dashboard-energys-balancing-act

… bringing tremendous opportunities for innovation.

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