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Energy Transition:
The Important Roles of Legacy, Scale and Technology

Kenneth B Medlock III, PhD
James A Baker III and Susan G Baker Fellow in Energy and Resource Economics, and
Senior Director, Center for Energy Studies
Rice University's Baker Institute

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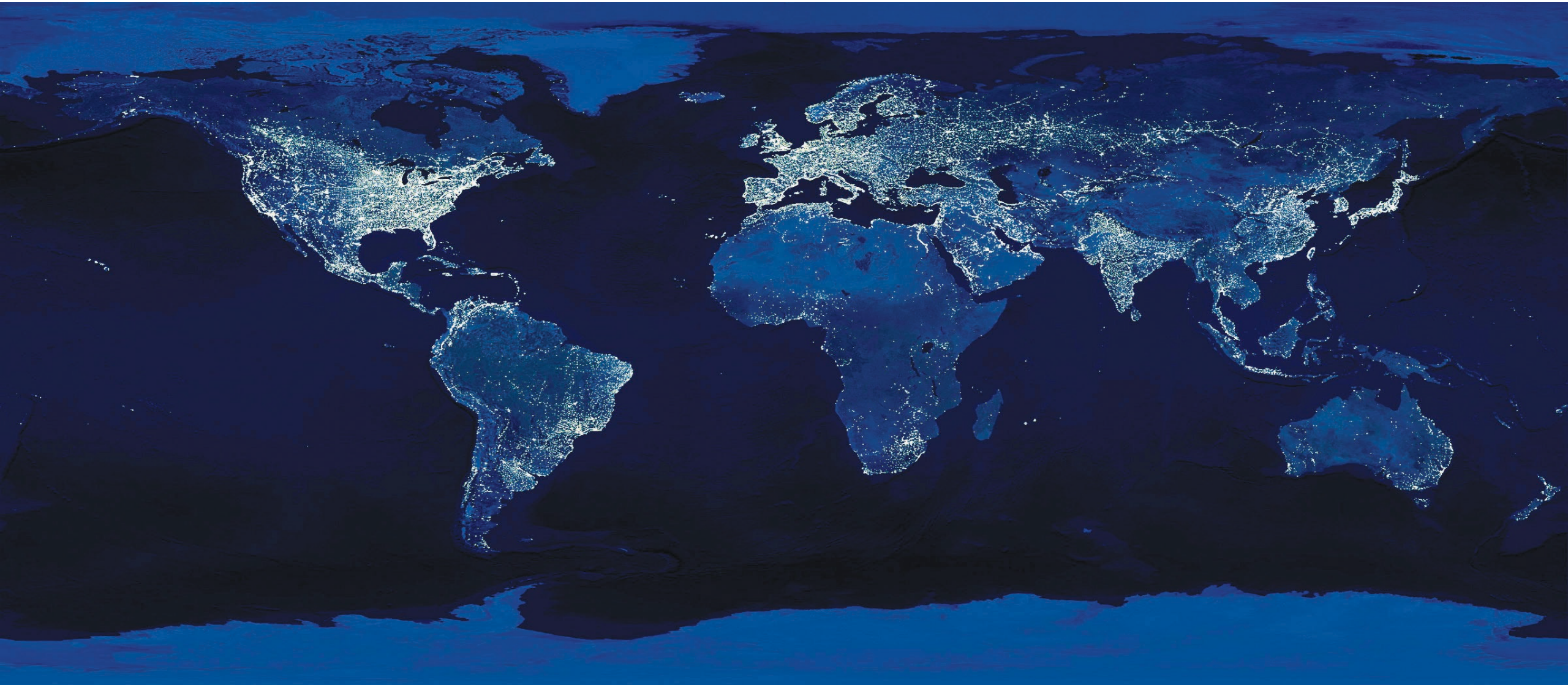
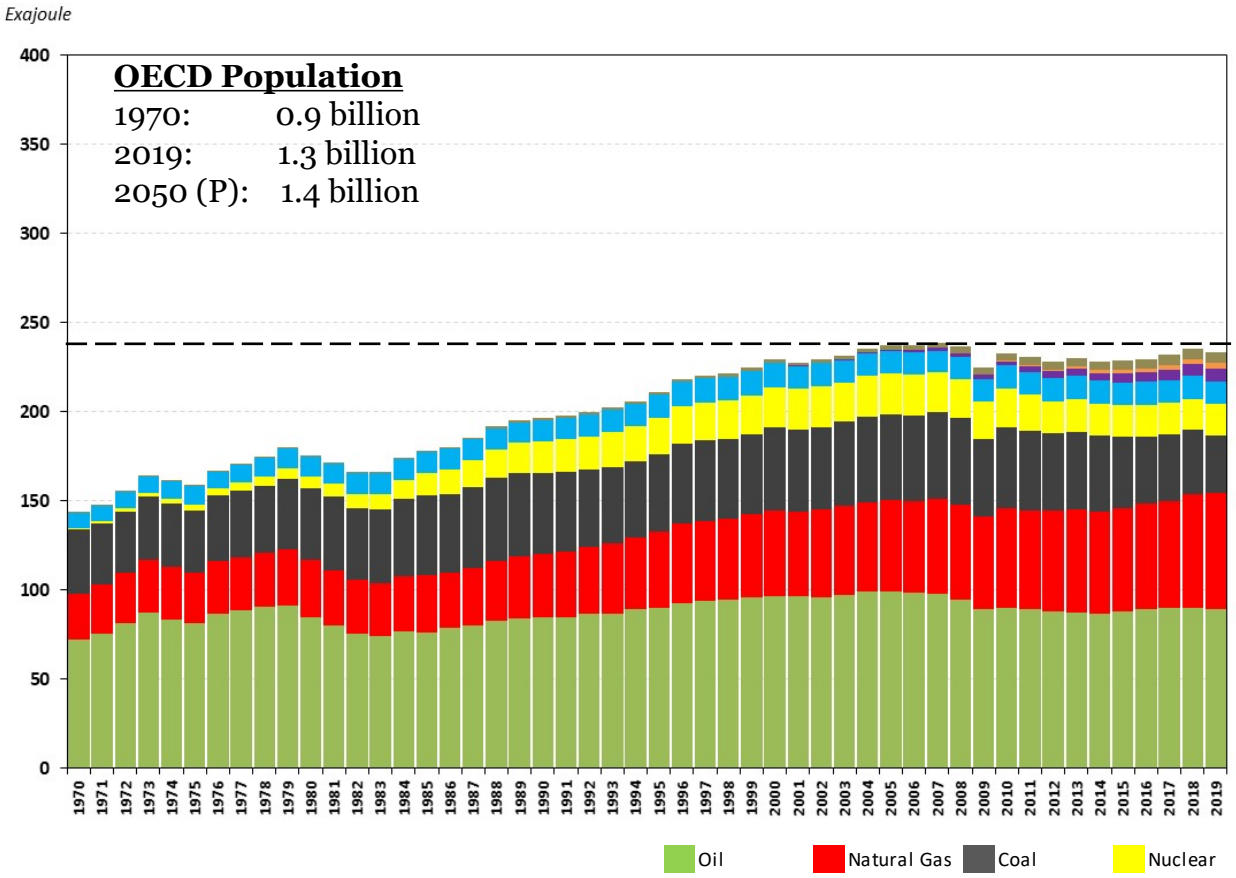
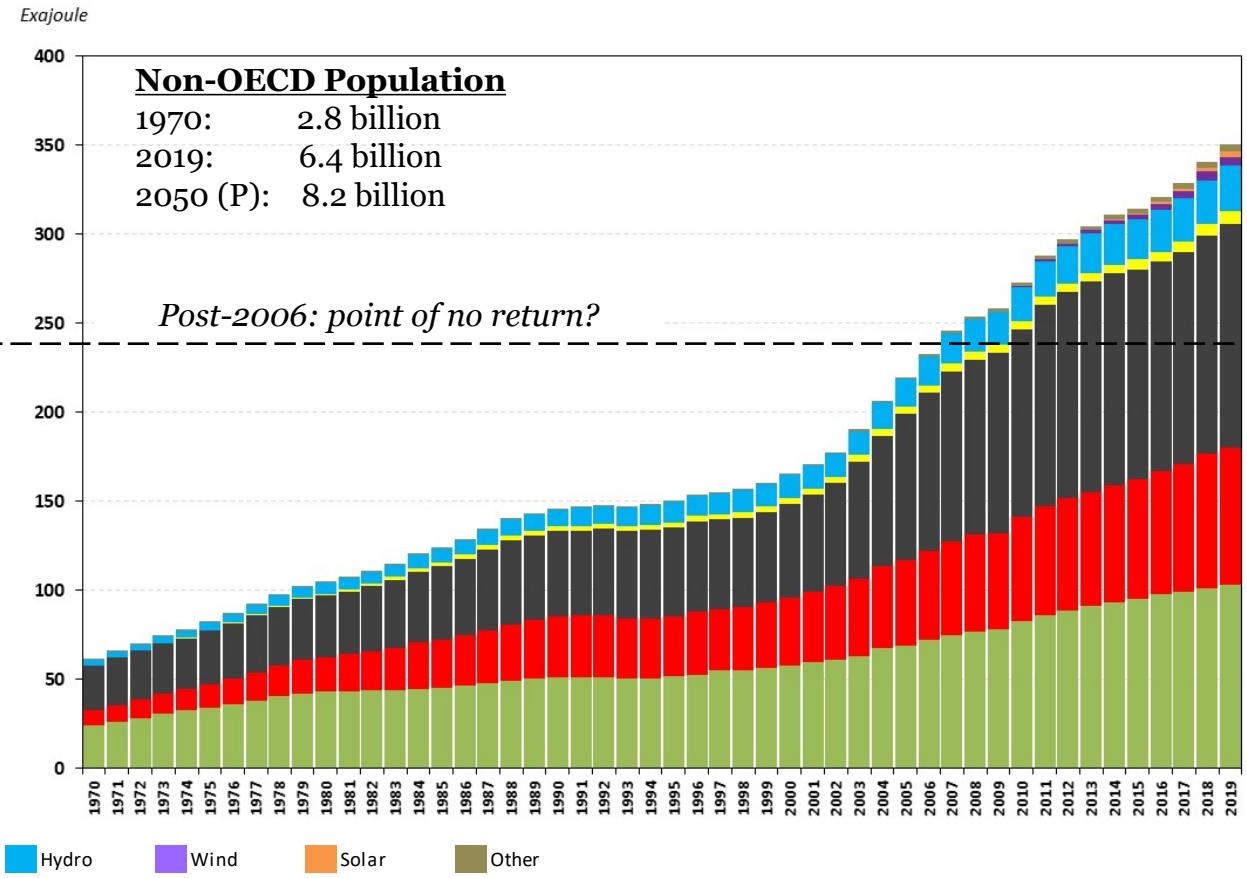
This conversation begins here…



The evolving energy landscape is a developing nation story…

- Energy demand is rising fastest in the developing world, largely driven by hydrocarbon fuels.
  - EU is 11.8% of global demand; N. America is 20.0% of global demand; developing Asia is 36.9% of global demand.
- Projections for population and economic growth indicate this trend will likely continue.



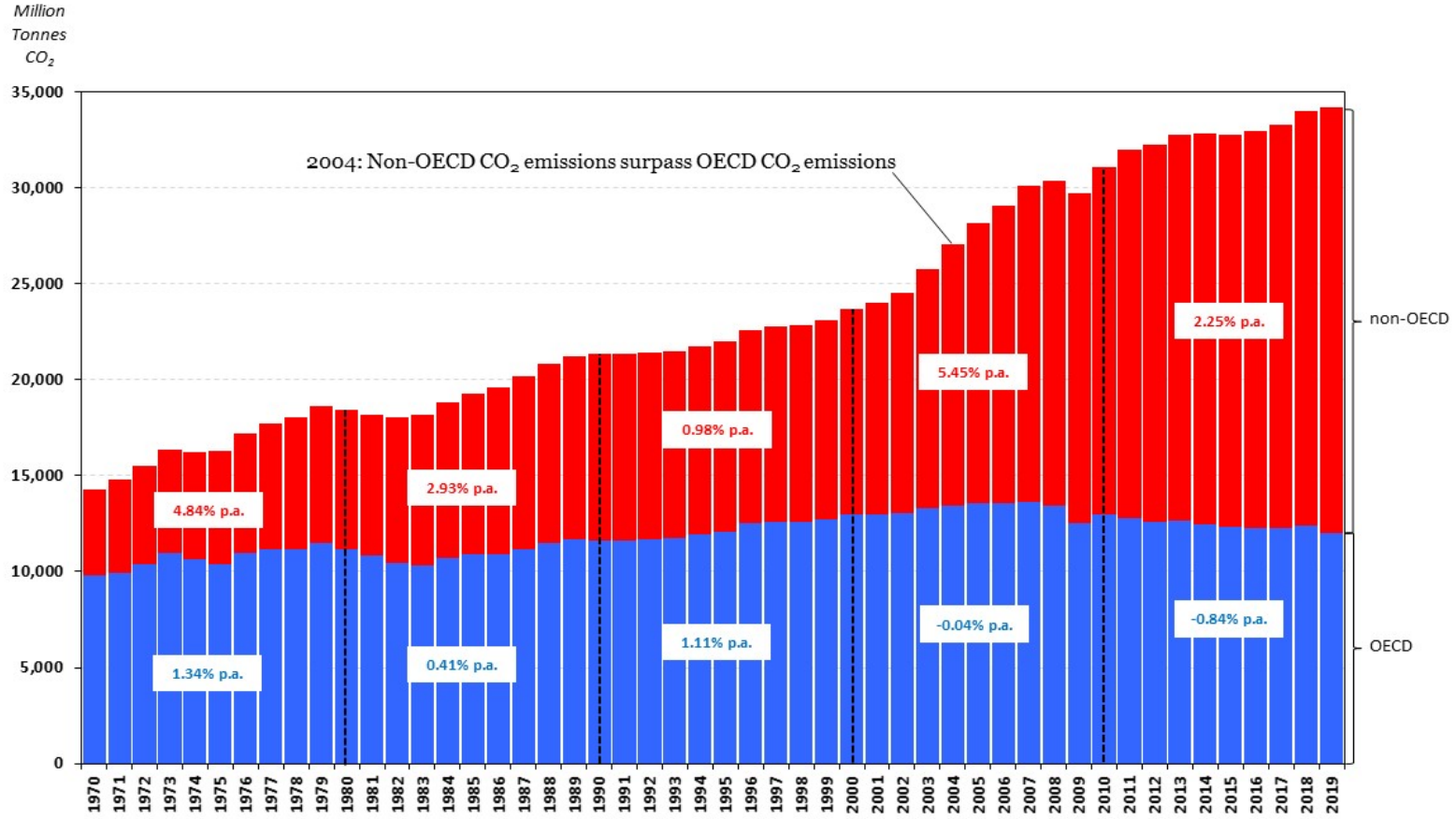


Oil | Natural Gas | Coal | Nuclear | Hydro | Wind | Solar | Other

Data Sources: BP Statistical Review, 2020; OECD.stat

… with implications for CO_2 emissions.

- Non-OECD emissions have grown substantially over the last 20 years, while OECD emission have declined.
- Even if OECD emissions dropped to zero now, global emissions would still exceed 1995 levels.
- Deep decarbonization requires action everywhere, which presents challenges related to legacy, scale and technology!



Data Sources: BP Statistical Review, 2020

Energy Transitions and the Roles of Legacy, Scale and Technology

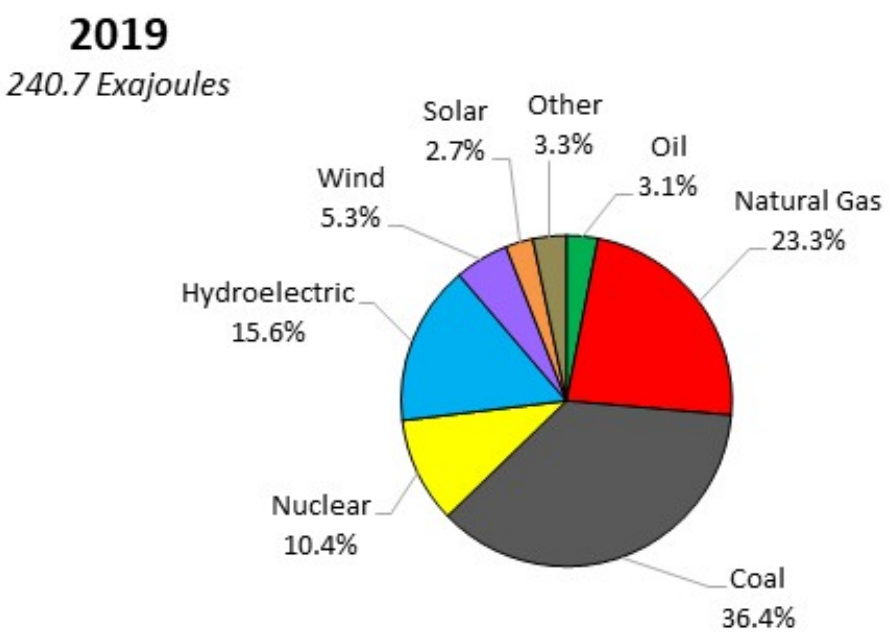
- **Energy ALWAYS transitions.**
- Technology, scale and legacy are each important factors.
  - Technology signals how fuels will ultimately compete. This can work in multiple, sometimes competing, directions by raising the efficiency of use of existing fuels *and* by introducing new competitive energy sources. Importantly, capital is a vehicle for technology deployment!
  - Scale matters because energy systems are large and must accommodate growth and expanding access.
  - Legacy of infrastructure and energy delivery systems is the footprint for change. Legacy is different everywhere, and is driven by large infrastructure investments, which are linked intimately to economics.
- Economics matter. The ***principle of comparative advantage*** is key to understanding what will happen where. Cost-benefit must be favorable for sustainable diffusion of new technology.
- Finally, policy and geopolitics shape, and are shaped, by all of the above.
- The most impactful yet oft understated "transitions" affecting energy markets in the last 20 years have been the shale revolution in the US and demand growth in Asia… what will COVID do?

More on the data behind the picture…

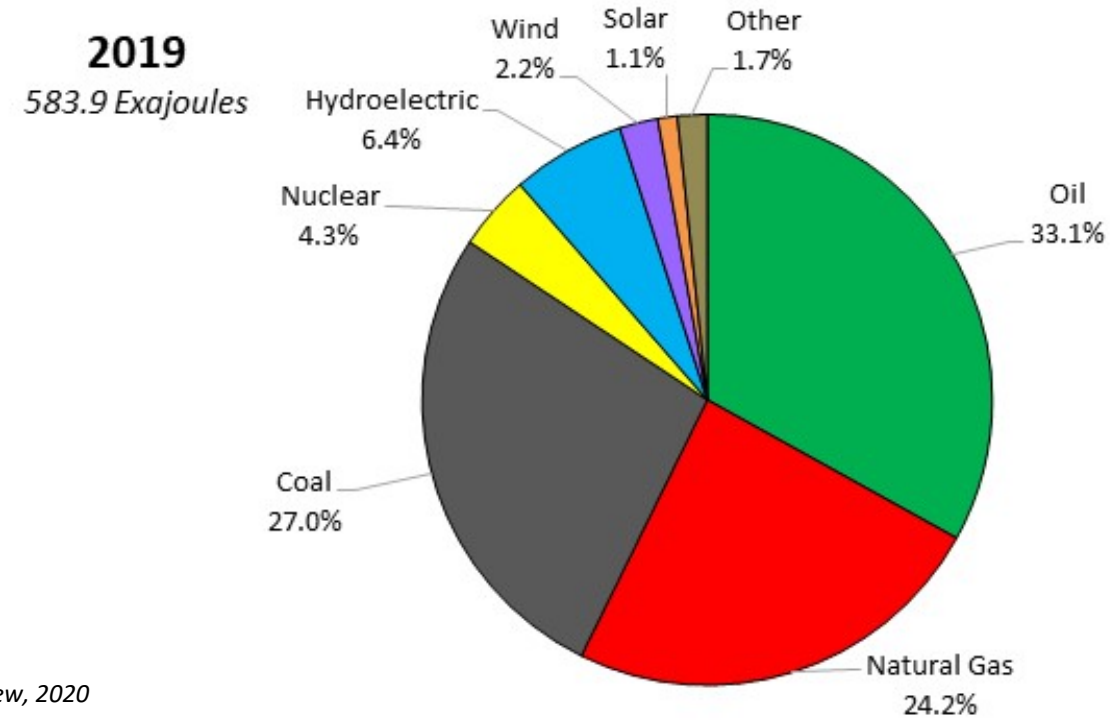
The current global energy landscape

- Renewables are a major focus of the energy transition discussion, and they are growing. In 2019, wind and solar represented 8.9% of global electric generation and 3.3% of total energy, which is up from 1.1% and 0.3%, respectively, in 2008…

Global Power Generation



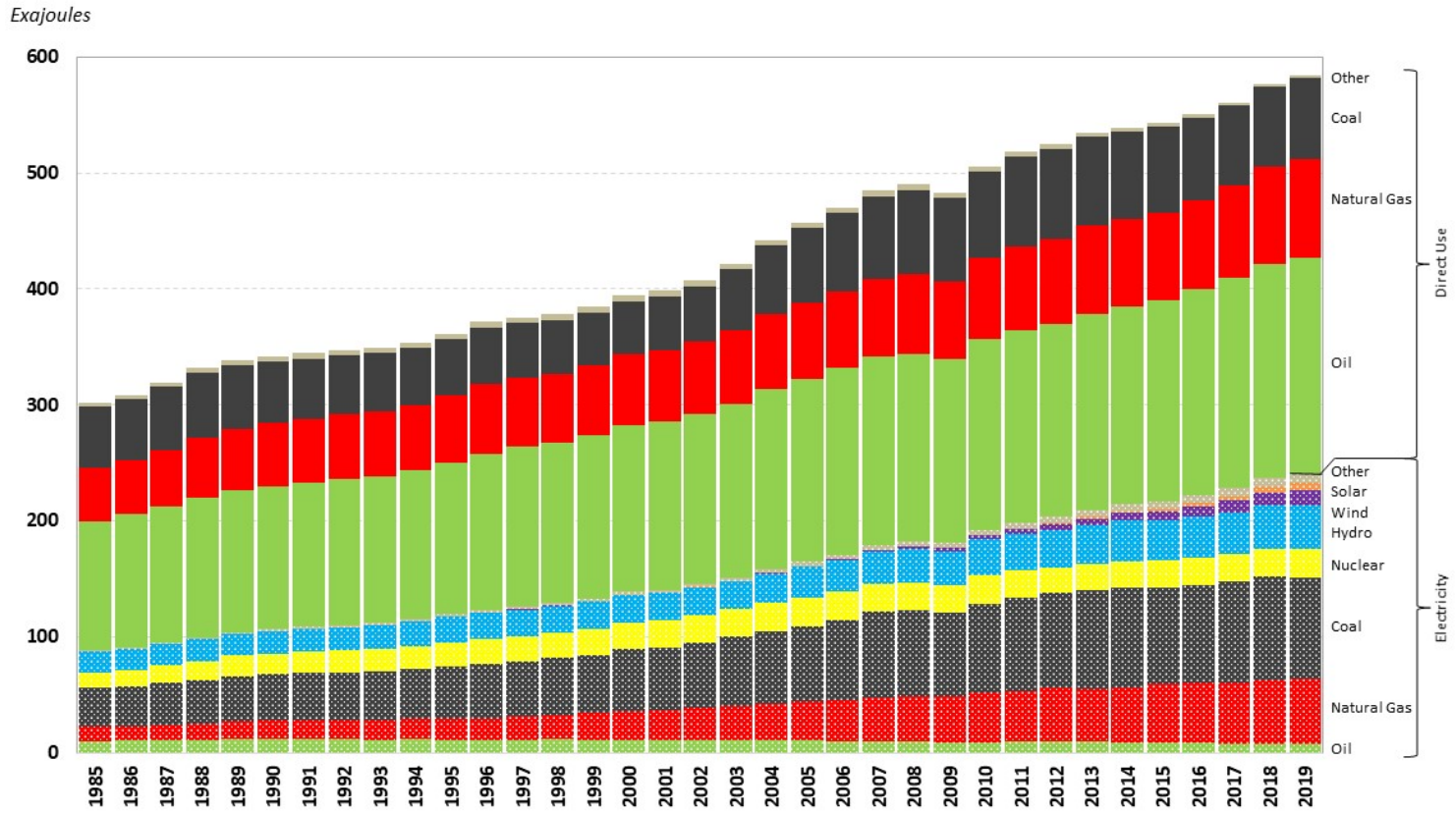
Global Primary Energy



Data Source: BP Statistical Review, 2020

The global energy landscape, the reality of "scale"…

- … but even with astounding year-on-year percentage increases for the last 20 years, wind and solar are still a relatively small proportion of the total energy mix.
- Even with continued growth, the prospect for replacing hydrocarbons is challenging.
  - Total energy demand continues to grow. So, incumbent fuels must be displaced, and new demand met, simultaneously.
  - Greater electrification is a challenge. Electricity is 41% of total energy in 2019, which is up from about 30% in 1985. But continuation of trend requires massive movement into transport and heavy industry.
  - Direct combustion of hydrocarbons is prominent, accounting for 99% of non-electric energy.



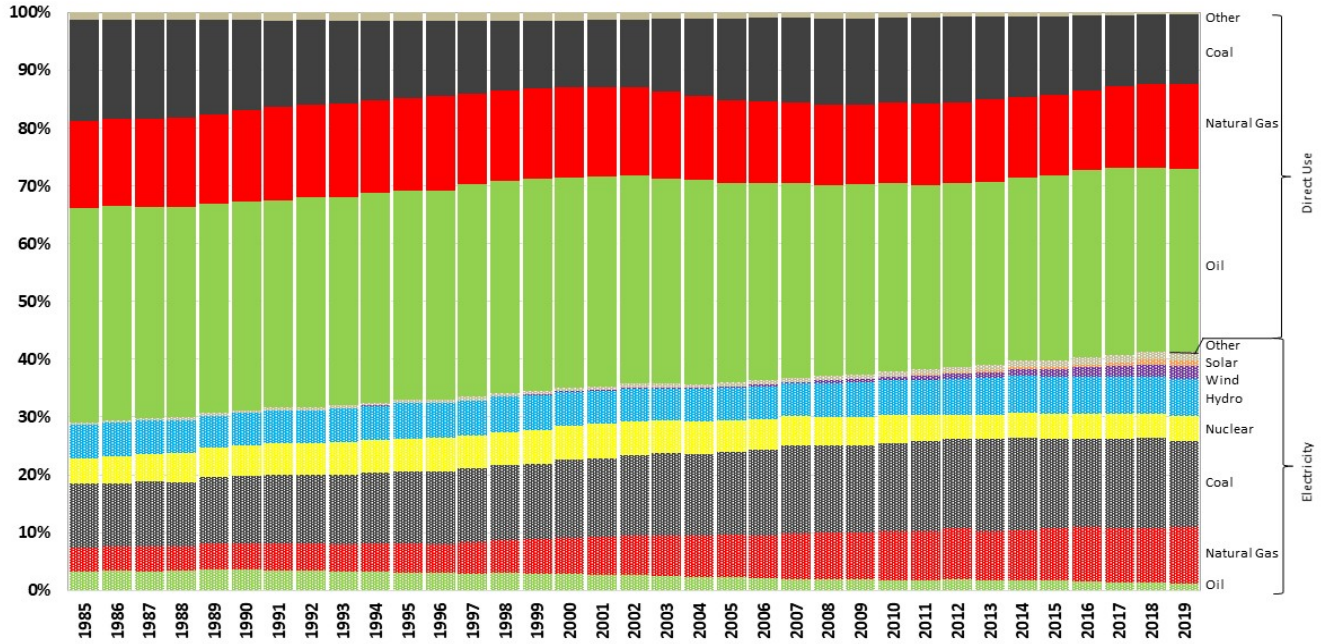
Data Source: BP Statistical Review, 2020

… and the implications for market shares of TPE

- Market shares are slow to change, especially relative to overall demand growth.
  - Coal: $28.6\%_{1985} \rightarrow 27.0\%_{2019}$; Oil: $40.2\%_{1985} \rightarrow 33.1\%_{2019}$; Natural Gas: $19.4\%_{1985} \rightarrow 24.2\%_{2019}$
  - Hydrocarbons: $88.2\%_{1985} \rightarrow 84.3\%_{2019}$
  - Total Primary Energy Demand: $302.2\ EJ_{1985} \rightarrow 583.9\ EJ_{2019}$, which is a 93.2% increase.
  - For hydrocarbon demand to have remained flat given the energy demand increase, market share would have had to decline to $45.6\%_{2019}$, which is a massive shift… and not complete decarbonization, thus highlighting scale!

This is effectively what we are asking the world to do by 2050… Moreover, most of this must come from developing nations!

- Decarbonization cannot be only about renewable energy technologies… changing the way we combust fossil fuels, carbon capture, nuclear energy, and expanding carbon sinks can all play a role! Again, the principle of comparative advantage matters, and solutions will vary by region.



Data Source: BP Statistical Review, 2020

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Contact:report@tky.ieej.or.jp