

# **Some Challenges for the Energy Transition**

***Rennes School of Business Summit***

October 2023

Ted Loch-Temzelides  
Rice University, USA

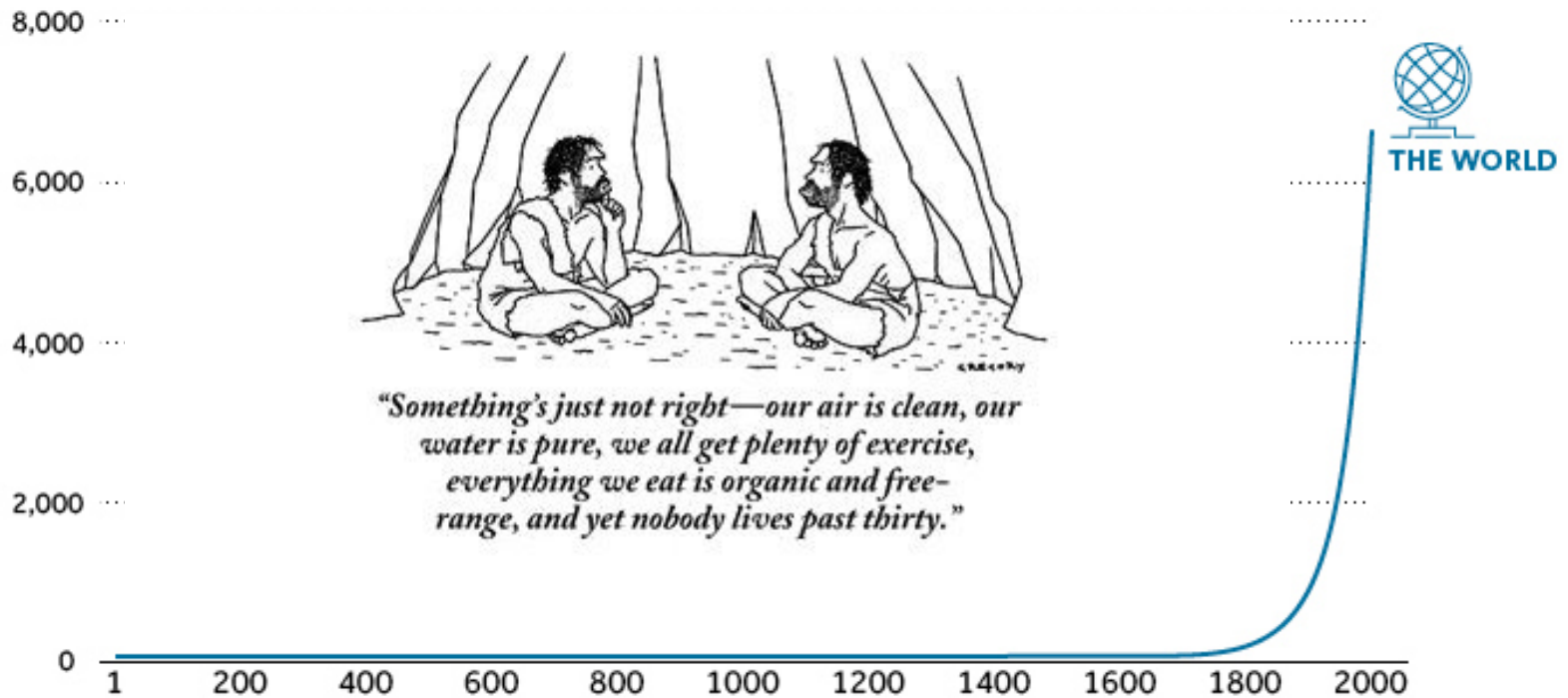
# Plan

- Aspects of economic growth and climate change
- Good news and some challenges for renewables
- Failure of climate policies
- Fossil fuel likely to be with us a while longer
- A historical anecdote

# **1. Economic Growth and Climate**

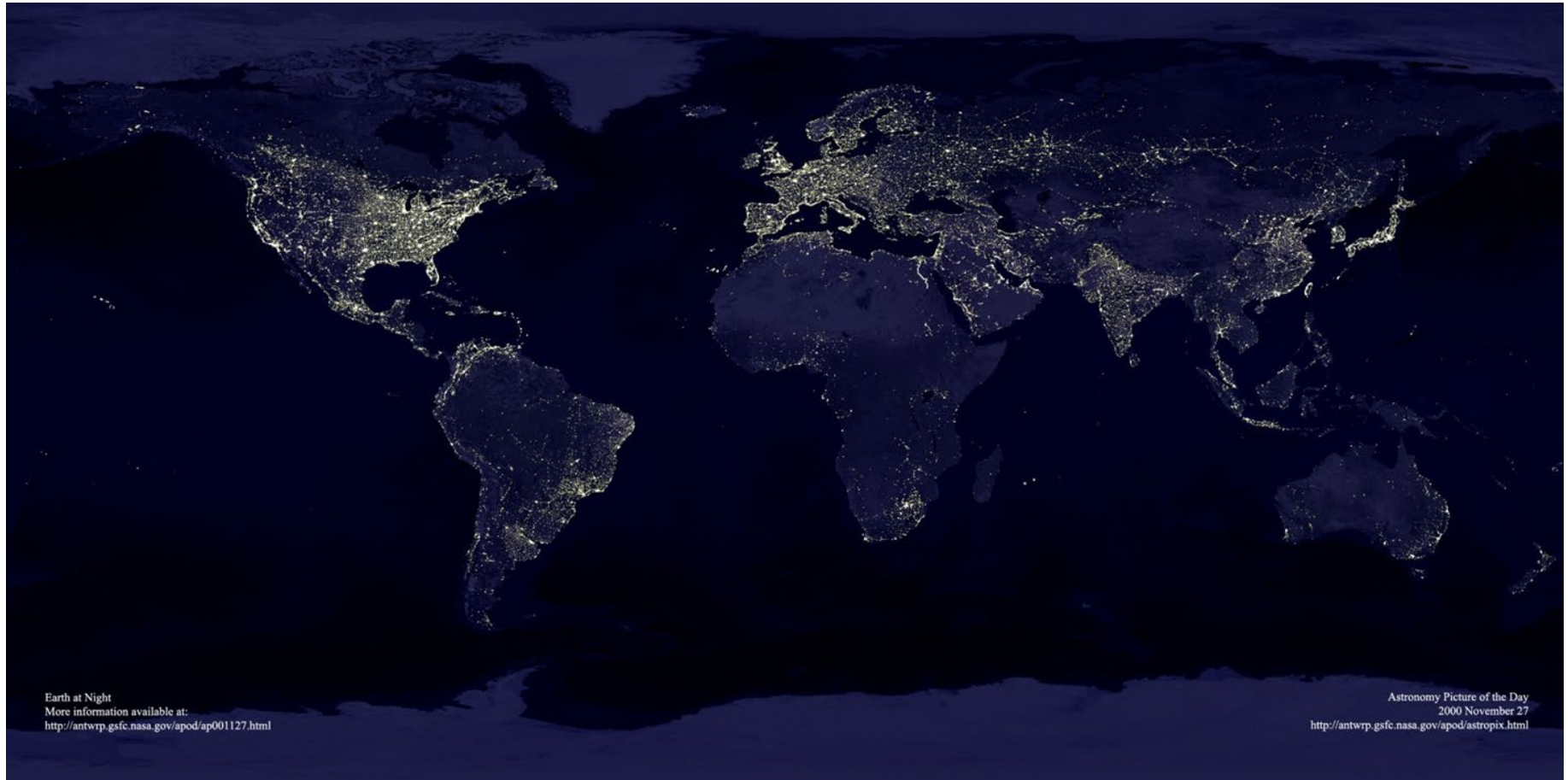
# 2,000 Years of Economic History in One Chart

World GDP Per Capita (1990\$)



SOURCE: "Statistics on World Population, GDP, and Per Capita GDP, 1-2008 AD", Angus Maddison; IMF

# Energy Demand Hand-in-Hand with Economic Growth

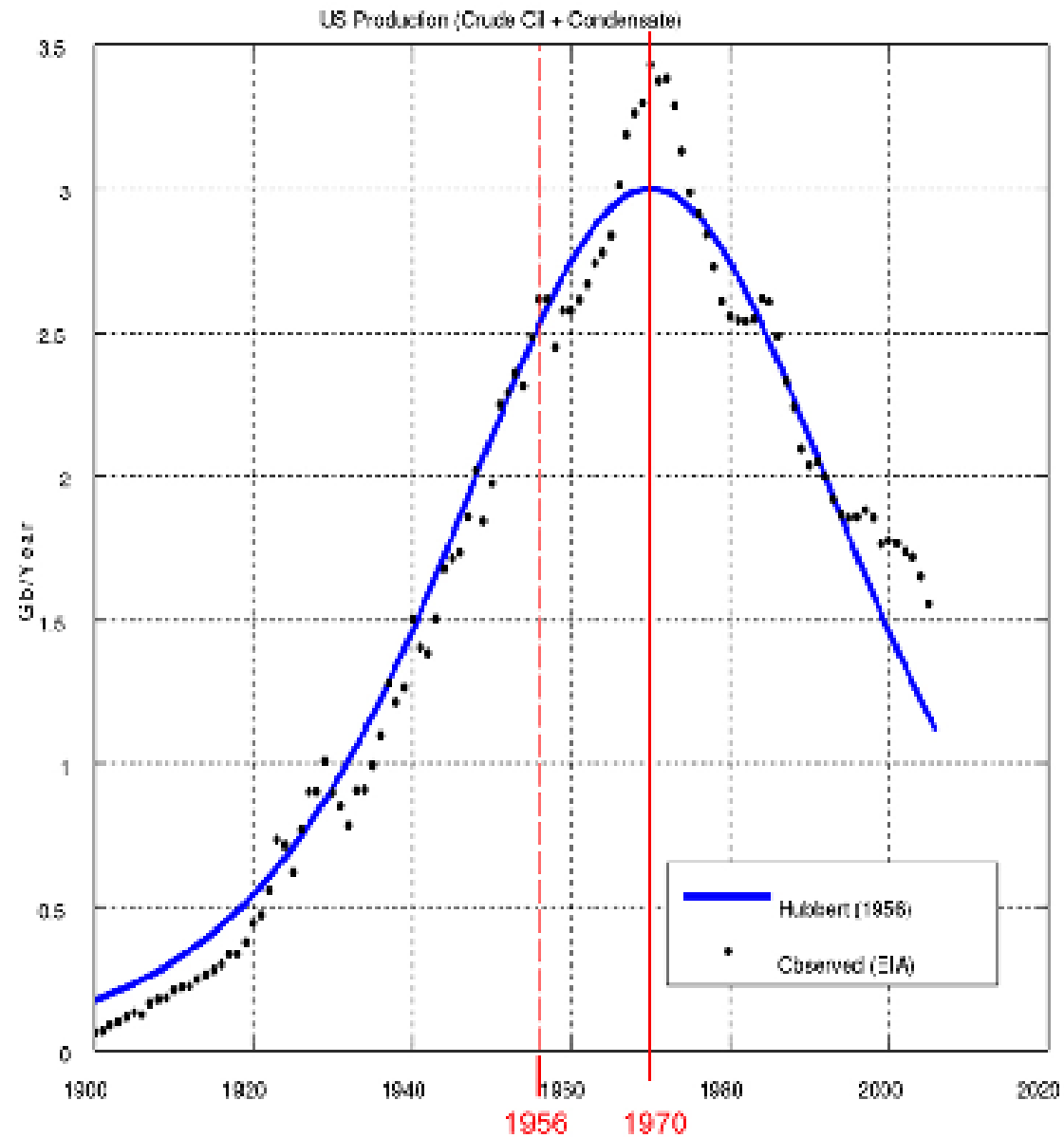


# What Fuels Growth

- Historically fossil fuel sources
  - Exhaustible
  - Externalities
    - GHG and Climate Change
    - Local Pollution and Public Health
    - Geopolitical dependence

# Fossil Fuel Scarcity

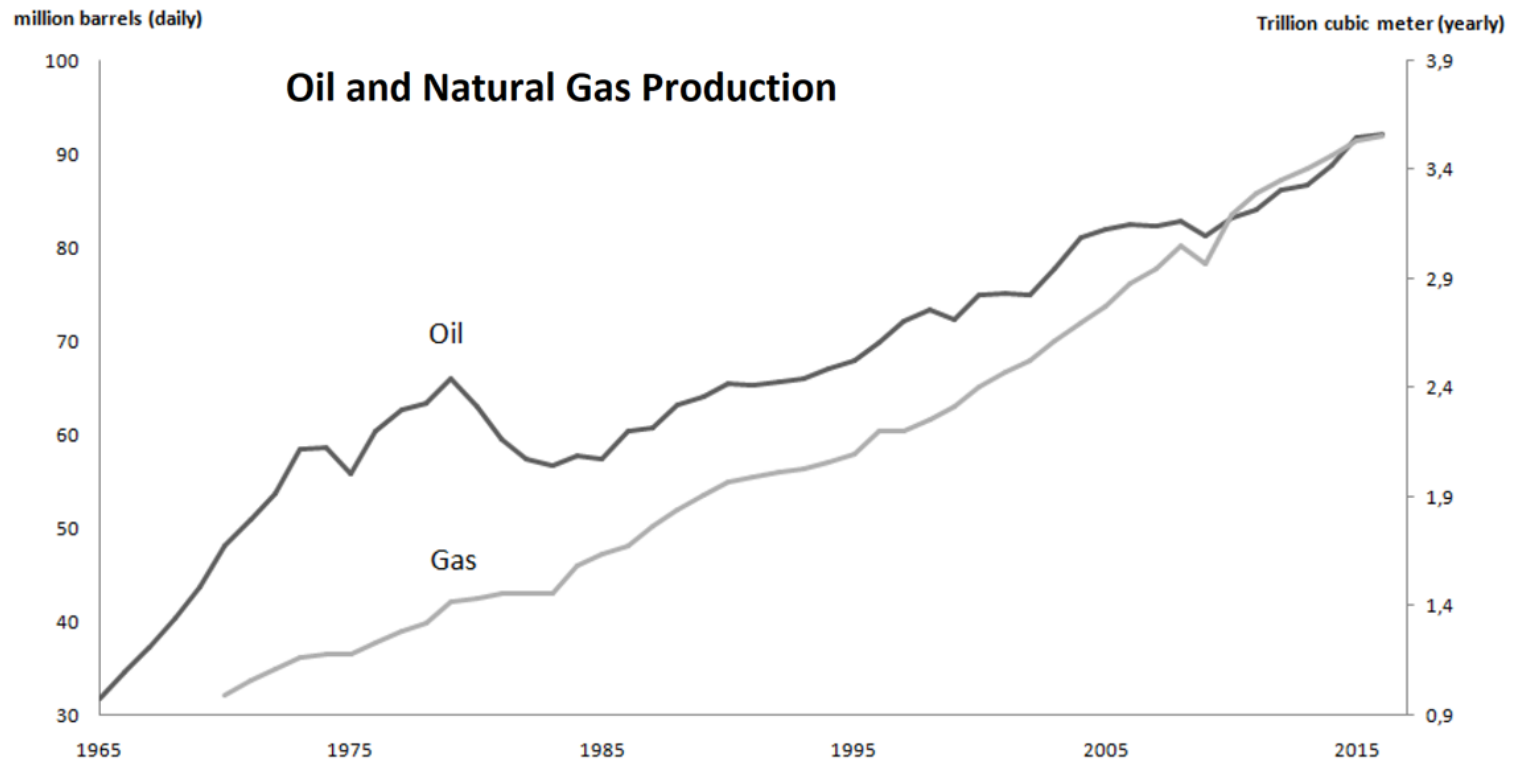
- Fossil fuels are exhaustible
- Does this matter?
- The “*Peak Oil*” Theory





# **The Moving “Parity Target” for Renewables**

# "Peak Oil" Supply Proved Wrong



Source: BP statistical review of world energy

# “Unconventional” Resources

- Shale, vast coal resources, off-shore, deep water, off-shore shale, ... methane hydrates
  - *“The stone-age did not end because we run out of stones”*
- “Peak demand” looks more likely than “peak supply”
- Need incentives to keep much of this resource in the ground
  - “Good citizenship” example not enough

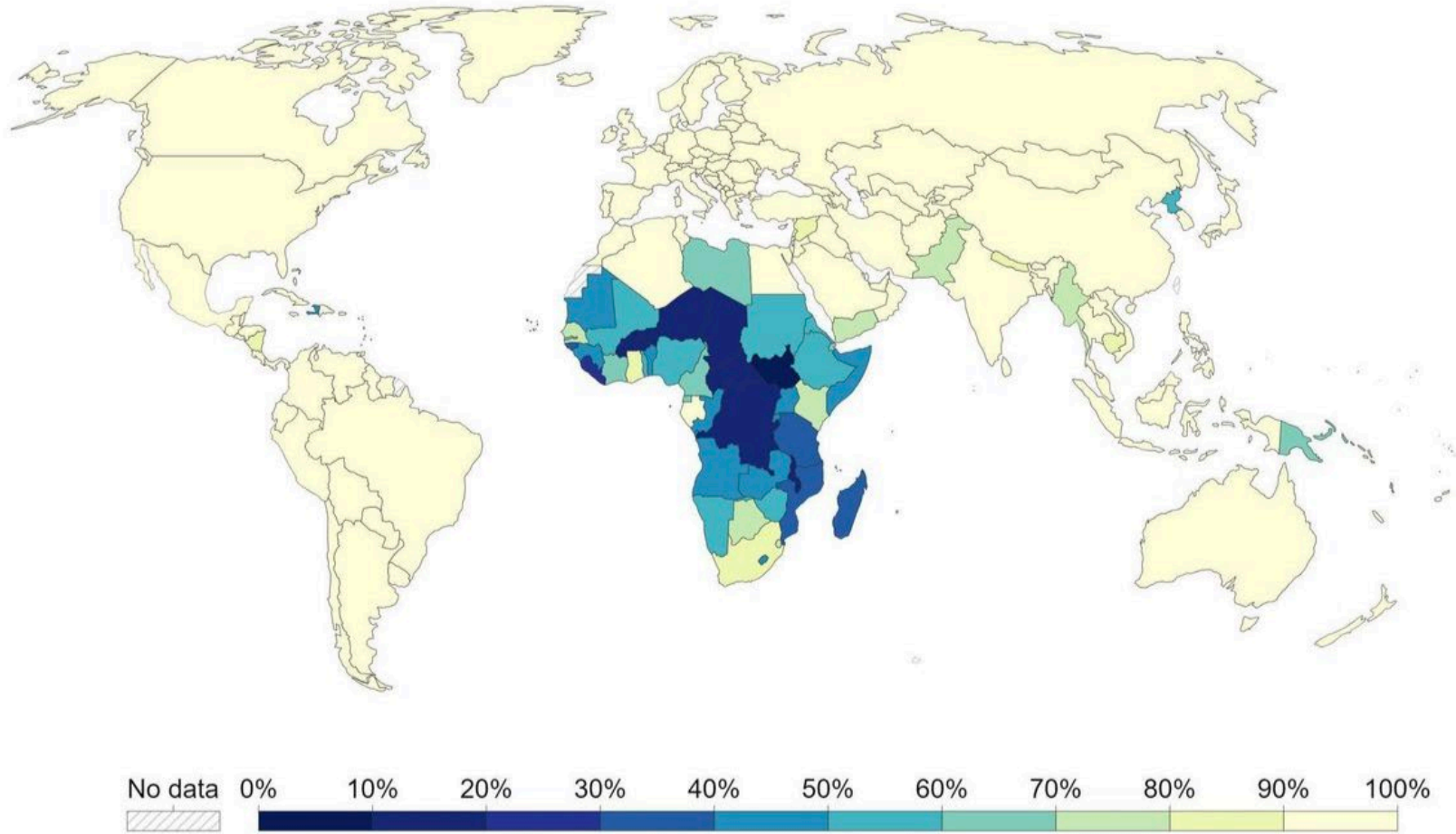
# **2. Energy Poverty**

# Energy Poverty

- About 1.3B people live in energy poverty
- More if we consider energy insecurity
- Mainly in the global south
  - Sub-Saharan Africa, Asia

# Electricity access, 2020

Share of the population with access to electricity. The definition used in international statistics adopts a very low cutoff for what it means to 'have access to electricity'. It is defined as having an electricity source that can provide very basic lighting, and charge a phone or power a radio for 4 hours per day.



# Some Consequences

- Water purification
  - Food, medicine storage
  - Health and education
  - Life expectancy
  - ...
- 
- People in energy poverty keen to use cheapest available energy source

# **3. Other Challenges**



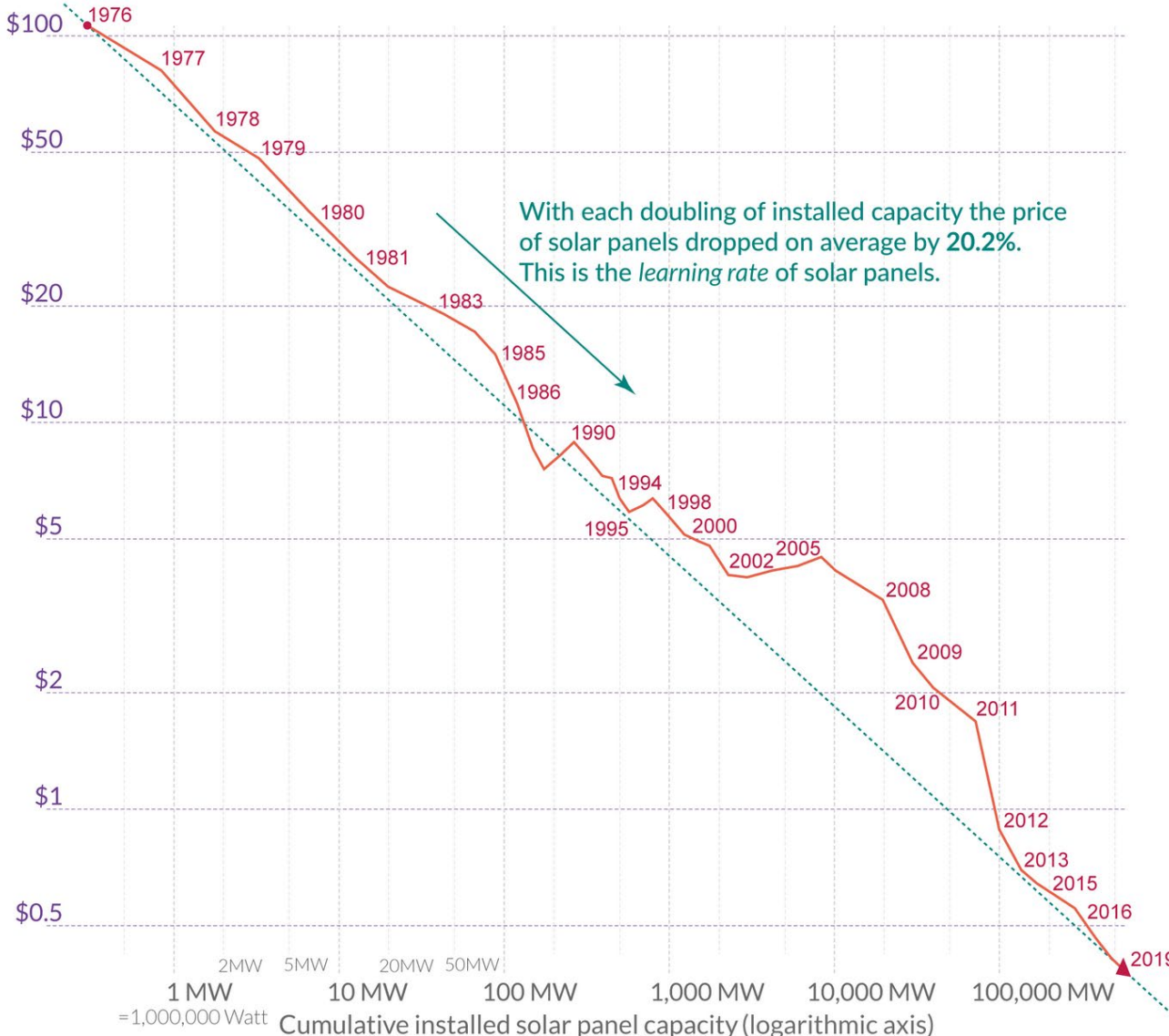
# **The Good News**

# Experience Curves: Solar

Following Wright's Law: the price of solar panels declined by 20% with each doubling of global cumulative capacity

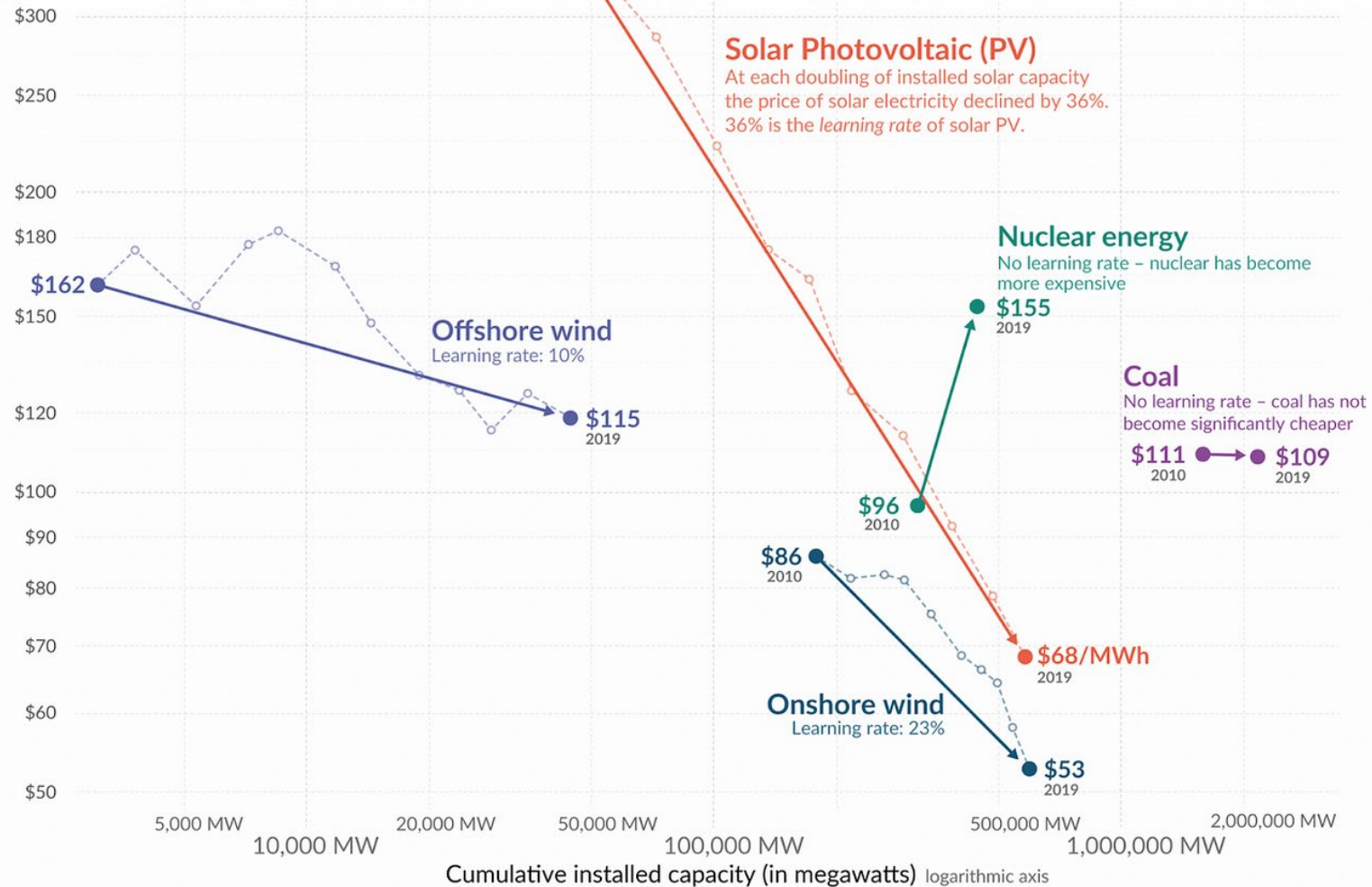


Price per Watt of solar panels (logarithmic axis)  
The prices are adjusted for inflation and presented in 2019 US-\$.



# Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not

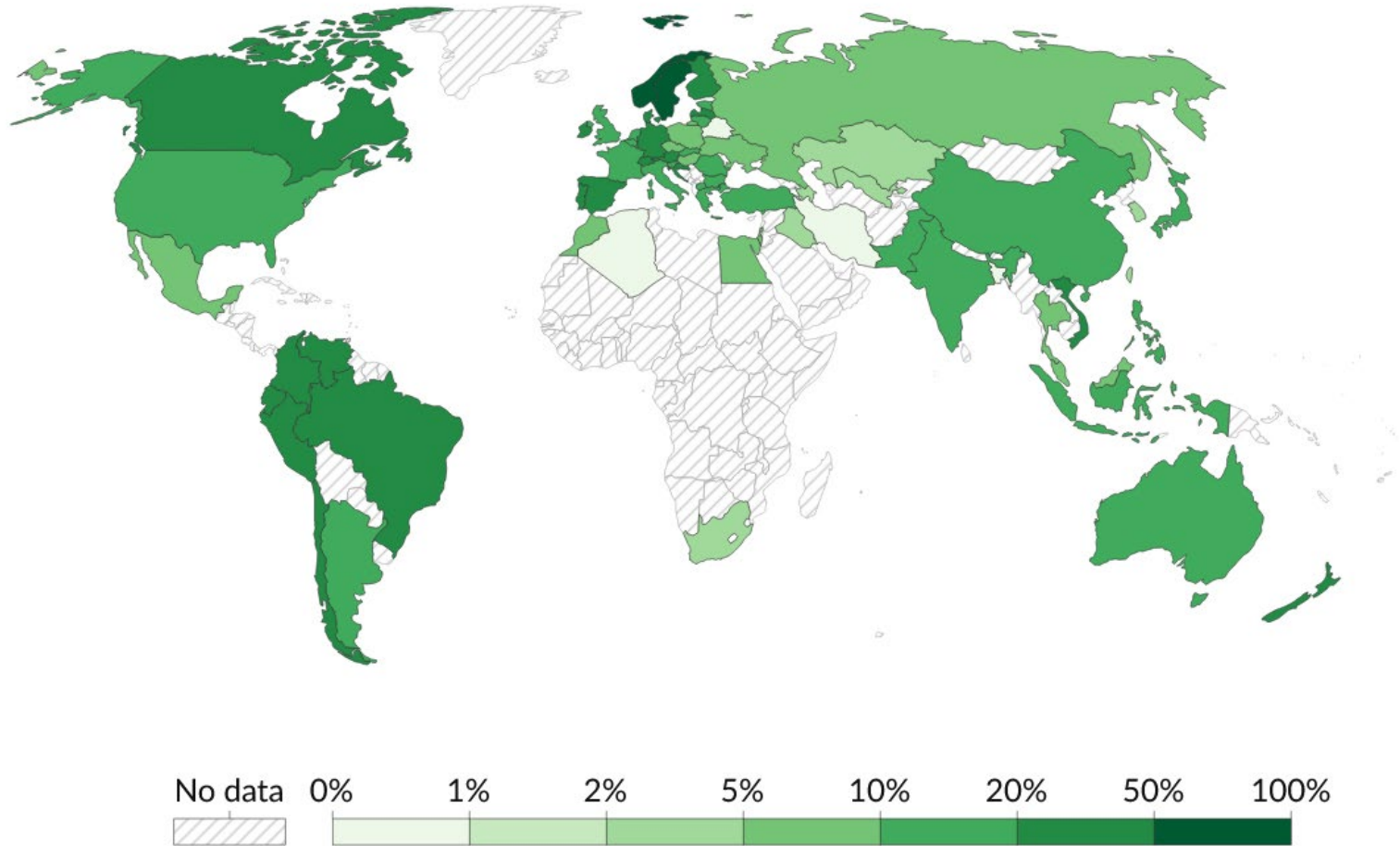
Price per megawatt hour of electricity  
 This is the global weighted-average of the levelized costs of energy (LCOE), without subsidies  
 logarithmic axis and adjusted for inflation



Source: IRENA 2020 for all data on renewable sources; Lazard for the price of electricity from nuclear and coal – IAEA for nuclear capacity and Global Energy Monitor for coal capacity. Gas is not shown because the price between gas peaker and combined cycles differs significantly, and global data on the capacity of each of these sources is not available. The price of electricity from gas has fallen over this decade, but over the longer run it is not following a learning curve.

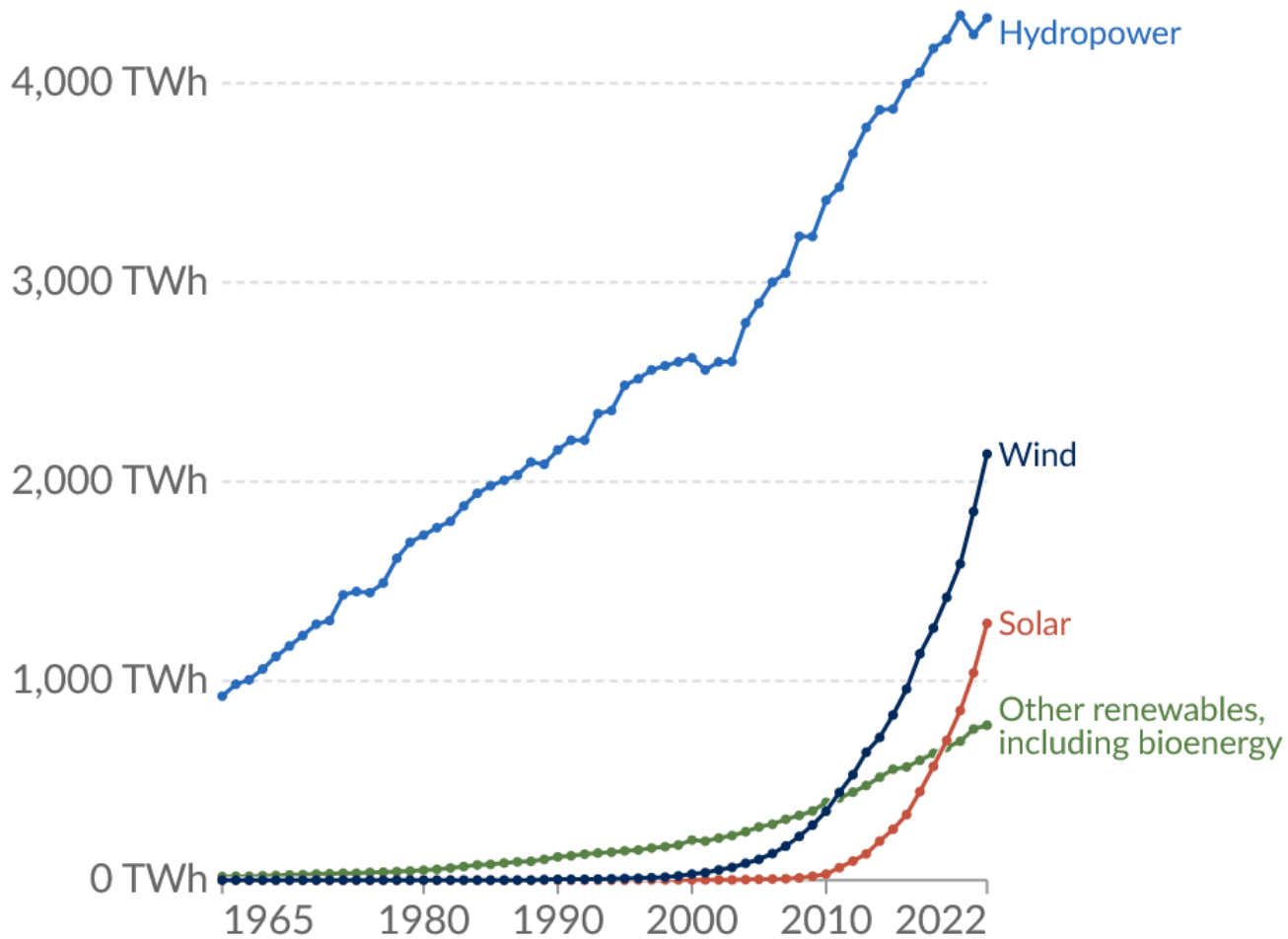
# Share of primary energy from renewable sources, 2022

Renewable energy sources include hydropower, solar, wind, geothermal, bioenergy, wave, and tidal. They don't include traditional biofuels, which can be a key energy source, especially in lower-income settings.



Source: Energy Institute Statistical Review of World Energy (2023)

# Modern renewable energy generation by source, World



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy

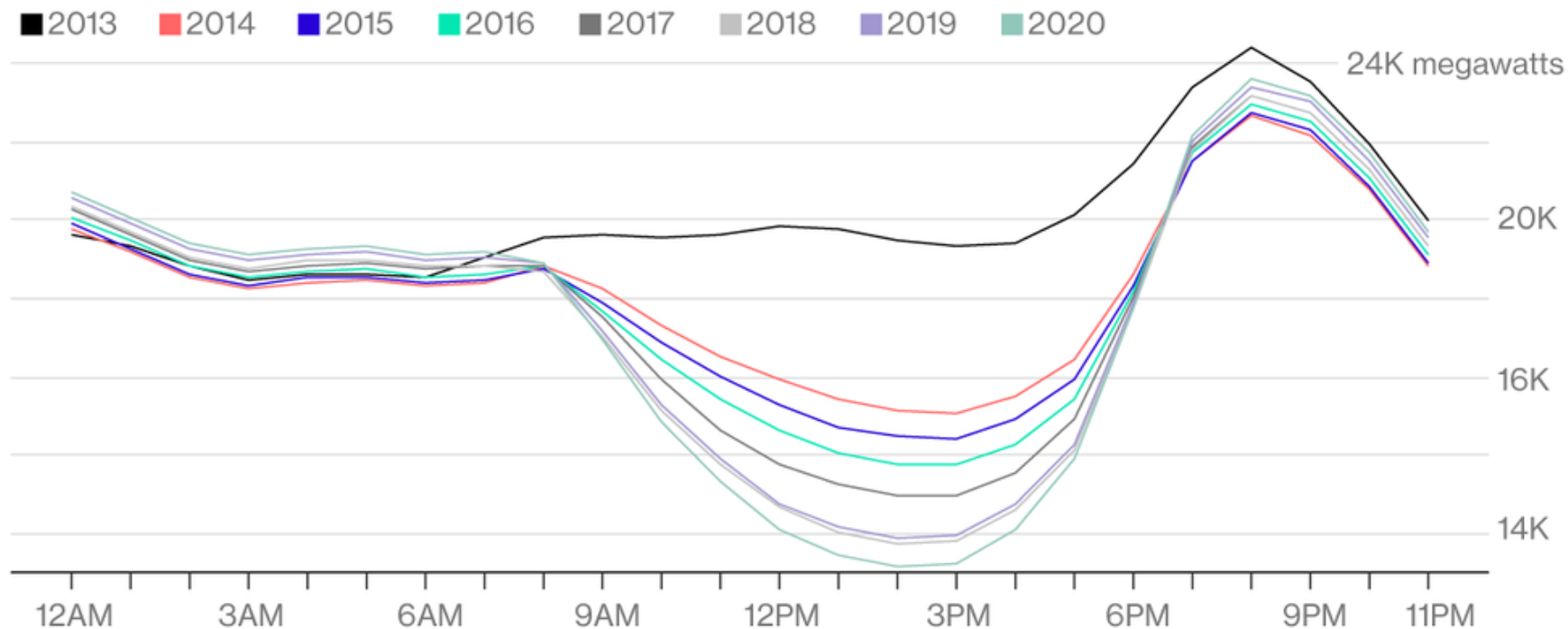
**Some Less Good News...**

# Intermittency

# Need for Storage: the “Duck Curve”

## Solar's Surge

The proliferation of solar farms in California has led to an oversupply of power generation in the middle of the day and steep drop-off in the evening



Source: California ISO

**Bloomberg**



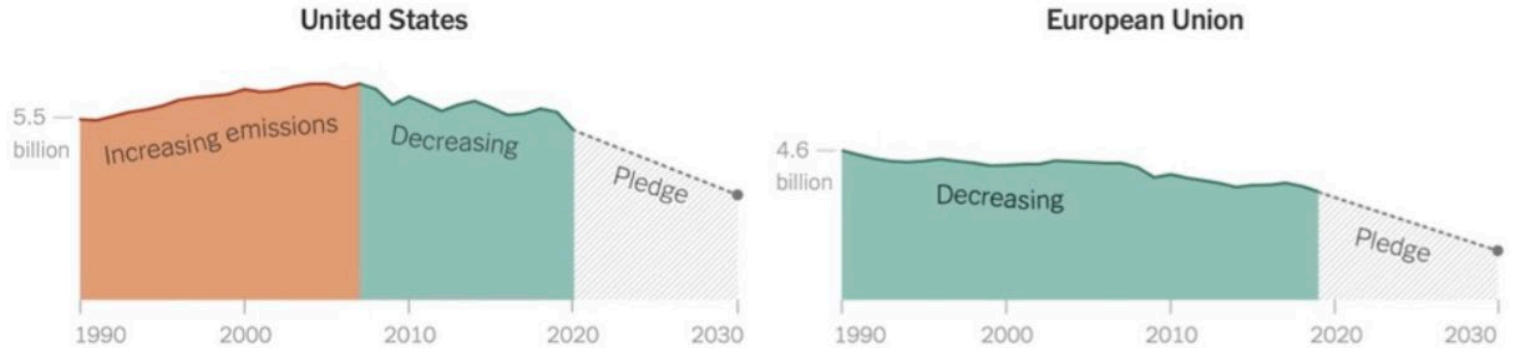
# **4. The Rise of Fossil-Fuel Demand in Asia**

- Climate change related to stock of GHG
  - Non-local in time or space
- Largest past emitters not as relevant for future flows
- Looks likely that fossil fuel will be used for decades to come to fuel Asian growth

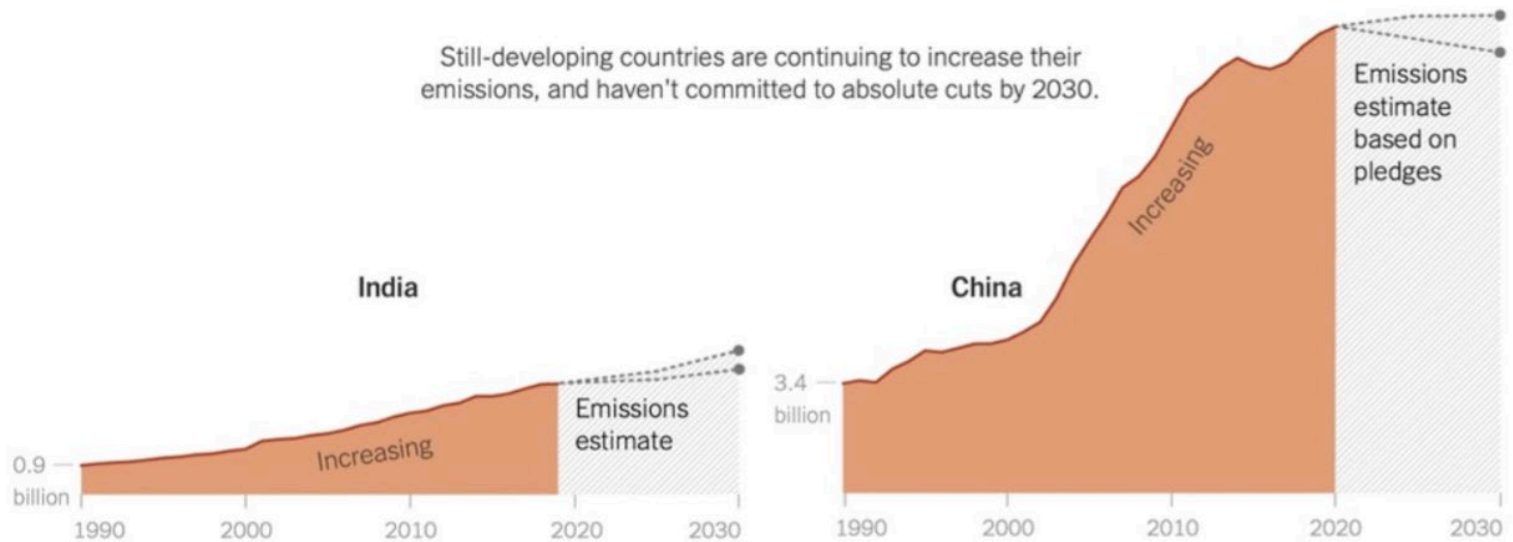
## Trajectories for the World's Largest Emitters

The United States was still increasing emissions until the mid-2000s, while Europe took earlier action.

In metric tons CO<sub>2</sub>



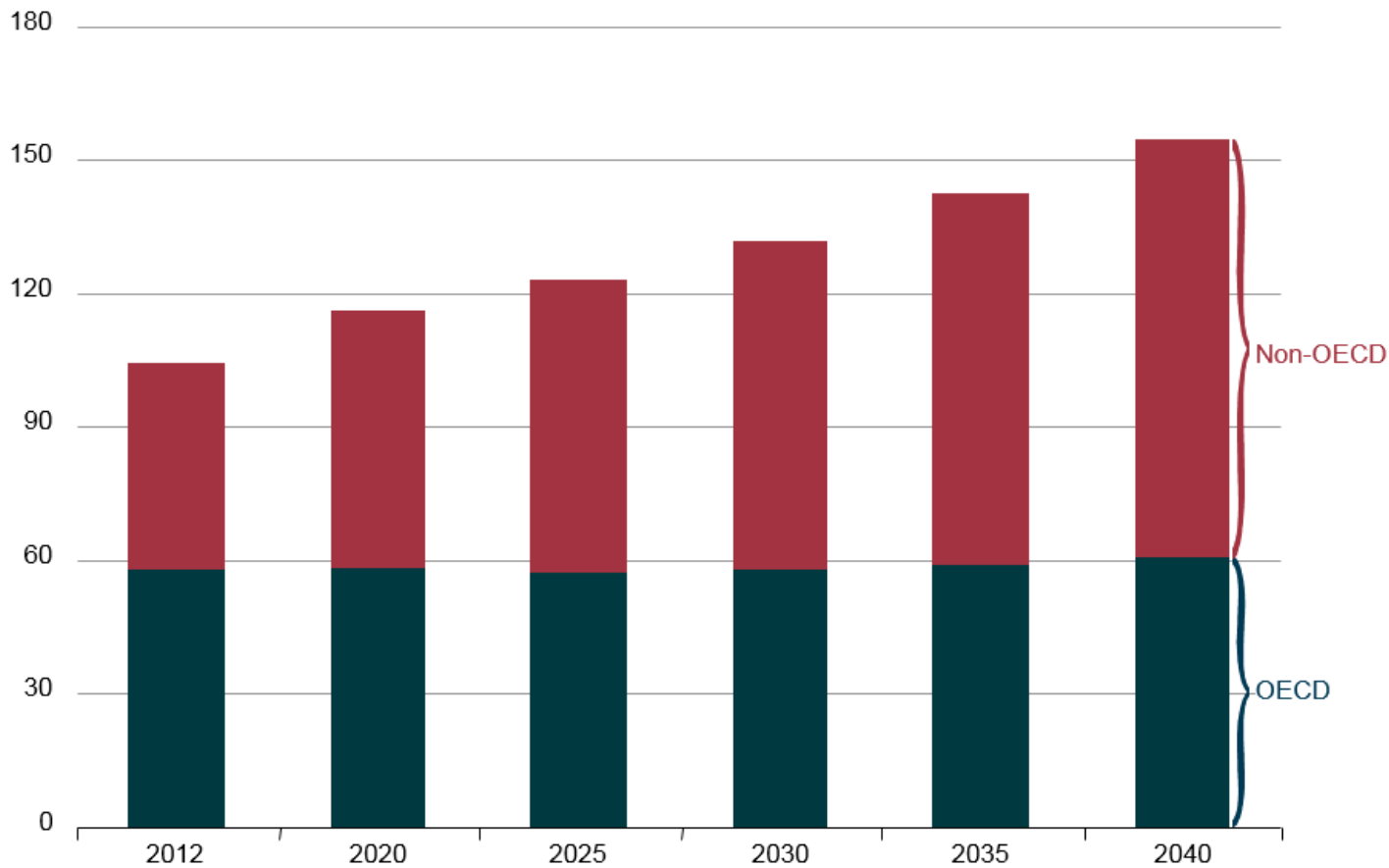
Still-developing countries are continuing to increase their emissions, and haven't committed to absolute cuts by 2030.



# Transportation

Delivered transportation energy consumption by country grouping, 2012–40

quadrillion Btu

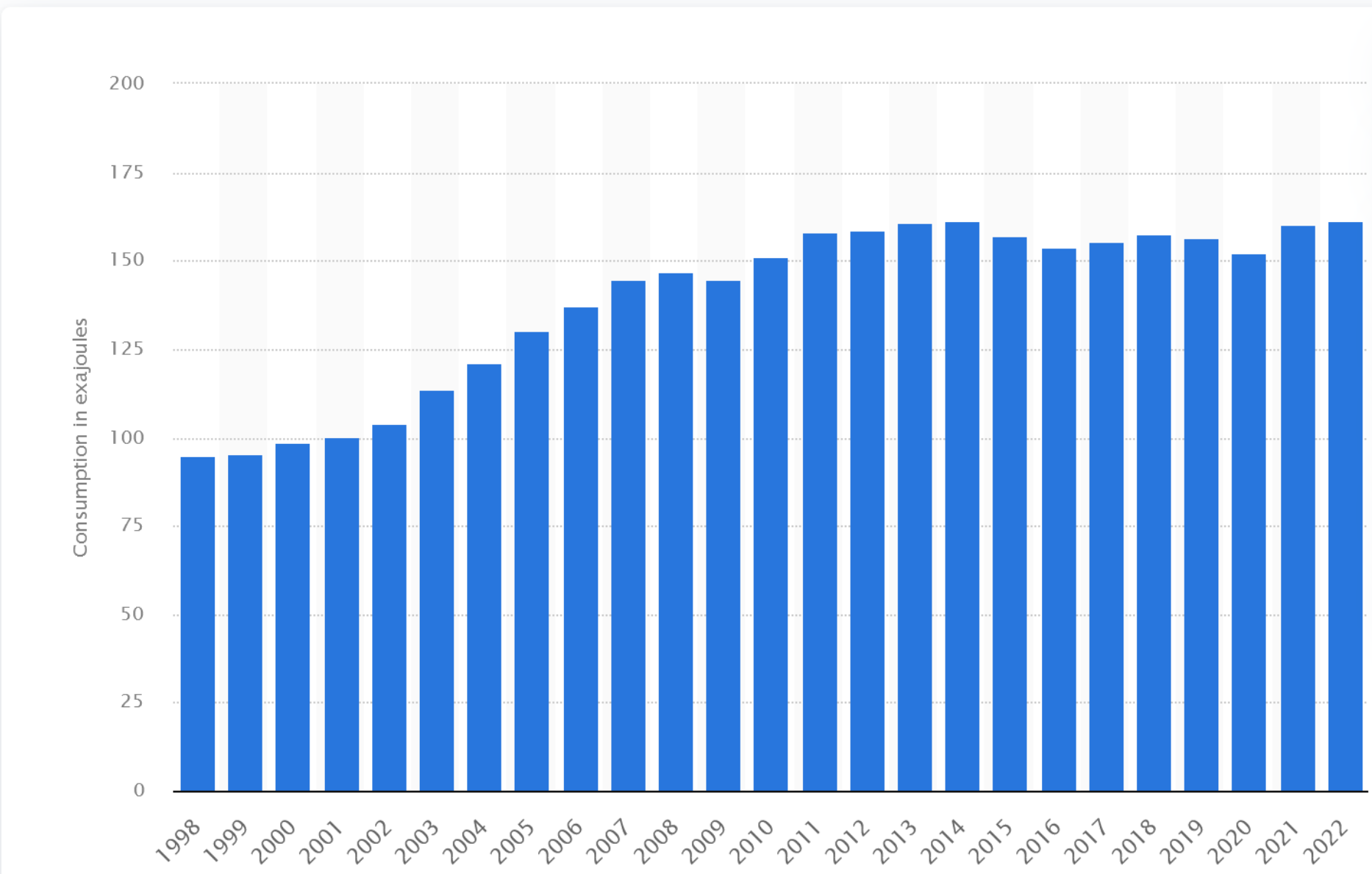


- At least coal is going away...

- At least coal is going away...
- Is it though?

# Coal consumption worldwide from 1998 to 2022

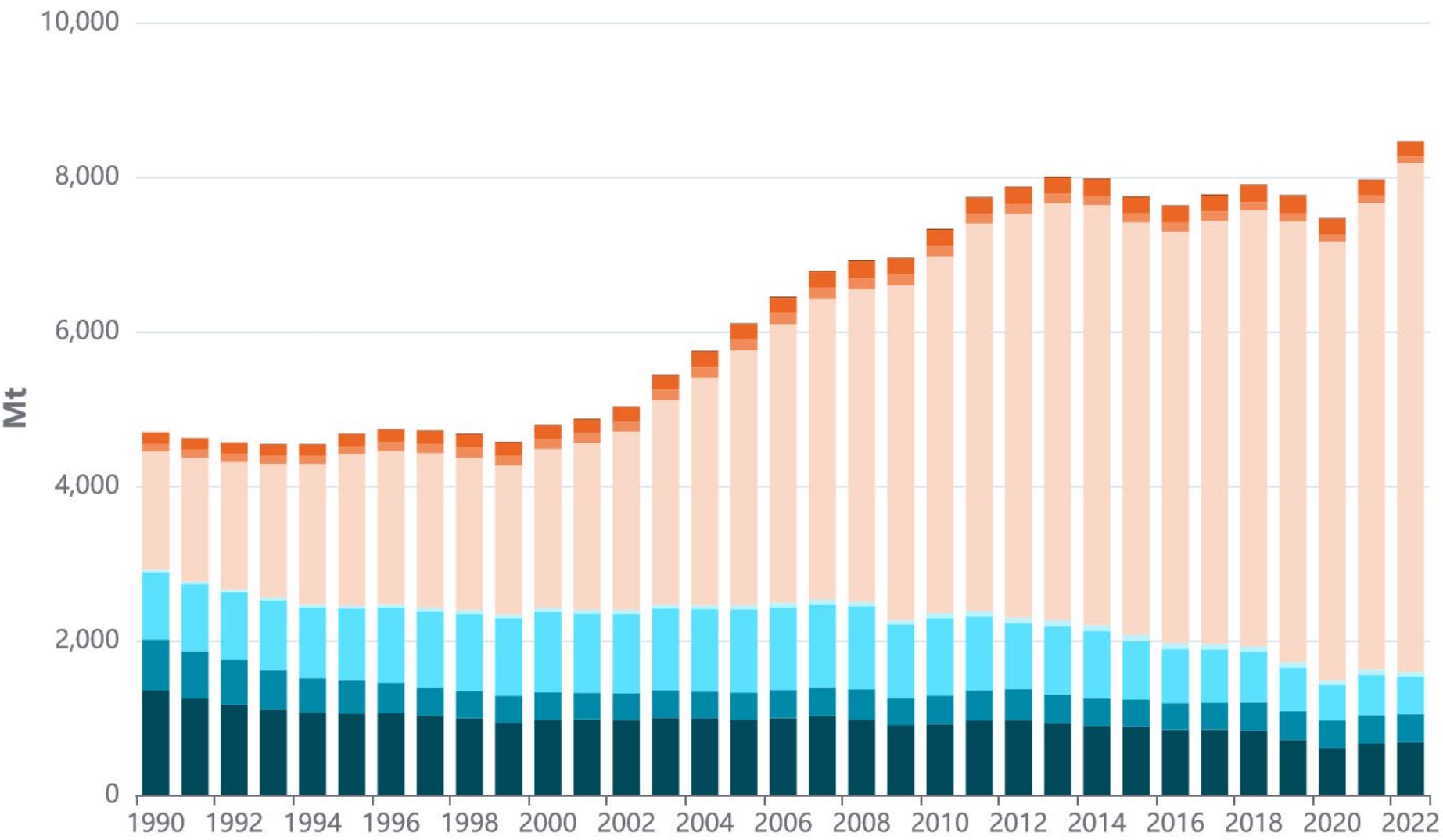
*(in exajoules)*



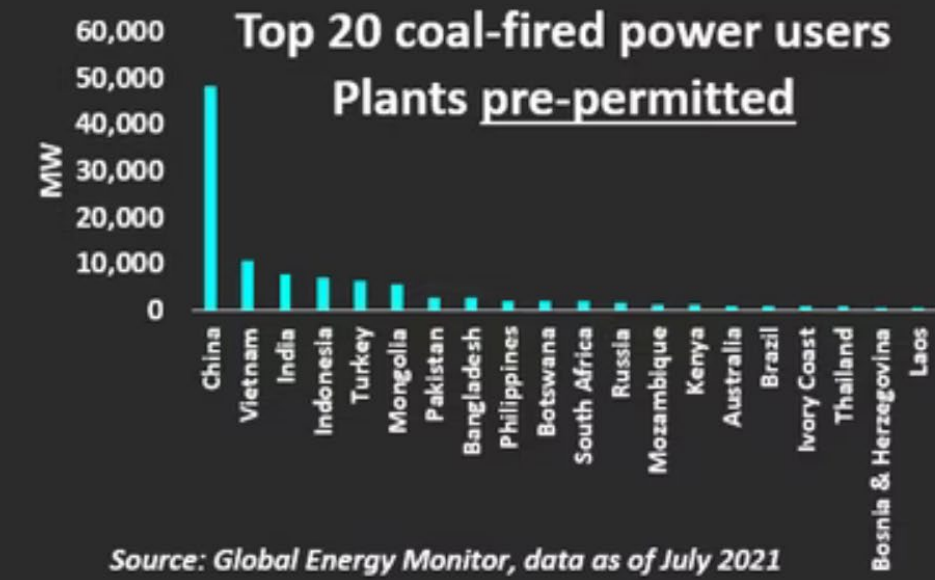
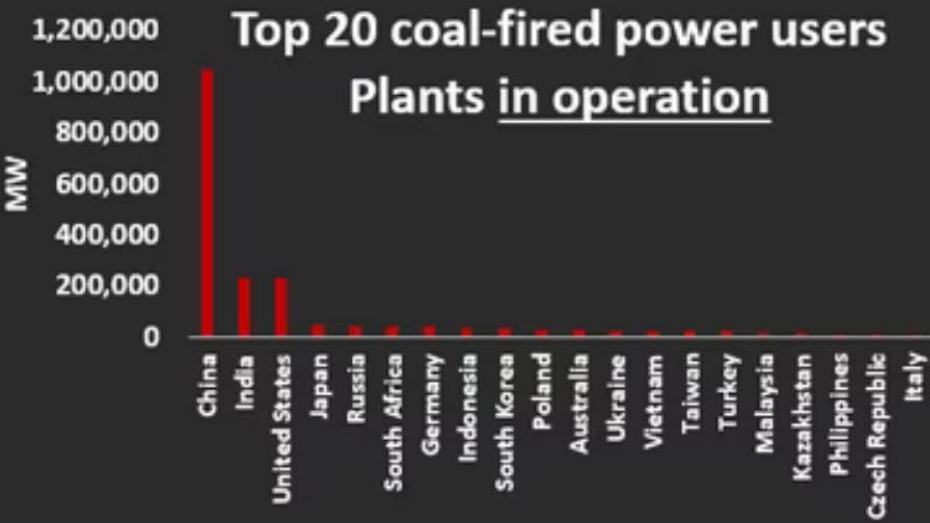
# Coal Consumption

- In 2022:
- 6.3% increase in world coal consumption
- 8.9% increase in coal consumption in Asia
  - 8.8% increase in coal consumption in China
  - 8.3% increase in coal consumption in India
  - 52% increase in coal consumption in Indonesia
- 2.3% increase in coal consumption in Europe
  - 3.5% increase in coal consumption in Germany
- 6.6% decline in coal consumption in the US
- 3/4 s of world's lignite consumption took place in Asia (54% in China)





Europe
  CIS
  North America
  Latin America
  Asia
  Pacific
  Africa
  Middle-East

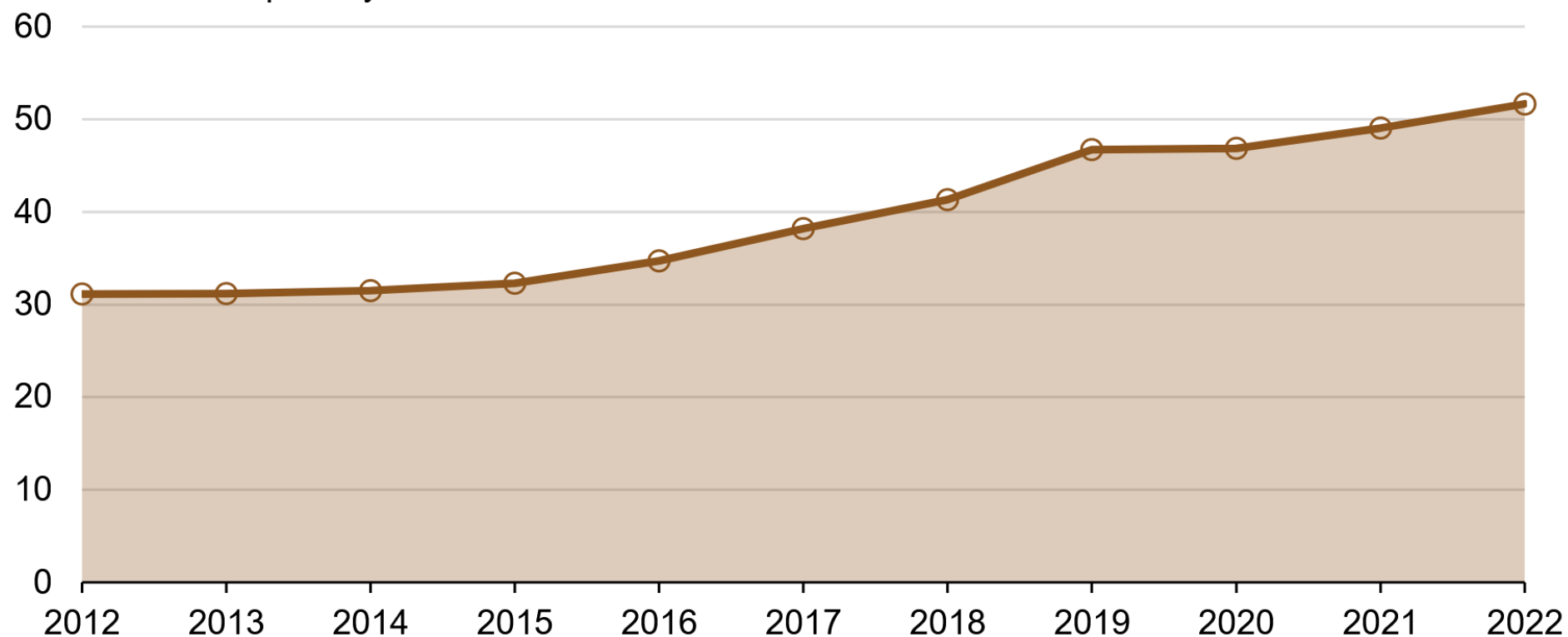


Source: Global Energy Monitor, data as of July 2021

# Global liquefied natural gas trade volumes set a new record in 2022

**Annual global liquefied natural gas trade (2012–2022)**

billion cubic feet per day



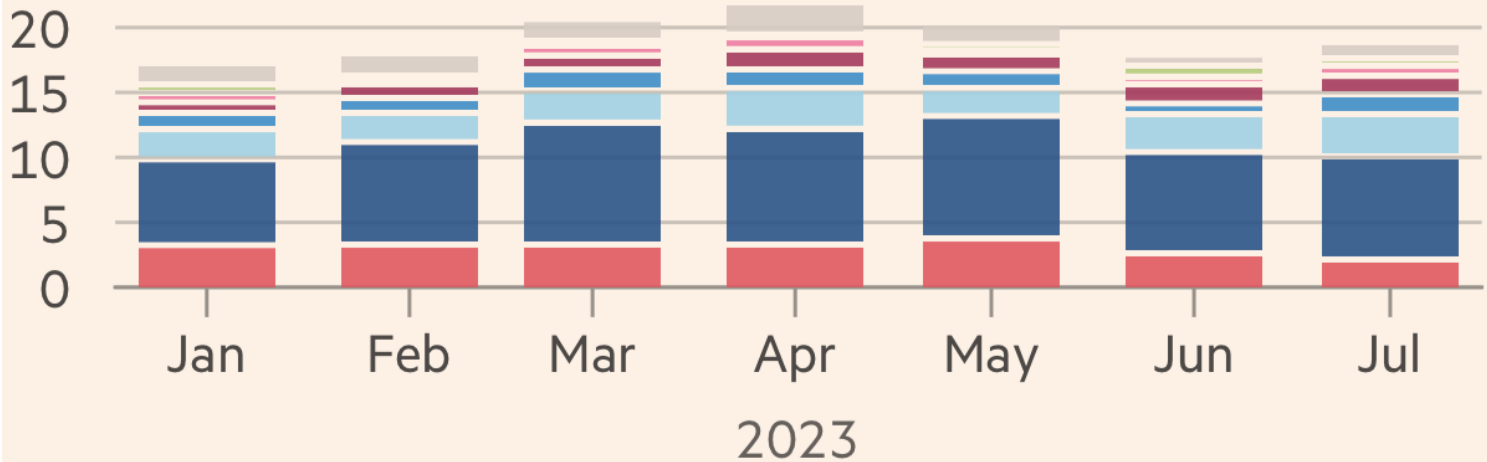
- US now a major LNG exporter to Europe

- US now a major LNG exporter to Europe
- Who else is Europe importing from?

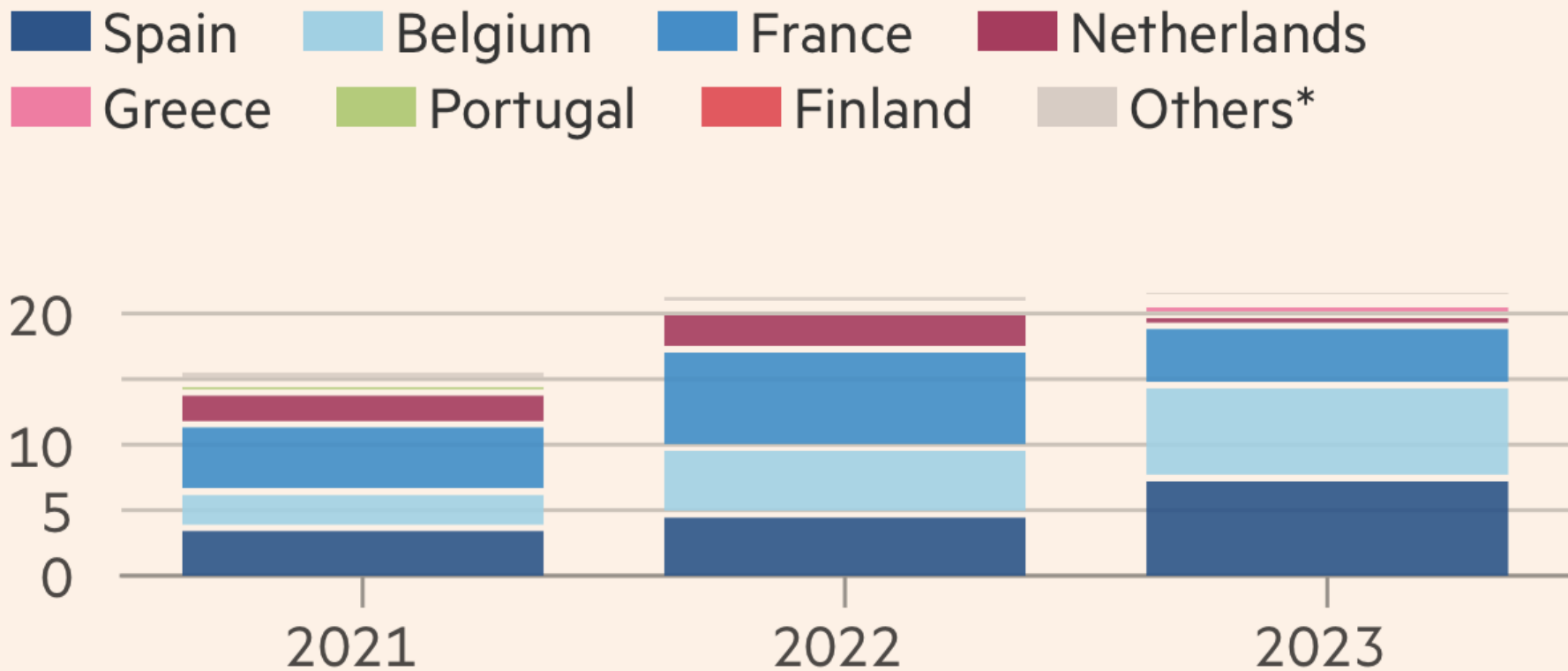
# Russia is the EU's second-biggest supplier of LNG this year

Origin of LNG exports to EU countries (cubic metres, mn)

Russia US Qatar Nigeria Algeria  
Norway Trinidad and Tobago Other\*



# Purchases of Russian LNG by EU countries Jan-Jul (cubic metres, mn)



# Europe

- Nuclear in France
- Moving away from nuclear in Germany
  - Used more coal as a result
- GB to delay climate targets:
  - “Climate goals have imposed unacceptable costs on ordinary people”
- EU buying less long-term LNG that it might need
  - Betting on mild winter o/w will compete with Asia in spot markets
- Europe too small (and too clean) to make a difference



# 5. Climate Policies

# Pigouvian Taxation

- Need to internalize the externality
- Impose tax = marginal (current and future) damage from emissions
- Most countries still subsidize fossil fuel use
- Why?

# Pigouvian Taxation

- Need to internalize the externality
- Impose tax = Marginal (current and future) damage from emissions
- Most countries still subsidize fossil fuel use
- Why?



# **6. A Historical Anecdote: “Technology to the Rescue”**

- The Great Environmental Crisis of...

- The Great Environmental Crisis of 1894



- The Great Environmental Crisis of 1894



- *“In 50 years, every street in London will be buried under 9 feet (2.75m) of manure”* – The Times

- The Great Environmental Crisis of 1894



- *“In 50 years, every street in London will be buried under 9 feet (2.75m) of manure”* – The Times
- Technological innovation: shift happens



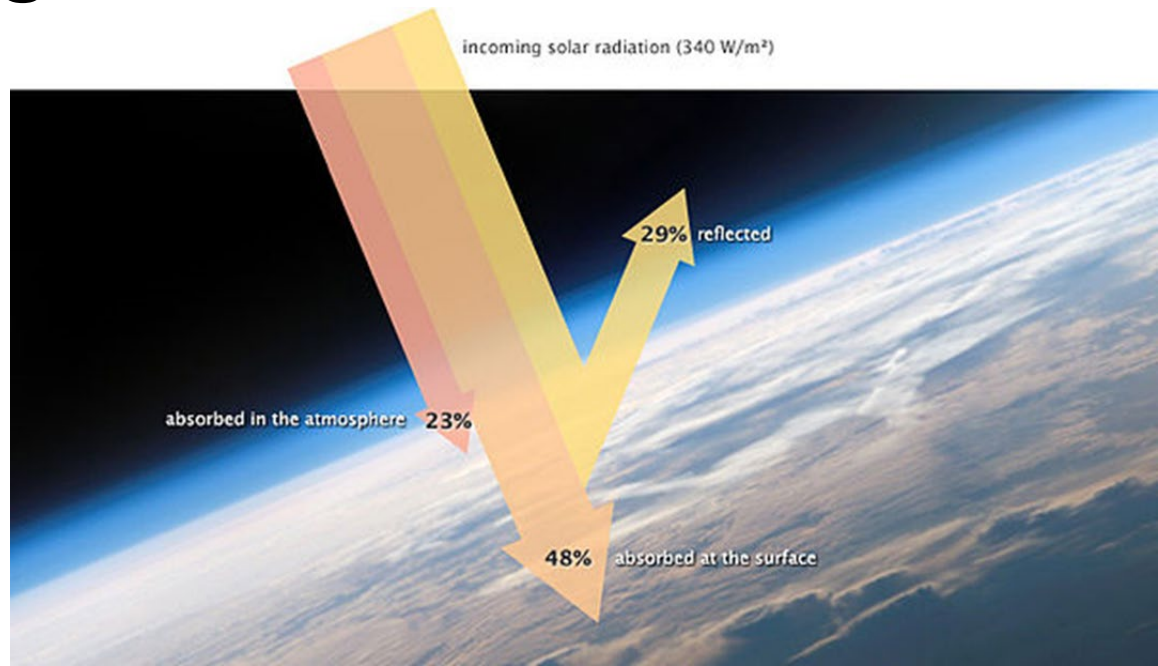
- The Great Environmental Crisis of 1894



- *“In 50 years, every street in London will be buried under 9 feet (2.75m) of manure”* – The Times
- Technological innovation: shift happens
- Automobiles (internal combustion) saved the day!
  - Steam vs. internal combustion engines (also electric)

# Current Technology Frontiers

- Various energy storage technologies
- Fusion (always 20 years away)
- Geoengineering
- ...



# 7. Some Takeaways

- Absent global climate policies, fossil fuel likely to be with us for a while
  - Asia a main driver of current and future demand
- Demand driven by economics
  - Decline in coal use in developed countries lowers its price, redistributing demand to developing countries

- Governments not great at picking winners
  - See diesel cars in Europe...
- Global carbon price would internalize externality and allow technologies to compete on equal footing
- Has proved extremely hard to implement
  - *Tax* is a dirty word (regressivity)
  - Coordination across countries difficult
- The world needs to do better!

**Thank you!**