

# Net zero – time to get real

Niall Mac Dowell

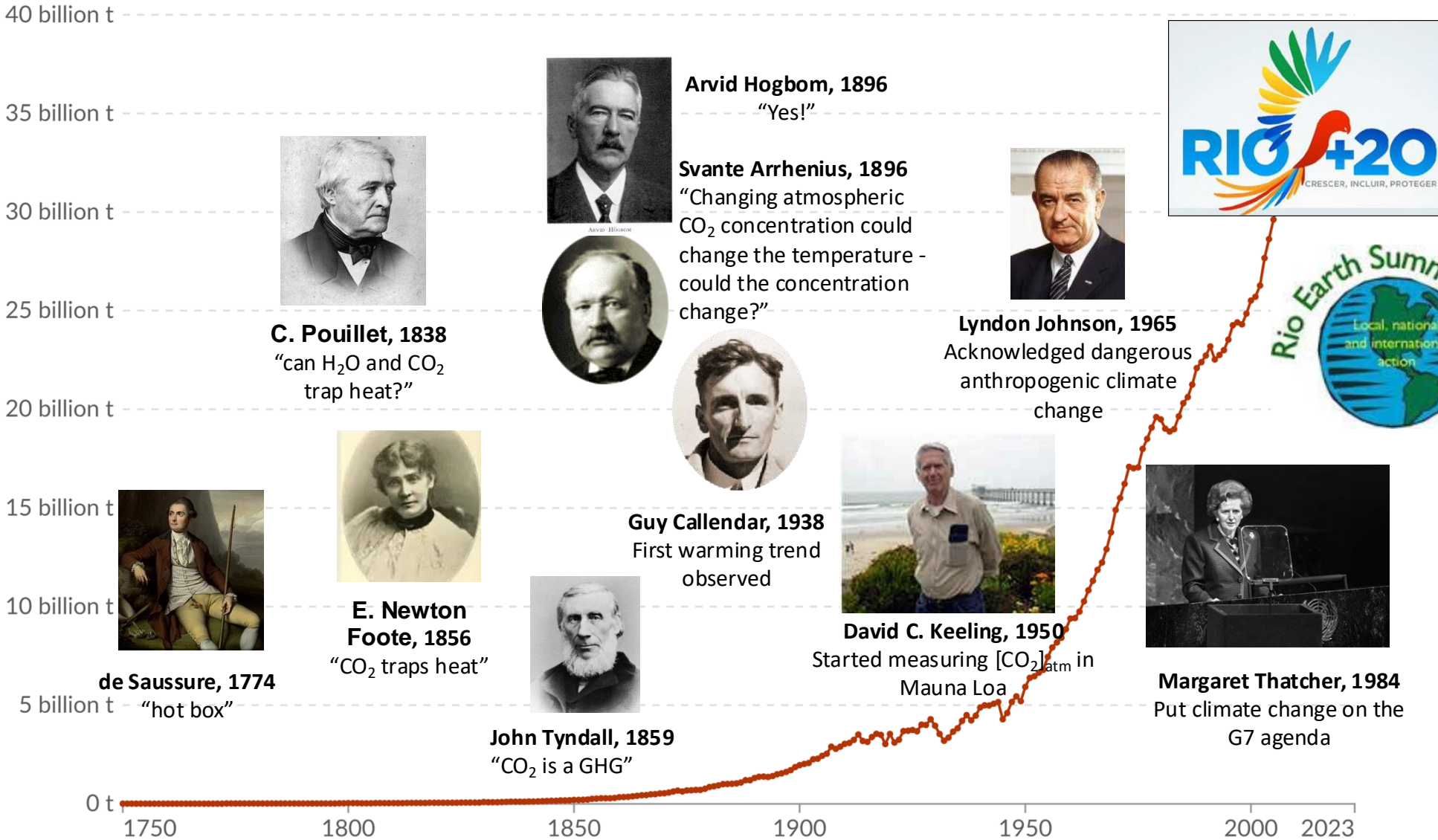
Imperial College London

[niall@imperial.ac.uk](mailto:niall@imperial.ac.uk)

# Annual CO<sub>2</sub> emissions



Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry<sup>1</sup>. Land-use change is not included.







# Estimates of Global Economic Impacts of Climate Change

## IPCC AR6 WGII (2022)

### (a) Statistical modeling

- Kahn et al. (2019)
- Kalkuhl & Wenz (2020)
- Burke et al. (2018) - SR
- Pretis et al. (2018)
- Maddison & Rehdanz (2011)
- Burke et al. (2015)

### (c) Meta analyses

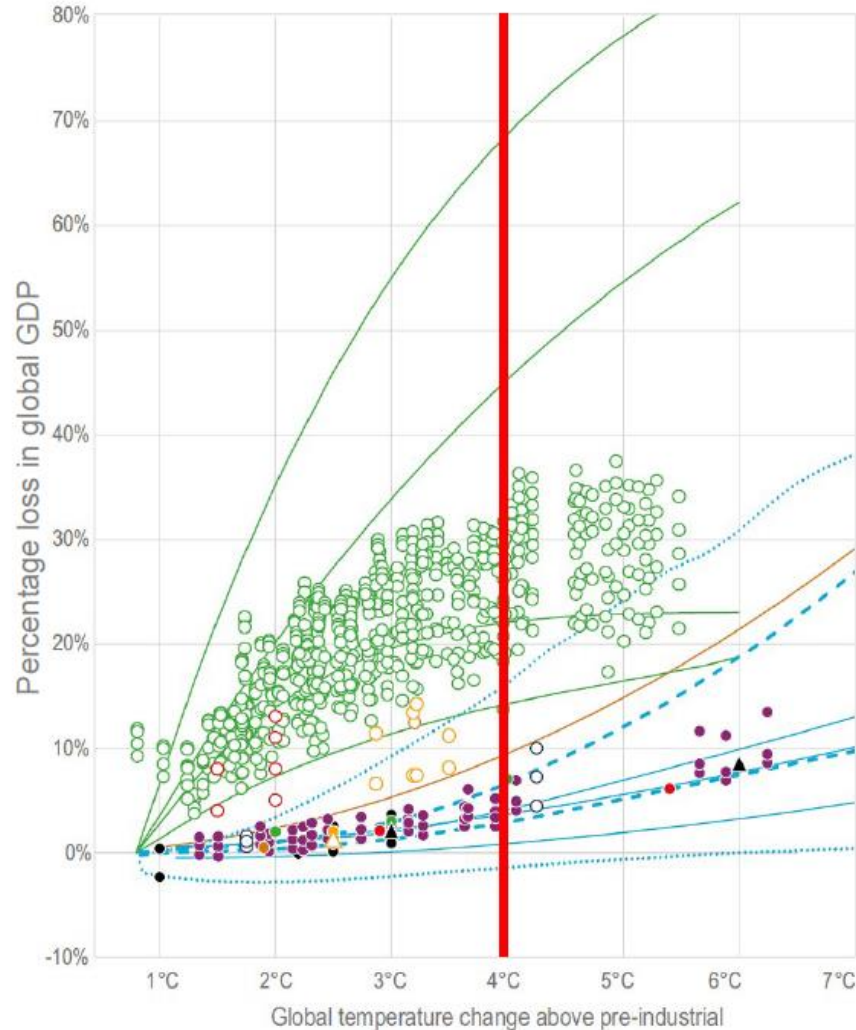
- ▲ Nordhaus & Moffat (2017)/Nordhaus (2016)
- ▲ Tol (2018)
- Howard & Sterner (2017)

### (b) Structural modeling

- Takakura et al. (2019)
- Dellink, Lanzi & Chateau (2019)
- Kompas et al (2018)
- Roson & van der Mensbrugghe (2012)
- Bosello et al. (2012)
- Rose et al. (2017)
- Rose et al. (2017) - FUND 5th & 95th
- Rose et al. (2017) - PAGE 5th & 95th

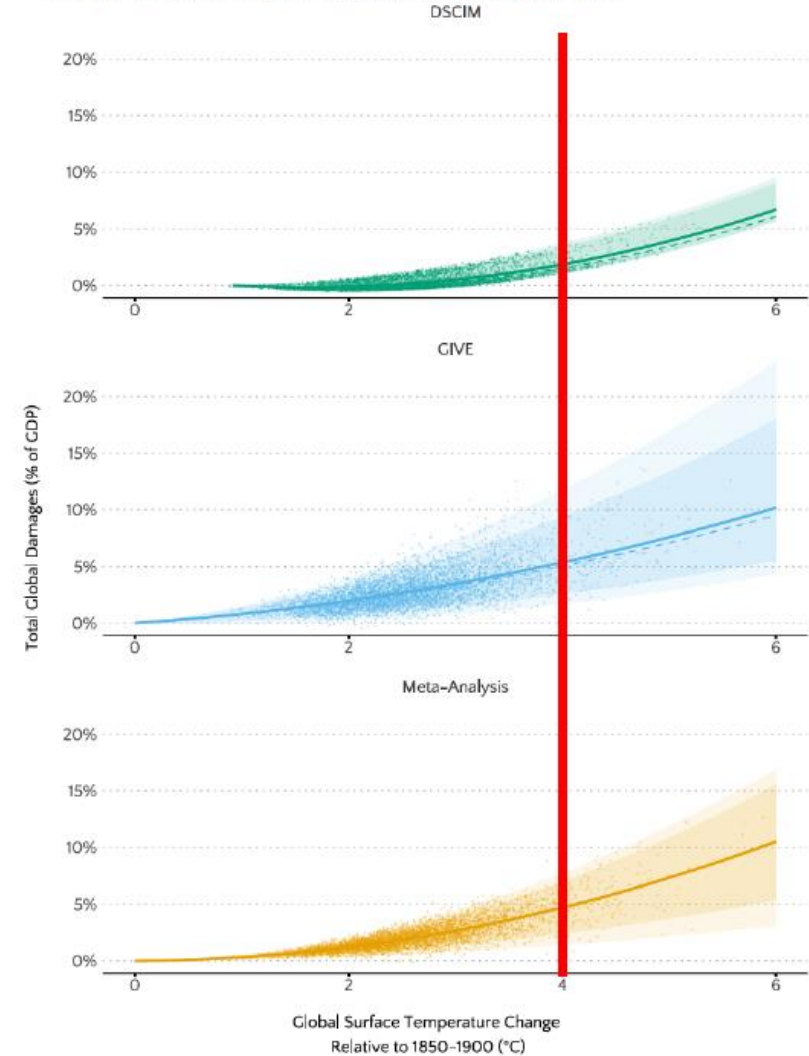
### (d) AR5 various methods

- AR5



## USEPA (2023)

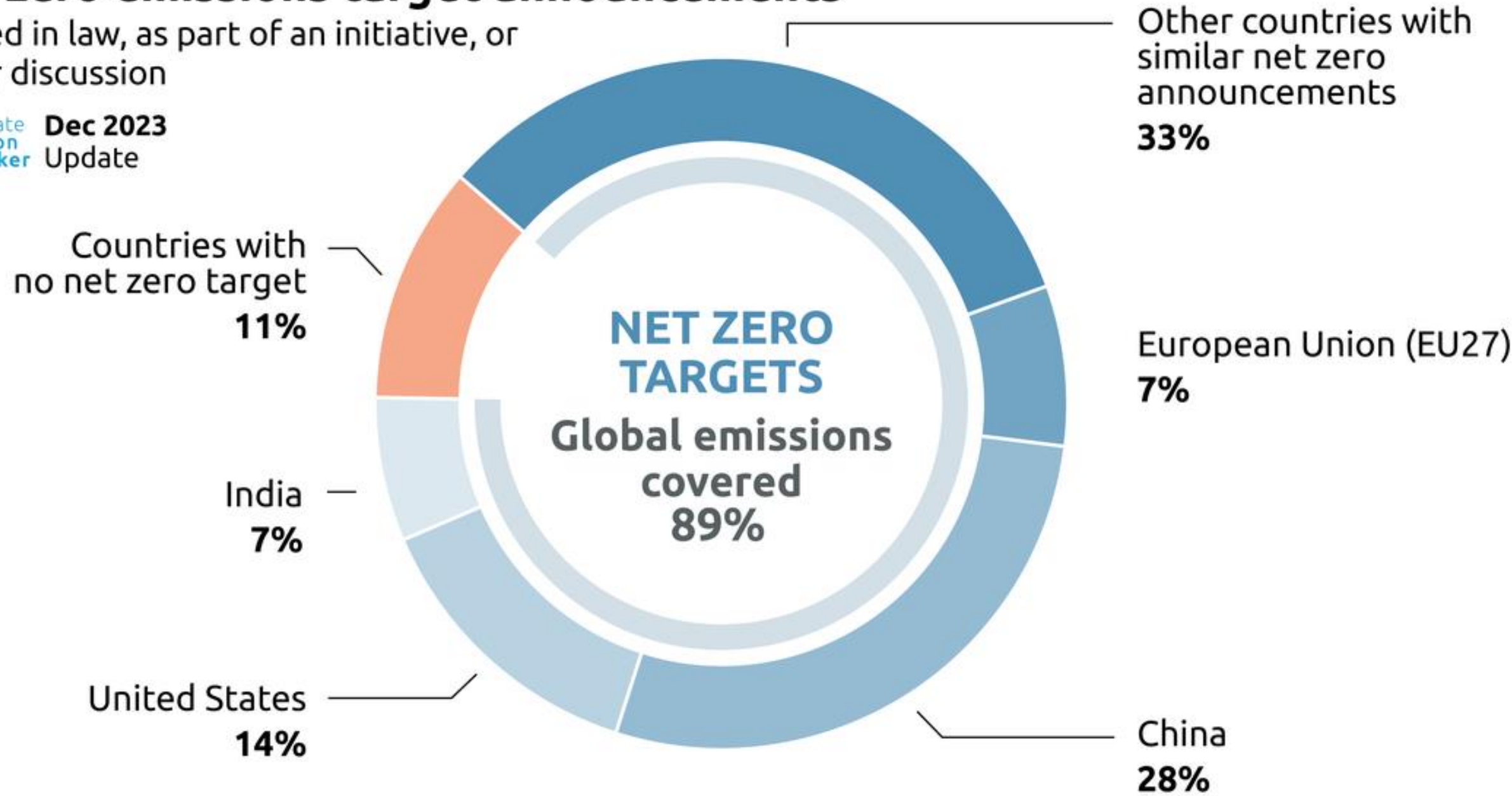
Figure 2.3.2: Annual Consumption Loss as a Fraction of Global GDP in 2100 due to an Increase in Annual Global Mean Surface Temperature in the three Damage Modules



# Net zero emissions target announcements

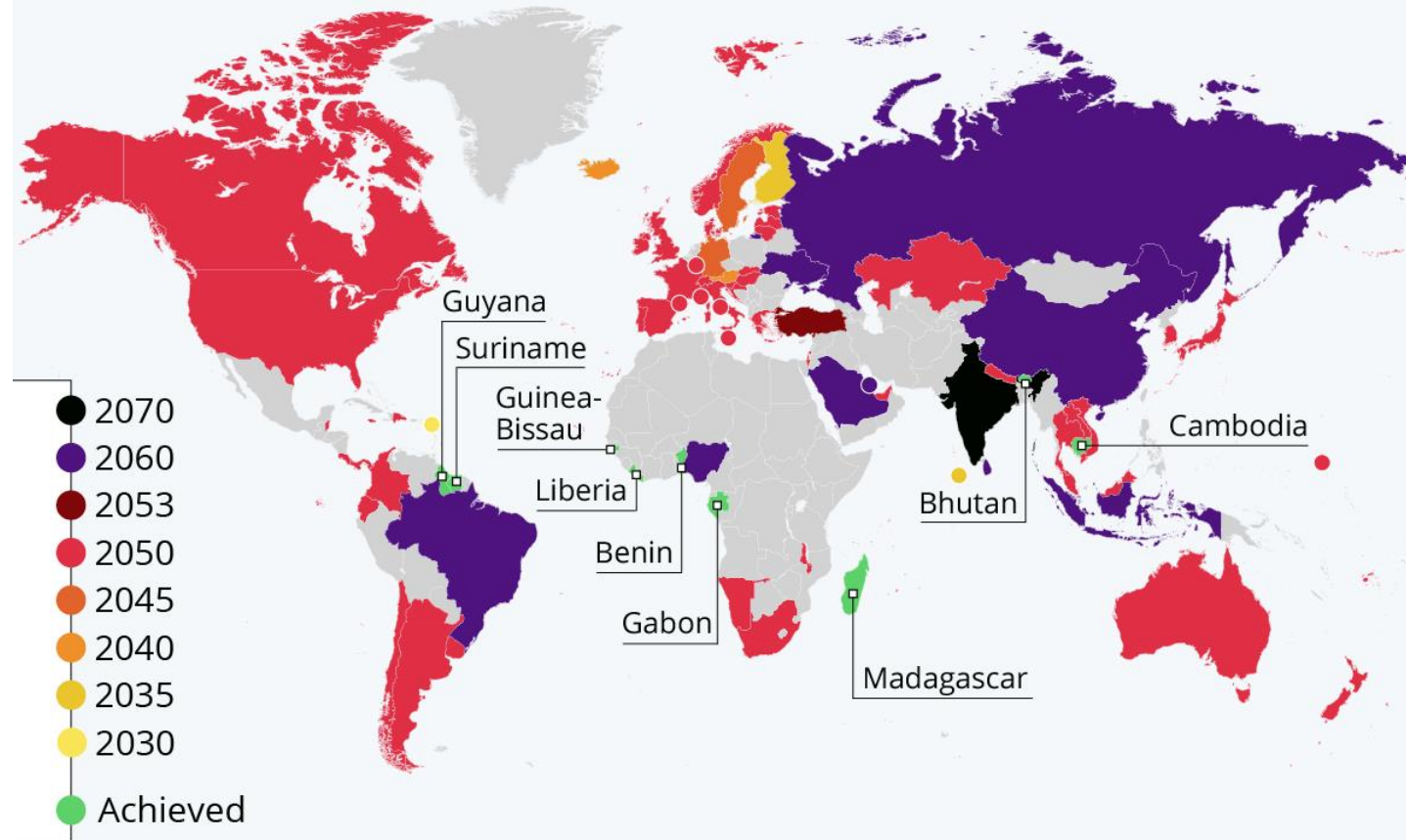
Agreed in law, as part of an initiative, or under discussion

 **Dec 2023**  
Update



# The Road to Net Zero

Countries with laws, policy documents or concrete timed pledges for carbon neutrality by target year



Source: Energy & Climate Intelligence Unit



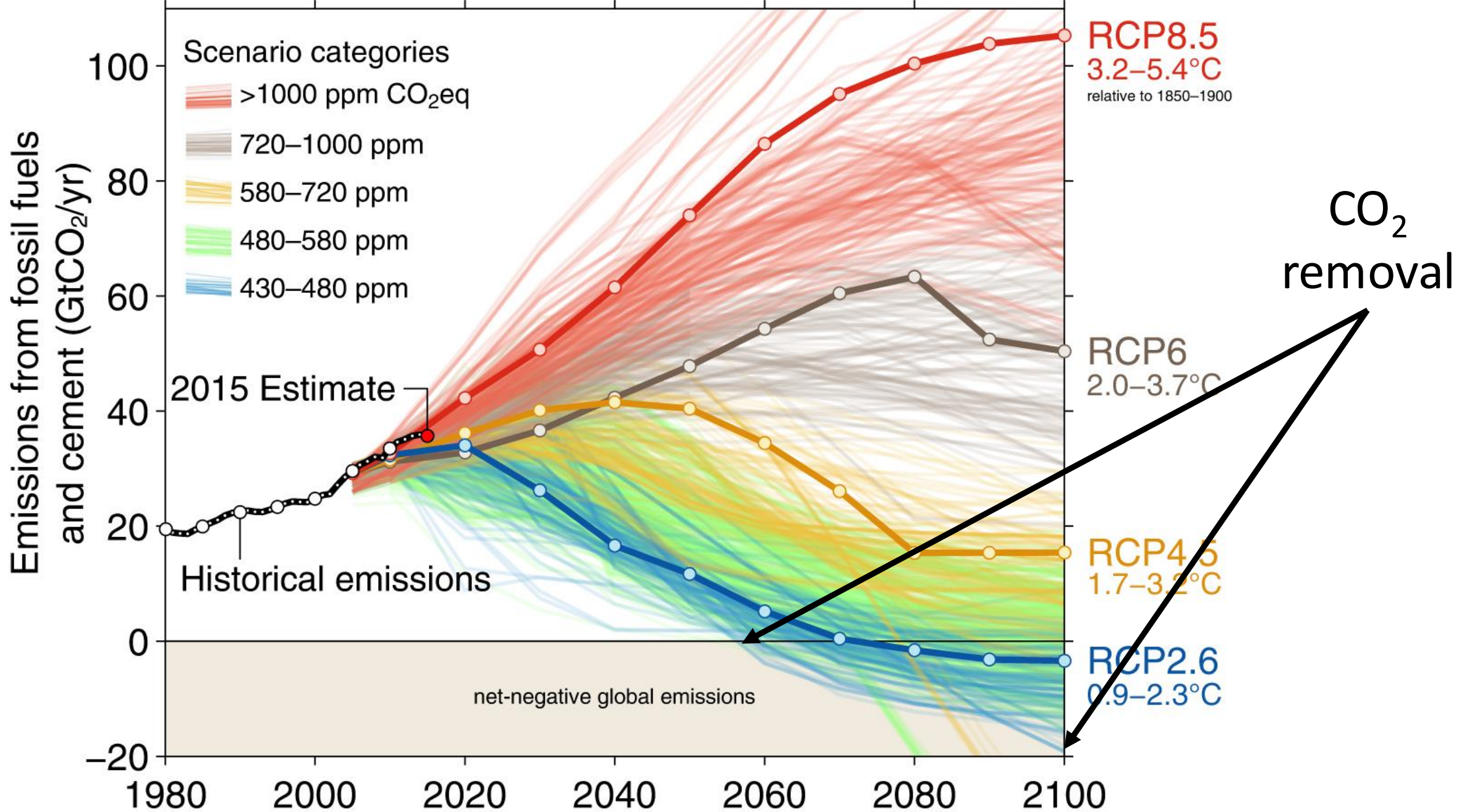
# So, what does net zero mean?

The term net zero is so ubiquitous as to be meaningless

- Zero greenhouse gas emissions?
- Net zero greenhouse emissions
- No fossil carbon in the energy system?
- Only wind, water, and solar energy?

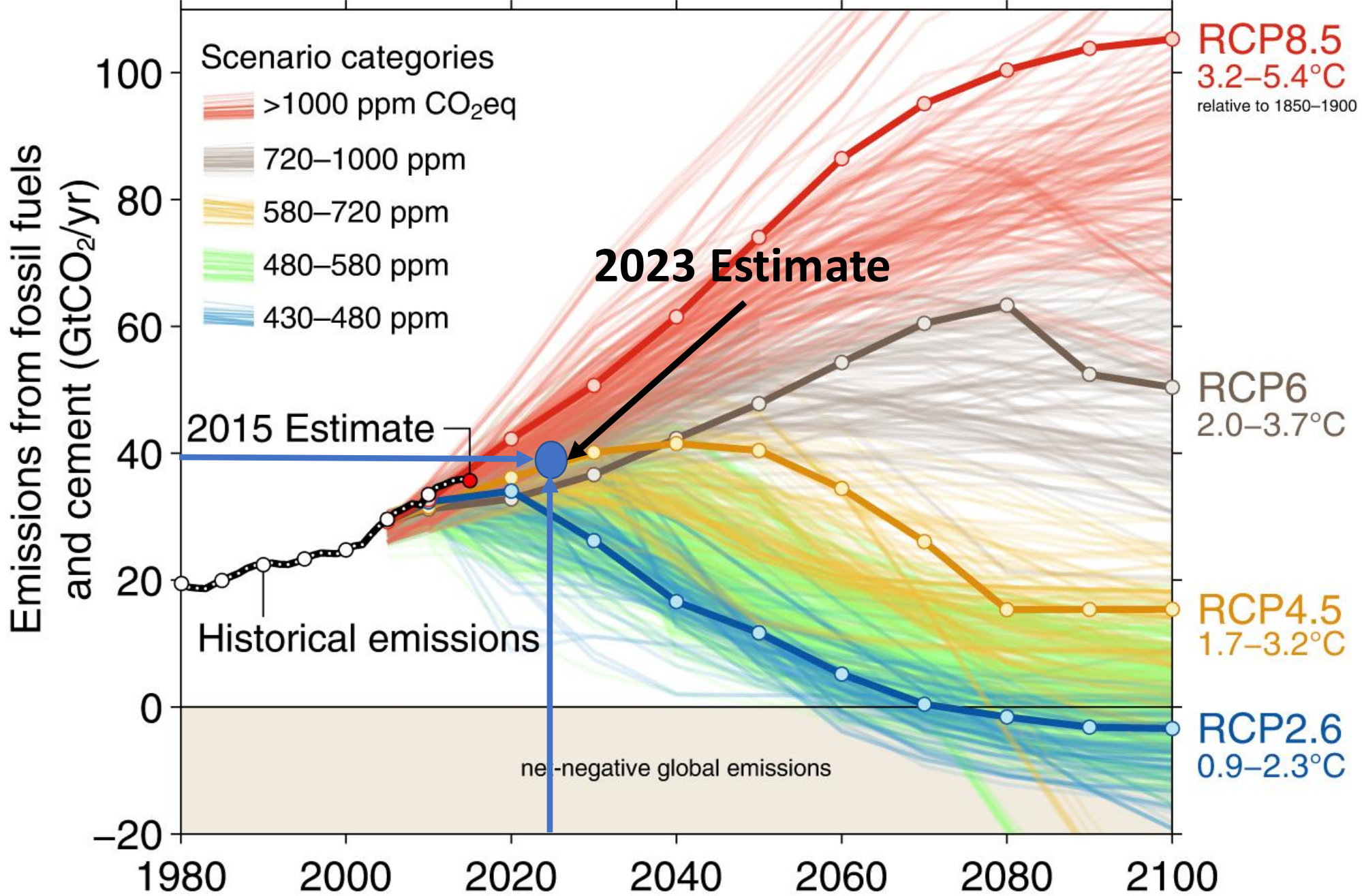


Data: CDIAC/GCP/IPCC/Fuss et al 2014



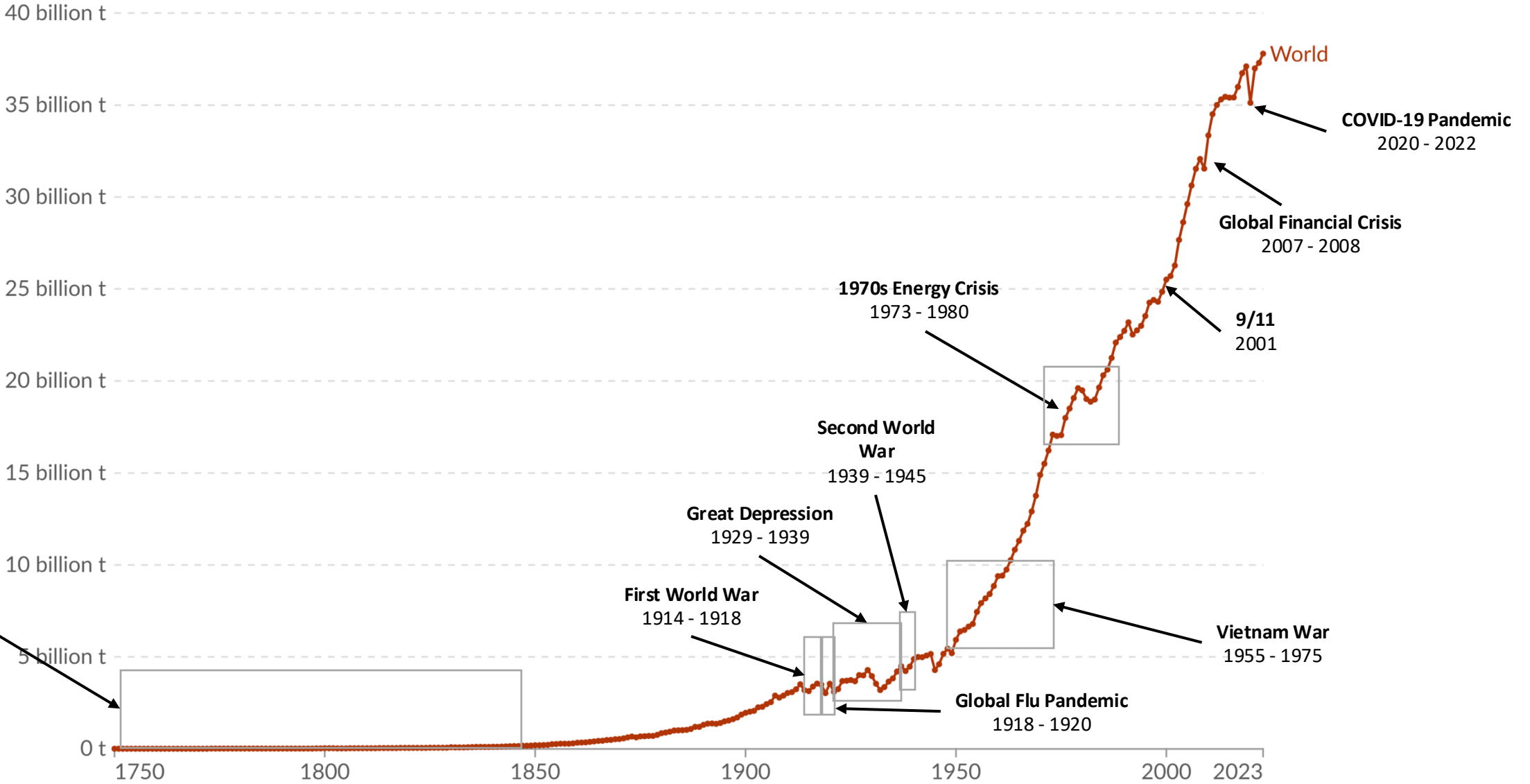


Data: CDIAC/GCP/IPCC/Fuss et al 2014

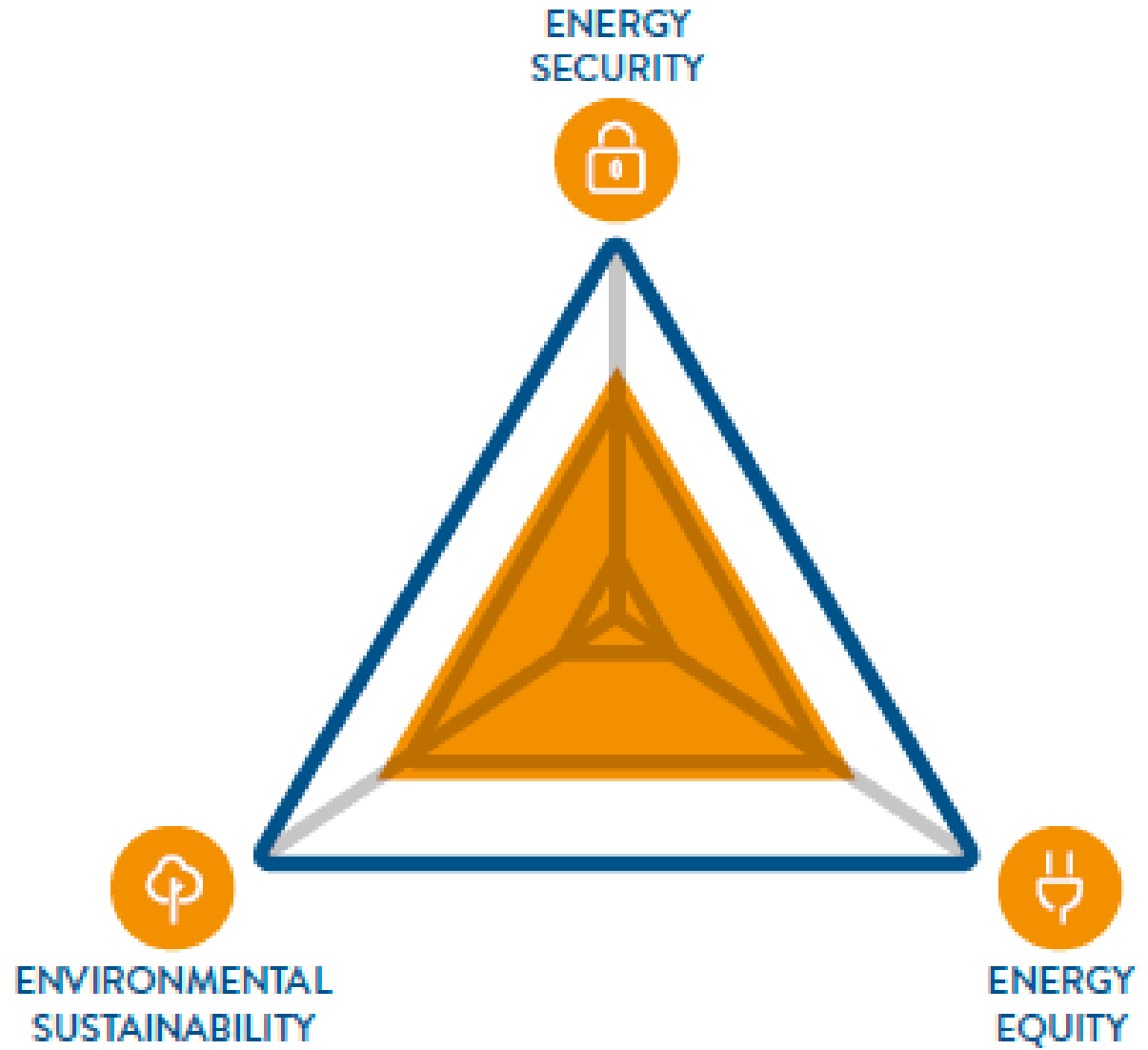


# Annual CO<sub>2</sub> emissions

Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry<sup>1</sup>. Land-use change is not included.



# Energy Trilemma..?





# ...or Energy Hierarchy?

**Germany (AVOID)**

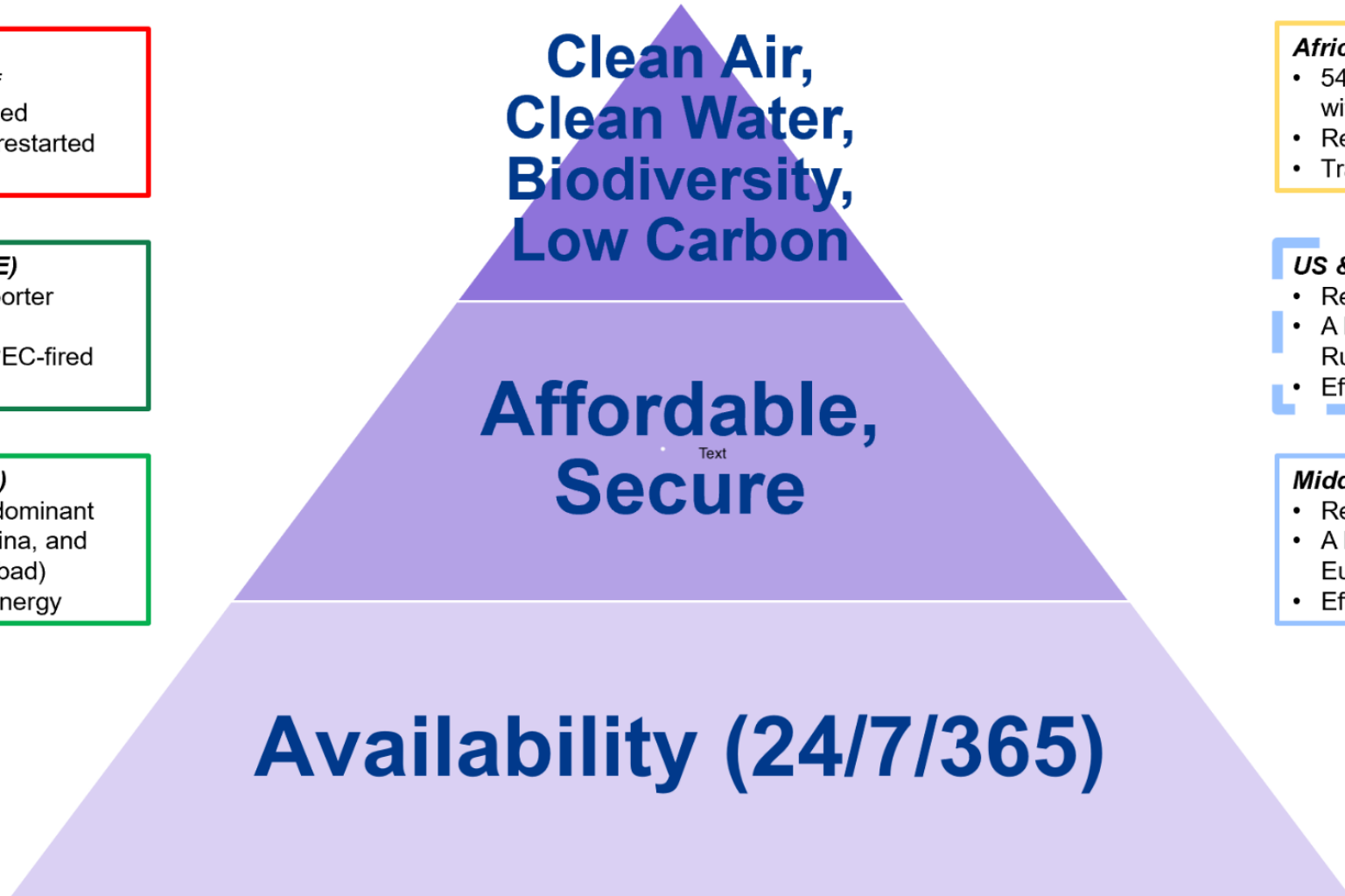
- Russian gas cut off
- Nuclear plants closed
- Lignite coal plants restarted

**China (ON DEFENSE)**

- Large crude oil importer
- Growth in EVs
- Coal-fired EVs > OPEC-fired ICE vehicles

**India (ON OFFENSE)**

- Poverty reduction dominant
- Learn from US, China, and Europe (good and bad)
- “All of the above” energy



**Africa (LOOKING FOR HOPE)**

- 54 diverse countries, each with S/D/poverty metrics
- Resource rich continent
- Transition won/lost here

**US & Canada (OPPORTUNITY)**

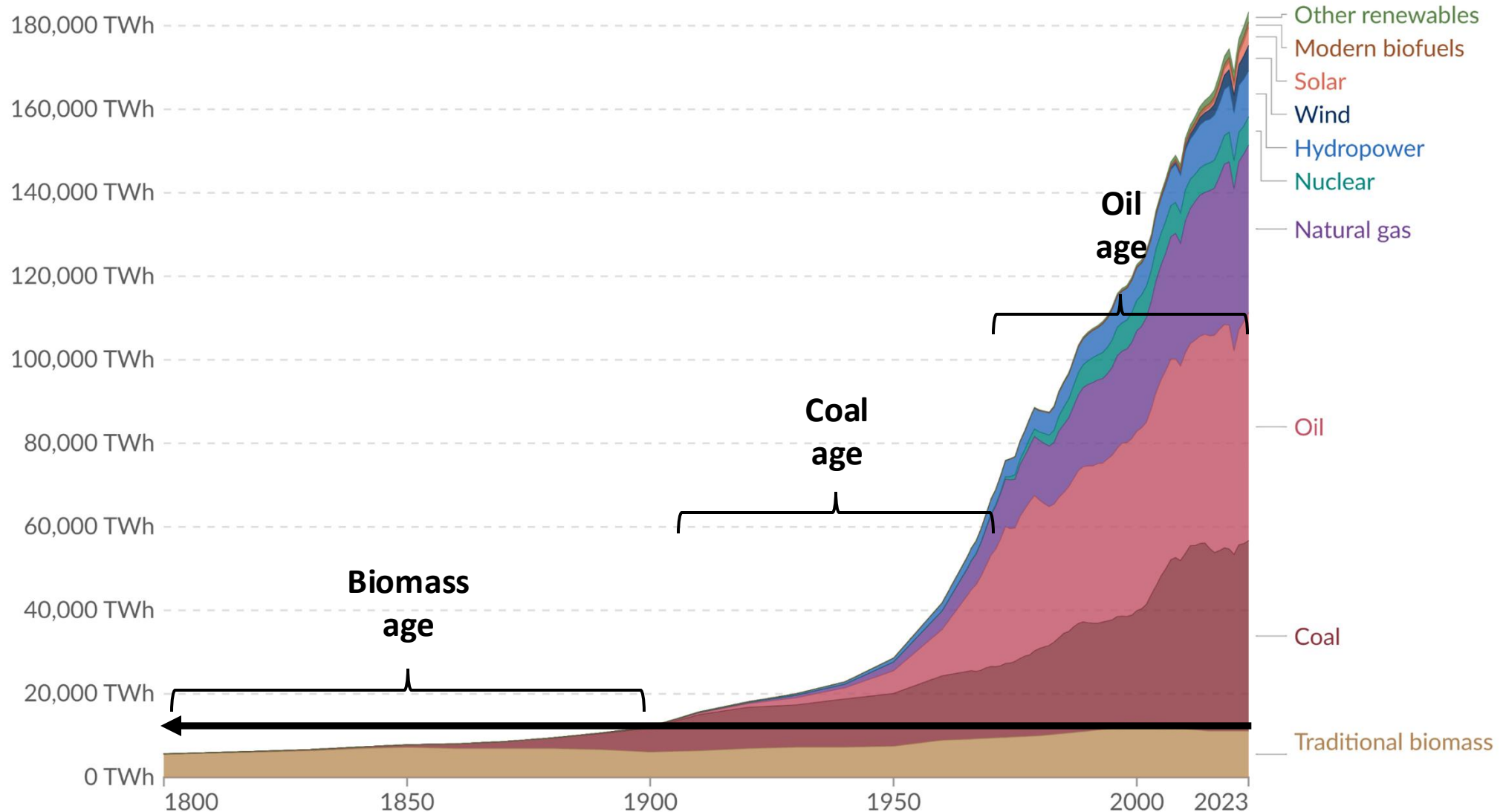
- Resource rich export potential
- A balance to Middle East, Russia, and elsewhere
- Efficiency gain opportunity

**Middle East (OPPORTUNITY)**

- Resource rich export potential
- A balance to US, Canada & Europe
- Efficiency gain opportunity

# Global primary energy consumption by source

Primary energy<sup>1</sup> is based on the substitution method<sup>2</sup> and measured in terawatt-hours<sup>3</sup>.

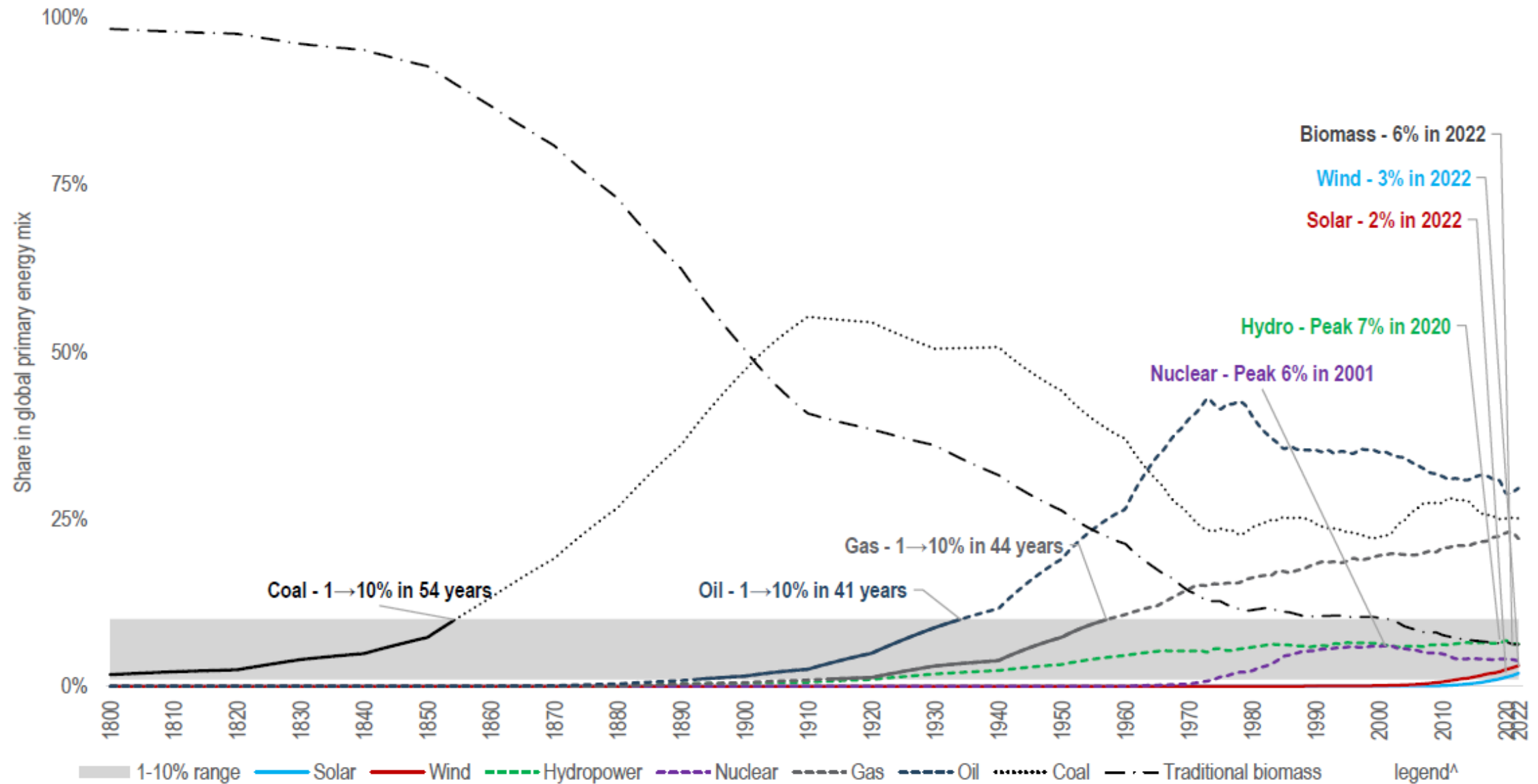


Data source: Energy Institute - Statistical Review of World Energy (2024); Smil (2017)

OurWorldinData.org/energy | CC BY

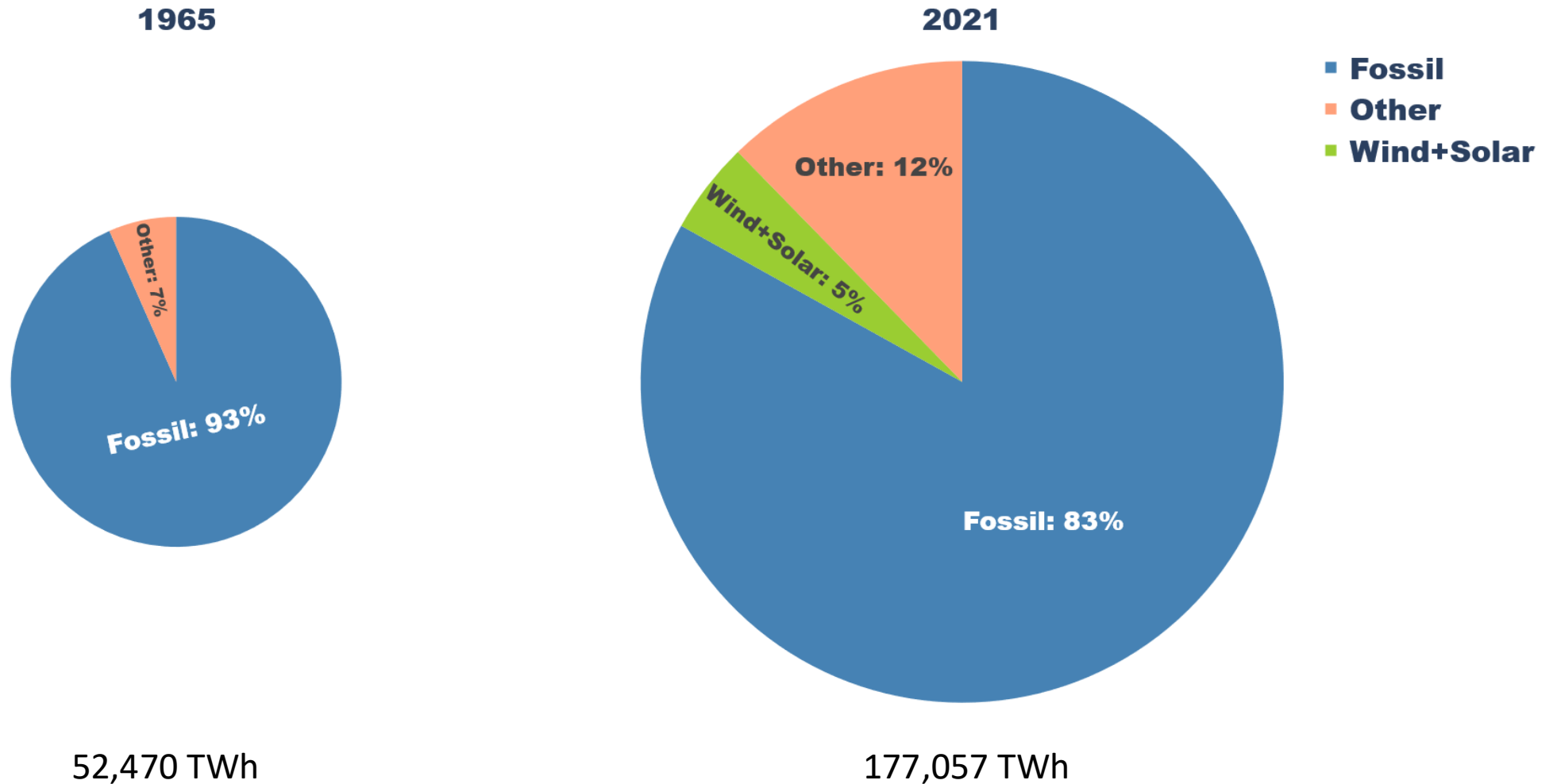
Note: In the absence of more recent data, traditional biomass is assumed constant since 2015.

# Global primary energy mix evolution



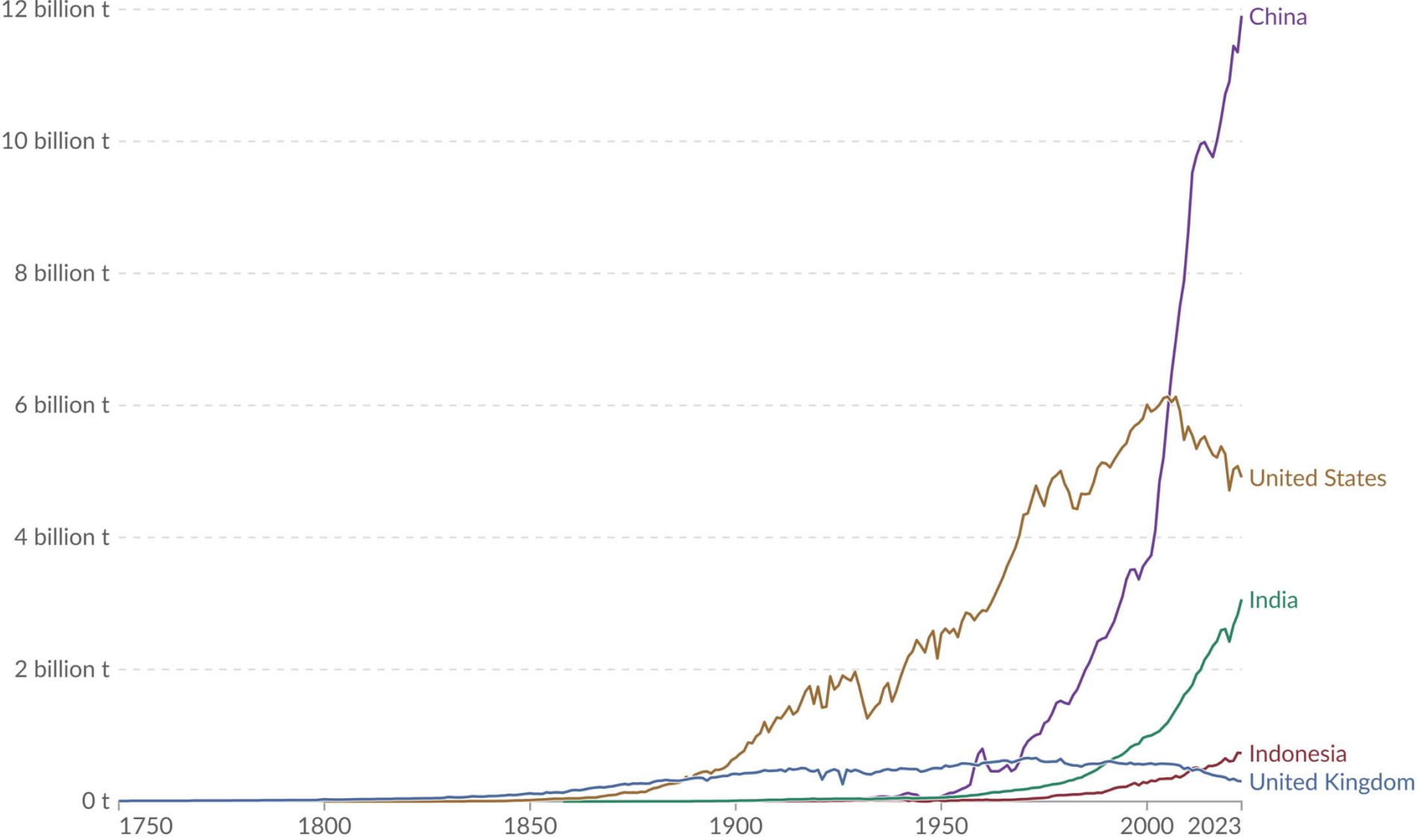


# Energy addition, not transition



# Annual CO<sub>2</sub> emissions

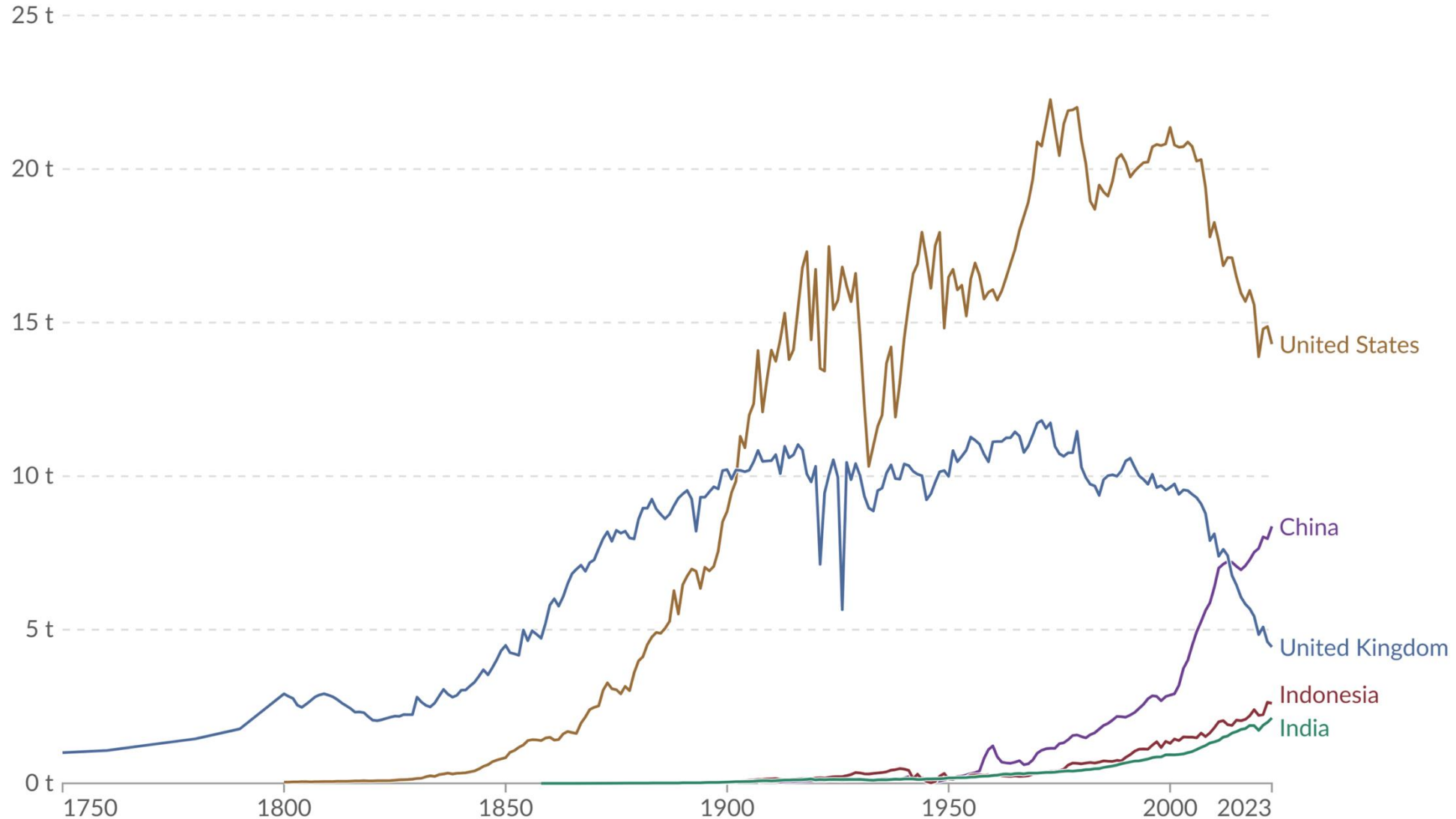
Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry<sup>1</sup>. Land-use change is not included.



Data source: Global Carbon Budget (2024)

# Per capita CO<sub>2</sub> emissions

Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry<sup>1</sup>. Land-use change is not included.

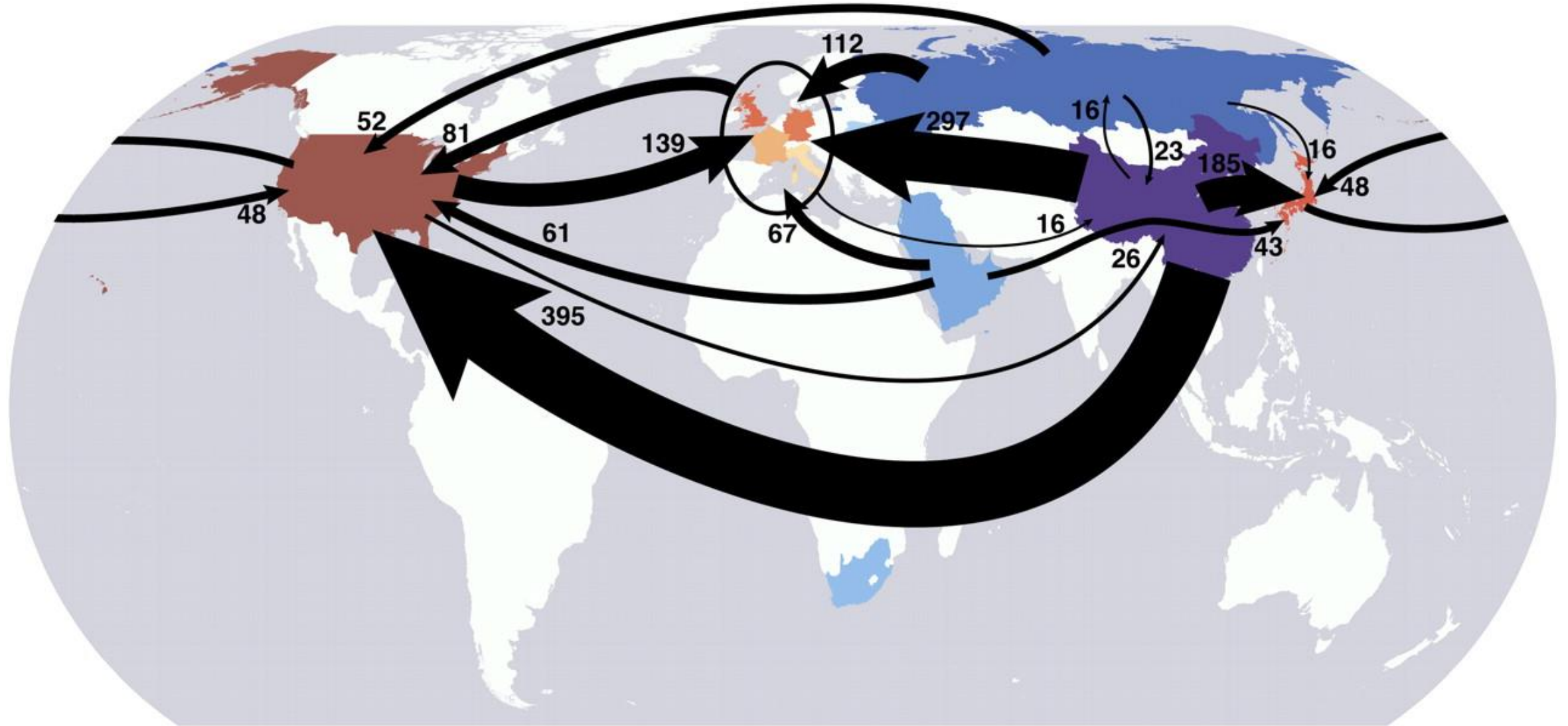


Data source: Global Carbon Budget (2024); Population based on various sources (2024)

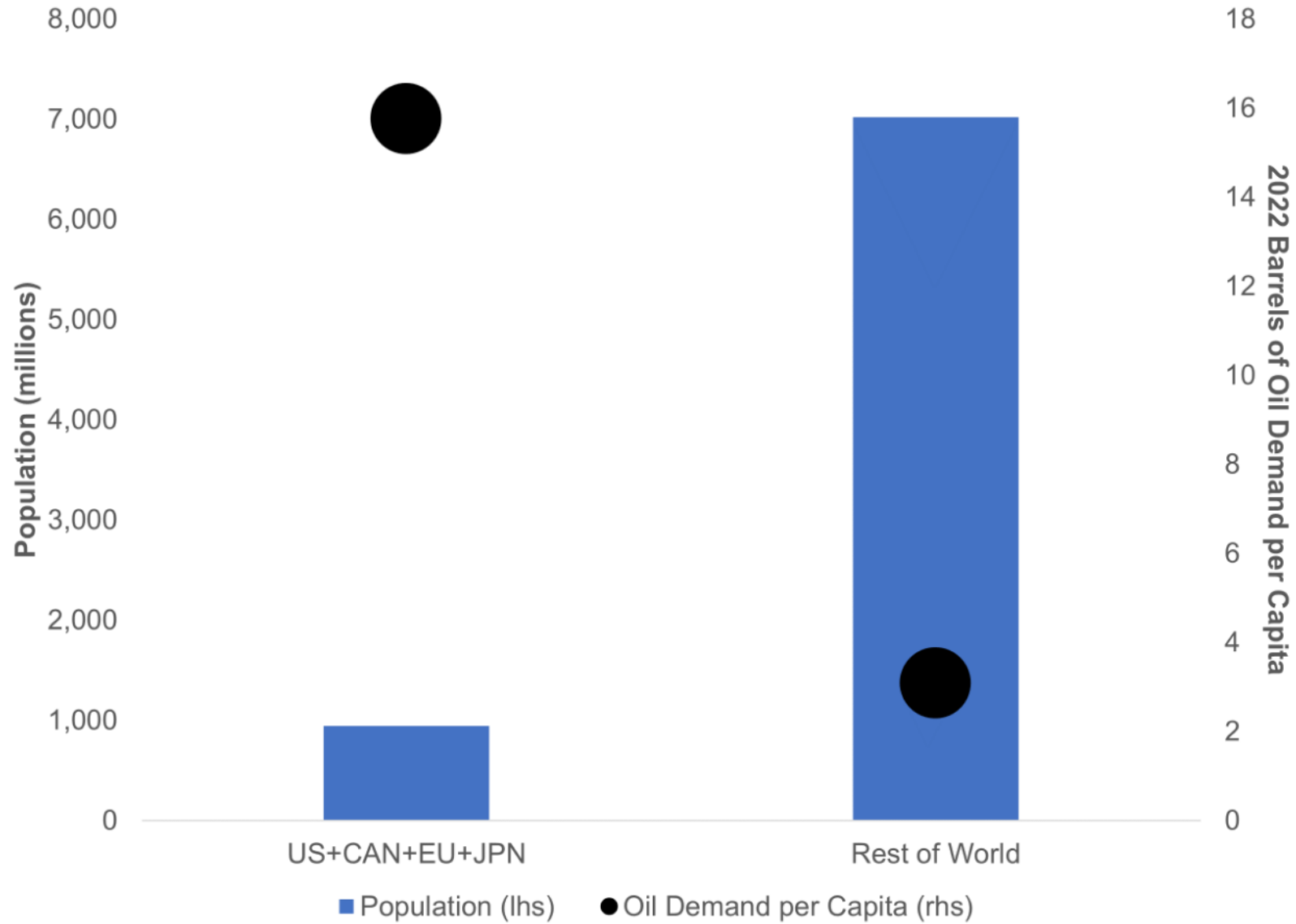
OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY



# Carbon emission $\neq$ carbon consumption

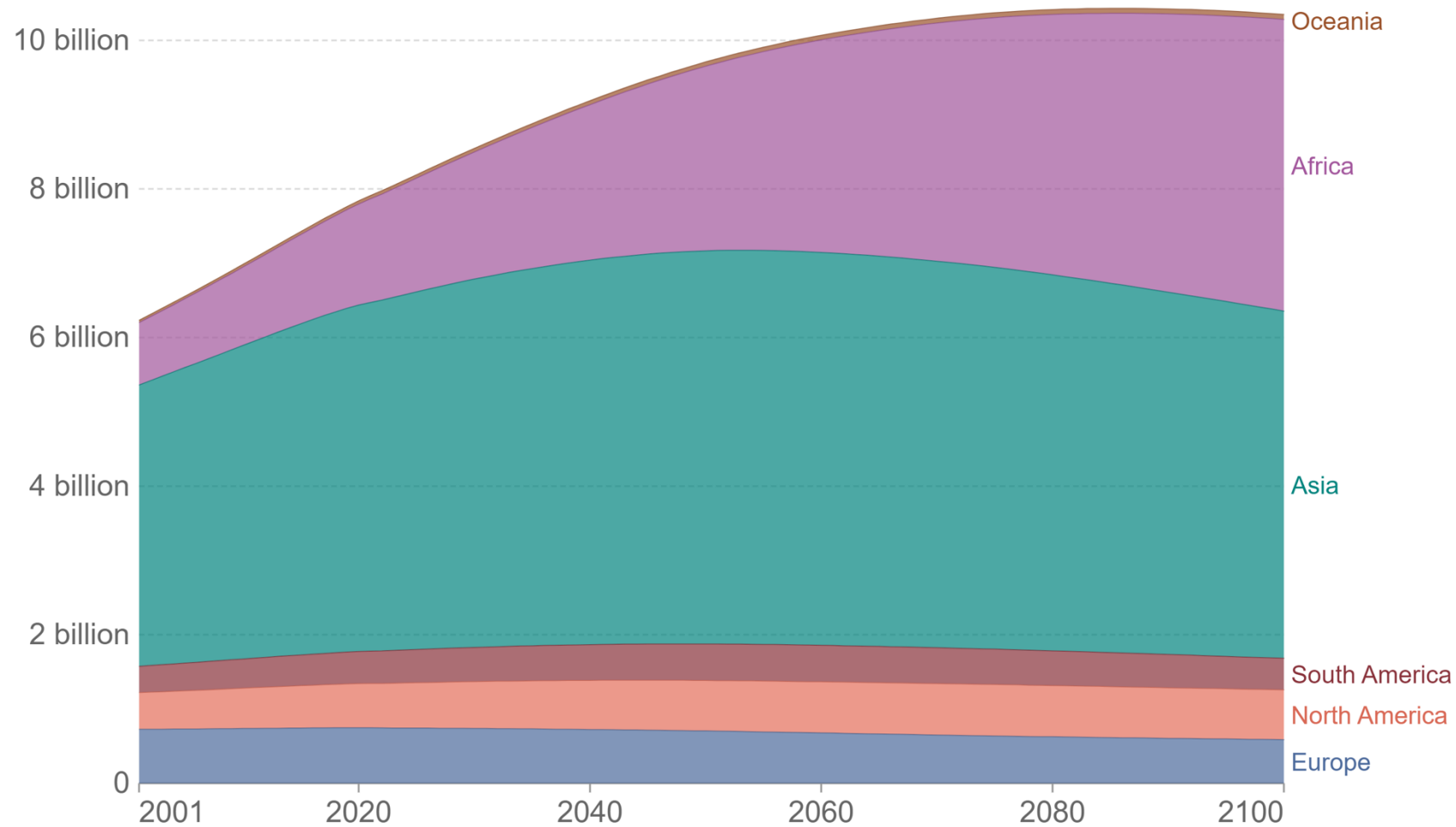


# Population vs Oil Demand



# Population by world region

Historic estimates with future projections based on the UN medium-fertility scenario<sup>1</sup>.



Data source: HYDE (2017); Gapminder (2023); UN (2022)

[OurWorldInData.org/population-growth](https://OurWorldInData.org/population-growth) | CC BY

Note: Historical country data is shown based on today's geographical borders.

**1. UN projection scenarios:** The UN's World Population Prospects provides a range of projected scenarios of population change. These rely on different assumptions in fertility, mortality and/or migration patterns to explore different demographic futures. [Read more: Definition of Projection Scenarios \(UN\)](#)

# “Rest of World” energy needs are huge...

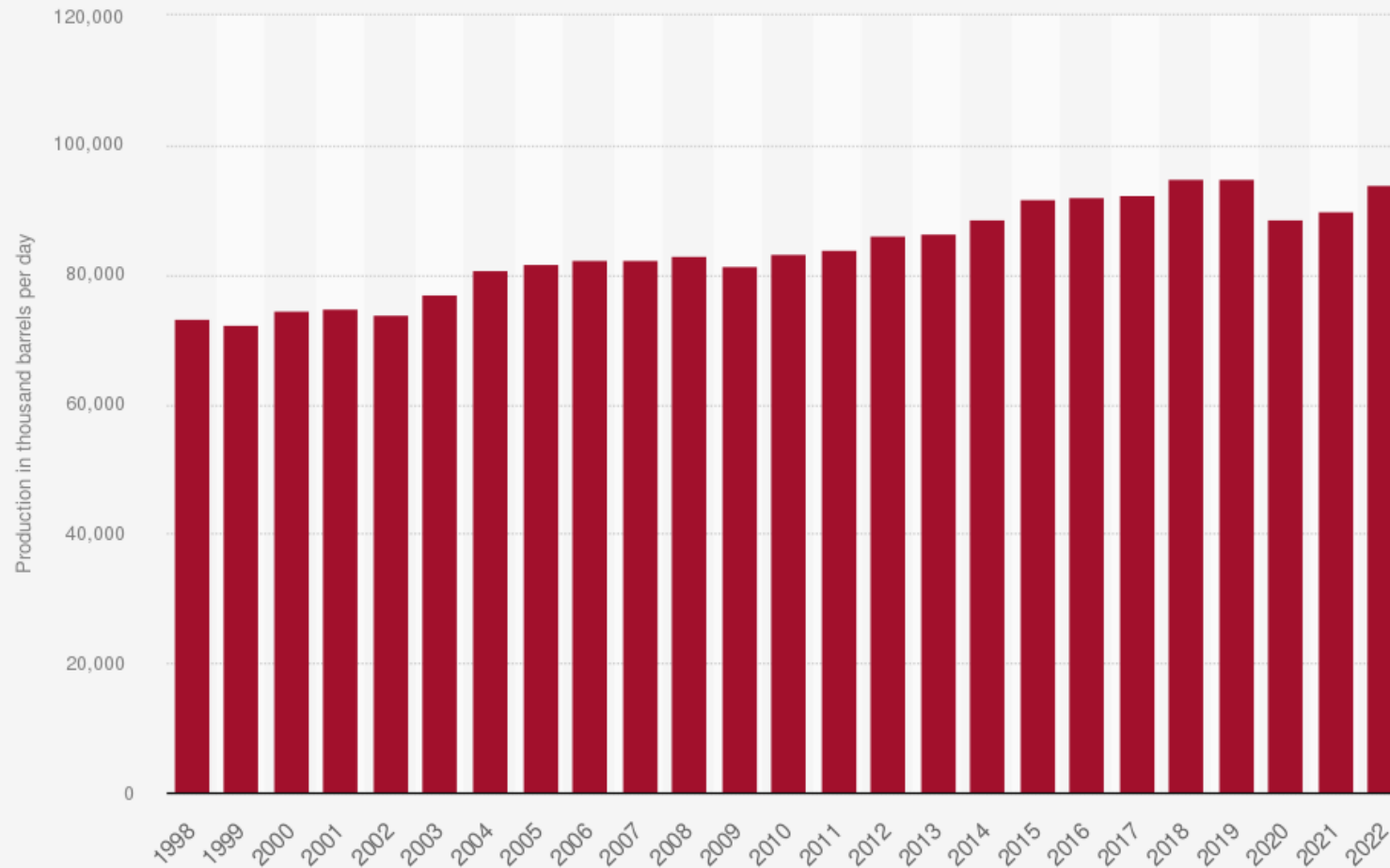
	2022 Oil Demand		base case					
	(mn b/d)	per capita	Future per capita oil demand					
			2	3	4	5	10	
India	5.3	1.4	7.3	10.9	14.6	18.2	36.4	future oil demand
			2.0	5.7	9.3	12.9	31.2	growth vs 2022
Africa	4.2	1.2	7.1	10.7	14.2	17.8	35.6	future oil demand
			2.9	6.4	10.0	13.6	31.4	growth vs 2022

- EU/US etc demand is ~ 13 bbl<sub>oil</sub>/capita
- If Africa and India increase to ~ 4 bbl<sub>oil</sub>/capita equivalent – China level – this equates to an additional ~ 20 M bbl<sub>oil</sub>/day demand
- Is this a lot?
- Won't electric vehicles (EVs) mitigate this?



# Is 20 M bbl<sub>oil</sub>/day a lot?

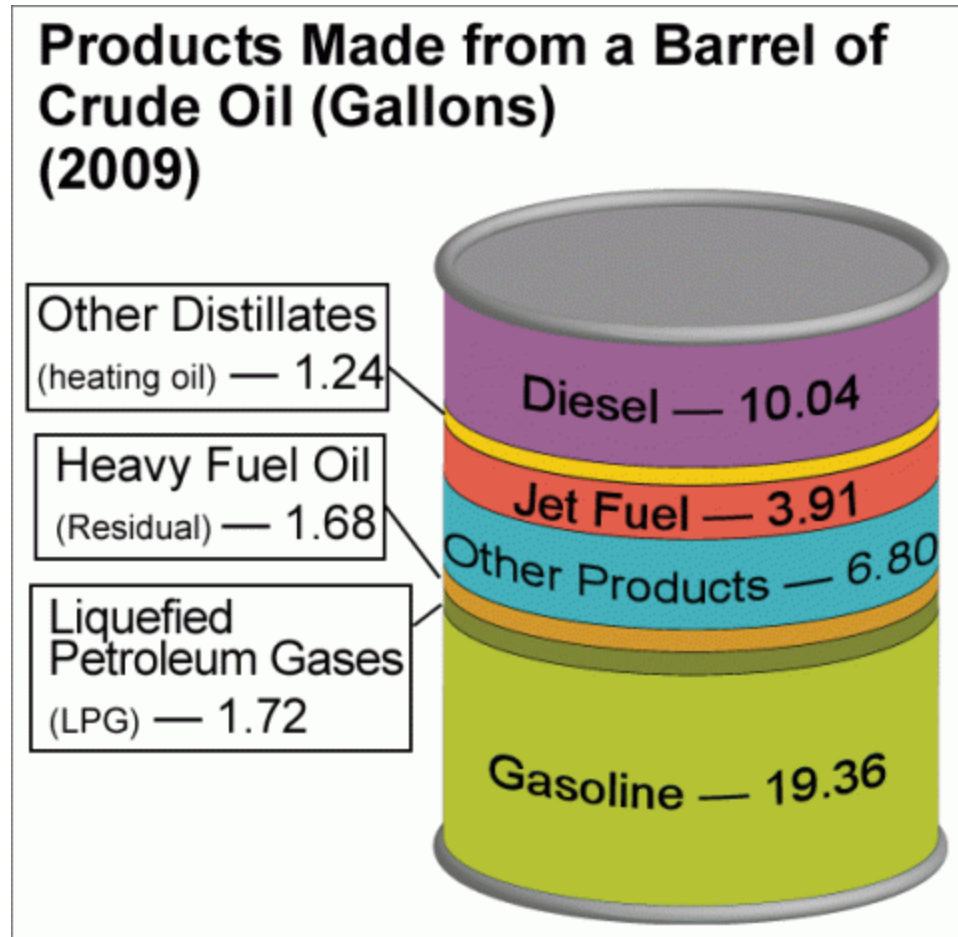
Oil production worldwide from 1998 to 2022 (in 1,000 barrels per day)



Sources  
KPMG; Kearney; Energy Institute  
© Statista 2023

Additional Information:  
Worldwide; KPMG; Kearney; 1998 to 2022

# But what about EVs...?



# Predictions are uncertain, especially about the future!

Commodities

## IEA, OPEC predictions of 2024 oil demand growth diverge further

By Alex Lawler and Natalie Grover

October 12, 2023 3:24 PM GMT+1 · Updated 20 days ago



[1/2] Pump jacks operate in front of a drilling rig in an oil field in Midland, Texas U.S. August 22, 2018. REUTERS/Nick Oxford/File Photo [Acquire Licensing Rights](#)

### Summary

- IEA trims 2024 oil demand forecast to 880,000 bpd
- OPEC sticks to 2024 forecast of 2.25 million bpd
- IEA cites signs of demand destruction from higher prices

LONDON, Oct 12 (Reuters) - The gap between two leading oil forecasters' views on 2024 demand growth widened on Thursday, with the International Energy Agency (IEA) predicting a sharper slowdown while

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ENERGY

## OPEC hikes long-term oil demand outlook — in stark contrast to other predictions of peak crude

PUBLISHED MON, OCT 9 2023 6:20 AM EDT | UPDATED MON, OCT 9 2023 6:56 AM EDT

Sam Meredith @SMEREDITH19

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### KEY POINTS

- OPEC and the IEA, both big names in the energy industry, are currently locked in a war of words over peak oil demand.
- In its 2023 World Oil Outlook, OPEC said it expected world demand to reach 116 million barrels per day (bpd) by 2045, roughly 6 million more barrels per day than it predicted this time last year.
- OPEC's forecasts contrast starkly with those of the IEA, which said last month that the world was now at the "beginning of the end" of the fossil fuel era.

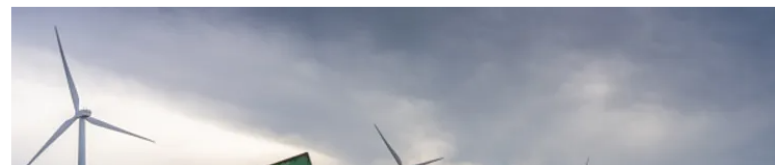


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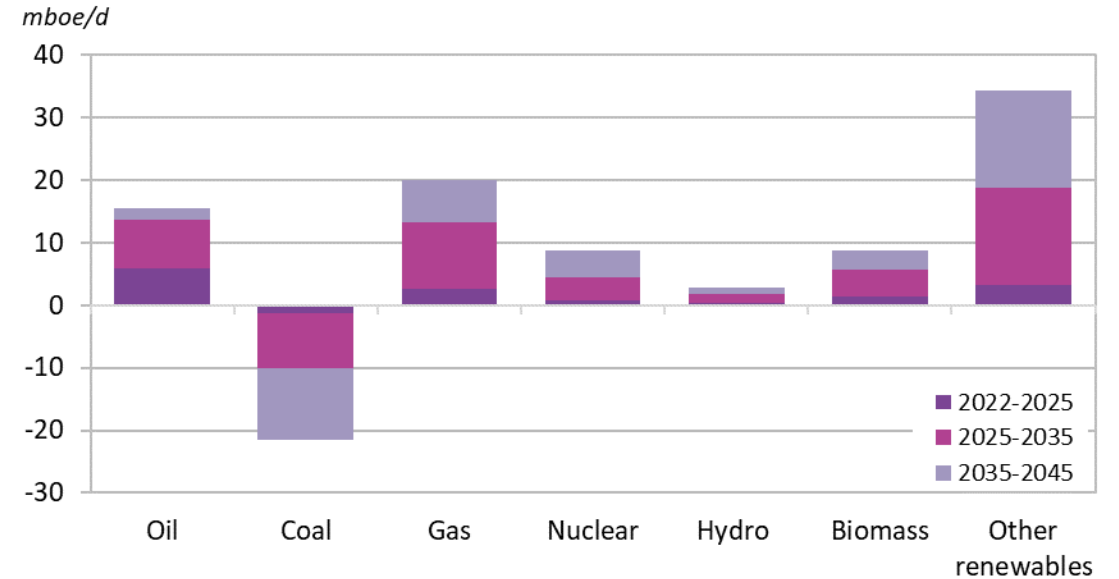
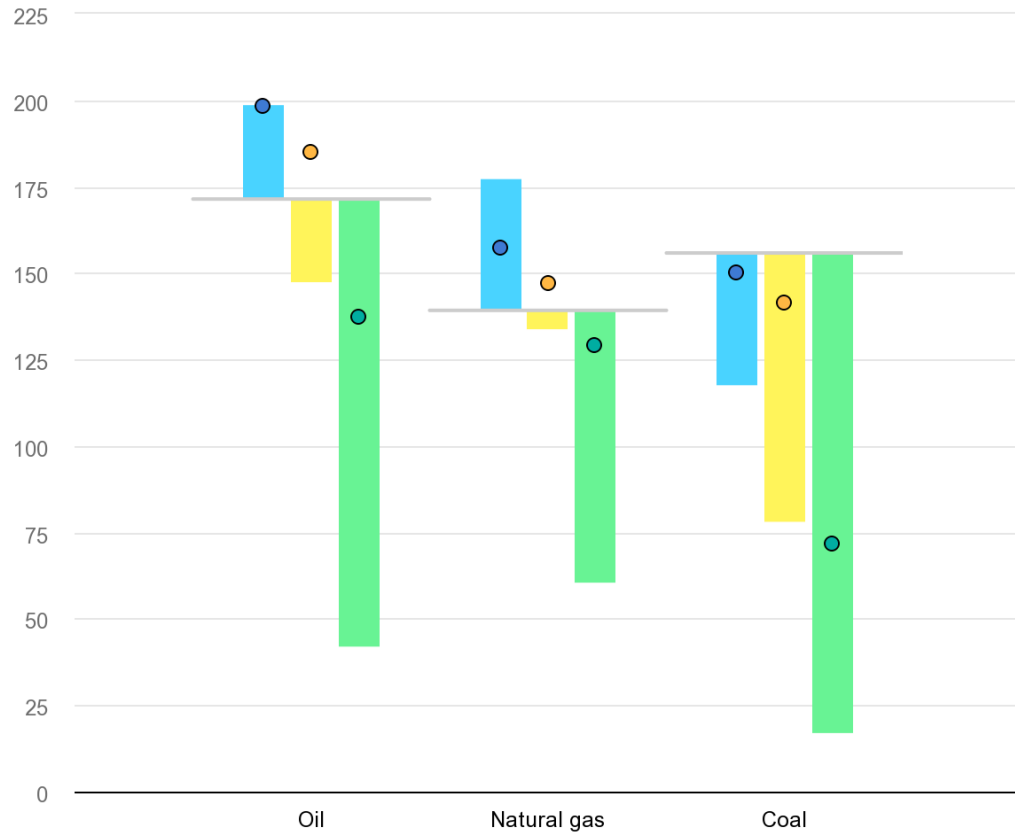
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### TRENDING NOW

28-year-old \$210,000 a in a hospita going to me



# Predictions are uncertain, especially about the future!



IEA, Fossil fuel use by scenario, 2020, 2030 and 2050, IEA, Paris  
<https://www.iea.org/data-and-statistics/charts/fossil-fuel-use-by-scenario-2020-2030-and-2050>, IEA. Licence: CC BY 4.0

OPEC, World Oil Outlook, 2023



# Future demand for coal?

S&P Global  
Commodity Insights

Commodities Products & Services Methodology Market Insights Energy Transition

## IN THIS LIST

### COAL

**Global coal trade to grow through 2050, driven by Asia and industrial coal use: EIA**

ENERGY | COAL

Platts Global Coal Alert

ENERGY | COAL | THERMAL COAL | LNG | NATURAL GAS | OIL | REFINED PRODUCTS | GASOLINE | JET FUEL | METALS | STEEL | STEEL RAW MATERIALS

Market Movers Asia, Oct.30-Nov.3: Chinese independent refineries' throughput, corn flows from US, Brazil in focus

OIL | ENERGY TRANSITION | ENERGY APPEC 2024

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Southeast Asia's procurement plans marches on even as India considers alternative fuels

METALS

Platts China Lithium Assessment

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Commodity Tracker: 4 charts to watch this week

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COAL — 24 Sep 2019 | 21:44 UTC — Houston

## Global coal trade to grow through 2050, driven by Asia and industrial coal use: EIA

### HIGHLIGHTS

Chinese imports to remain flat

India will lead industrial coal use

Houston — The global coal trade is projected to continue growing through 2050, largely driven by Asia, as industrial coal use increase and the power generation market in Asia grows, the Energy Information Administration said in its International Energy Outlook 2019 released Tuesday.

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Coal · 1 Min Read

## Coal projected to be India's largest source of power in 2040: World Coal Association

She said that coal will continue to play a vital role in supporting intermittent renewable energy sources to underpin infrastructure development and industrialization



Published On Feb 12, 2021 at 08:18 AM IST

Read by:  
5777 Industry Professionals



New Delhi: Coal is projected to remain the largest single source of electricity in India in 2040, according to Michelle Manook, Chief Executive, World Coal Association. She said that coal will continue to play a vital role in

supporting intermittent renewable energy sources to underpin



John Barroso



Cathy McMorris Rodgers

# The People vs. The IEA..?

Congress of the United States  
Washington, DC 20510

March 20, 2024

Fatih Birol, Ph.D.  
Executive Director  
International Energy Agency  
9 rue de la Fédération  
75739 Paris Cedex 15  
France

Dear Dr. Birol:

We are writing to you because we are concerned that the International Energy Agency (IEA) has strayed from its core mission—promoting energy security.

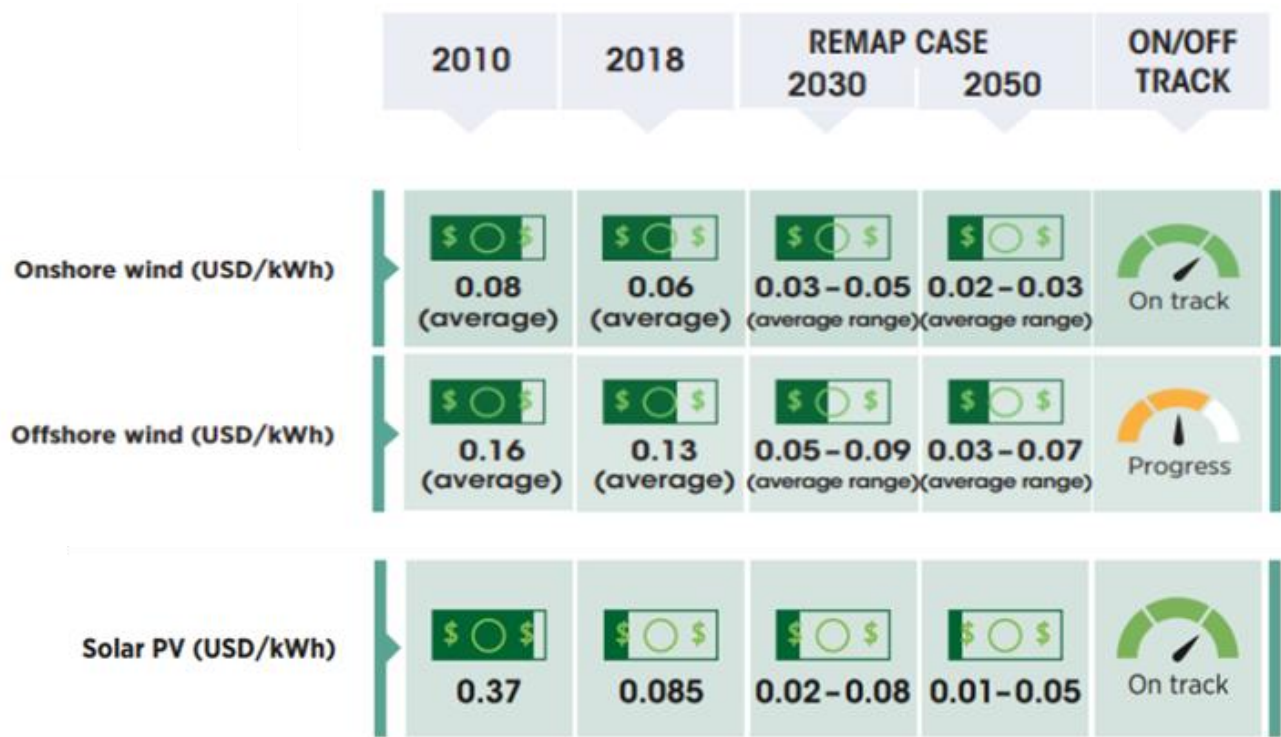
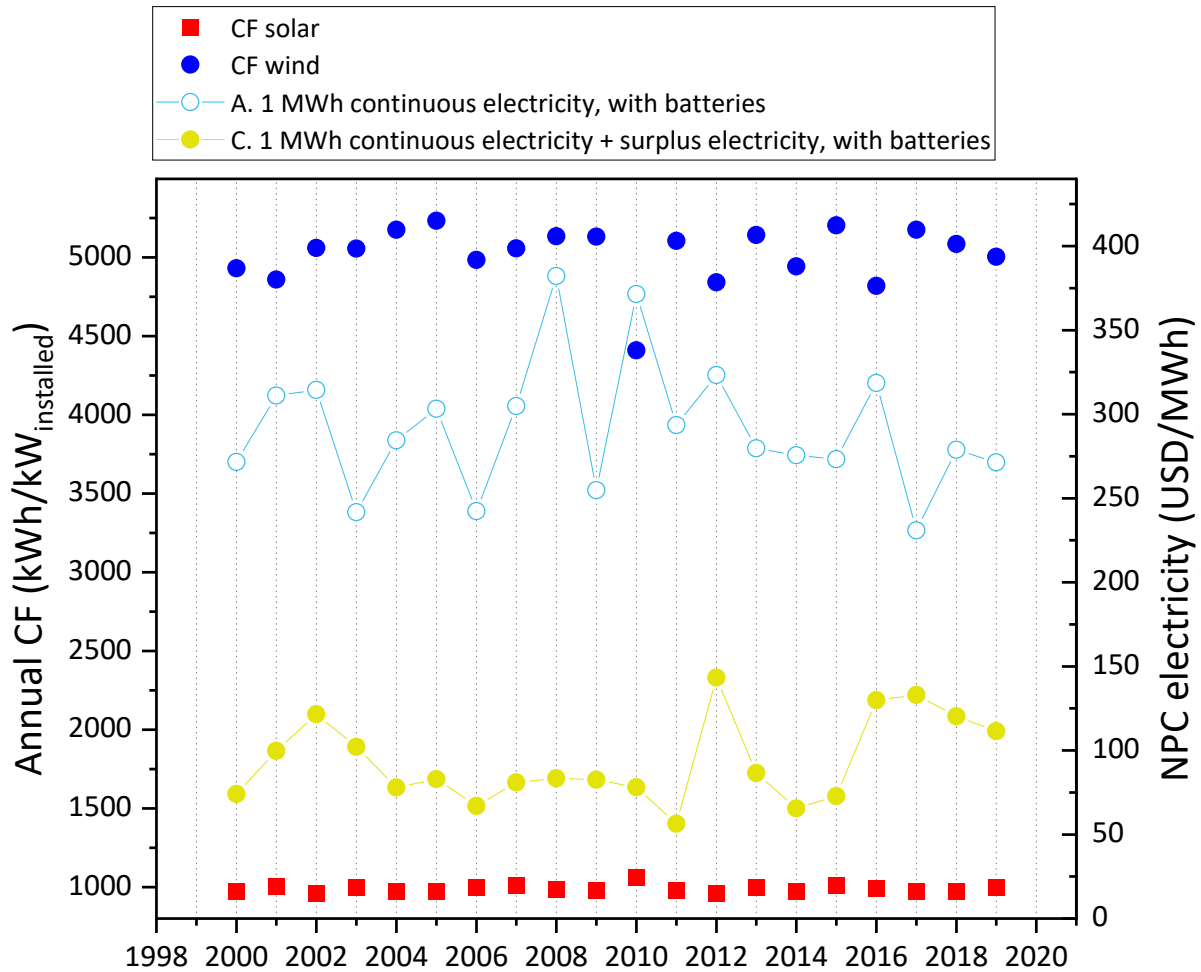
Indeed, we would argue that in recent years the IEA has been undermining energy security by discouraging sufficient investment in energy supplies—specifically, oil, natural gas, and coal. Moreover, its energy modeling no longer provides policymakers with balanced assessments of energy and climate proposals. Instead, it has become an “energy transition” cheerleader.

Until recently, the IEA has served as a valuable source of reliable information on the security of oil markets, and it has provided a mechanism whereby oil-consuming countries can respond effectively to oil shortages. The IEA also provides global energy forecasts as part of its mission. As you have noted, IEA forecasts have a tremendous influence on shaping how the world sees future energy trends. Consequently, the IEA must conduct its energy security mission in an objective manner. We believe the IEA is failing to fulfill these responsibilities.

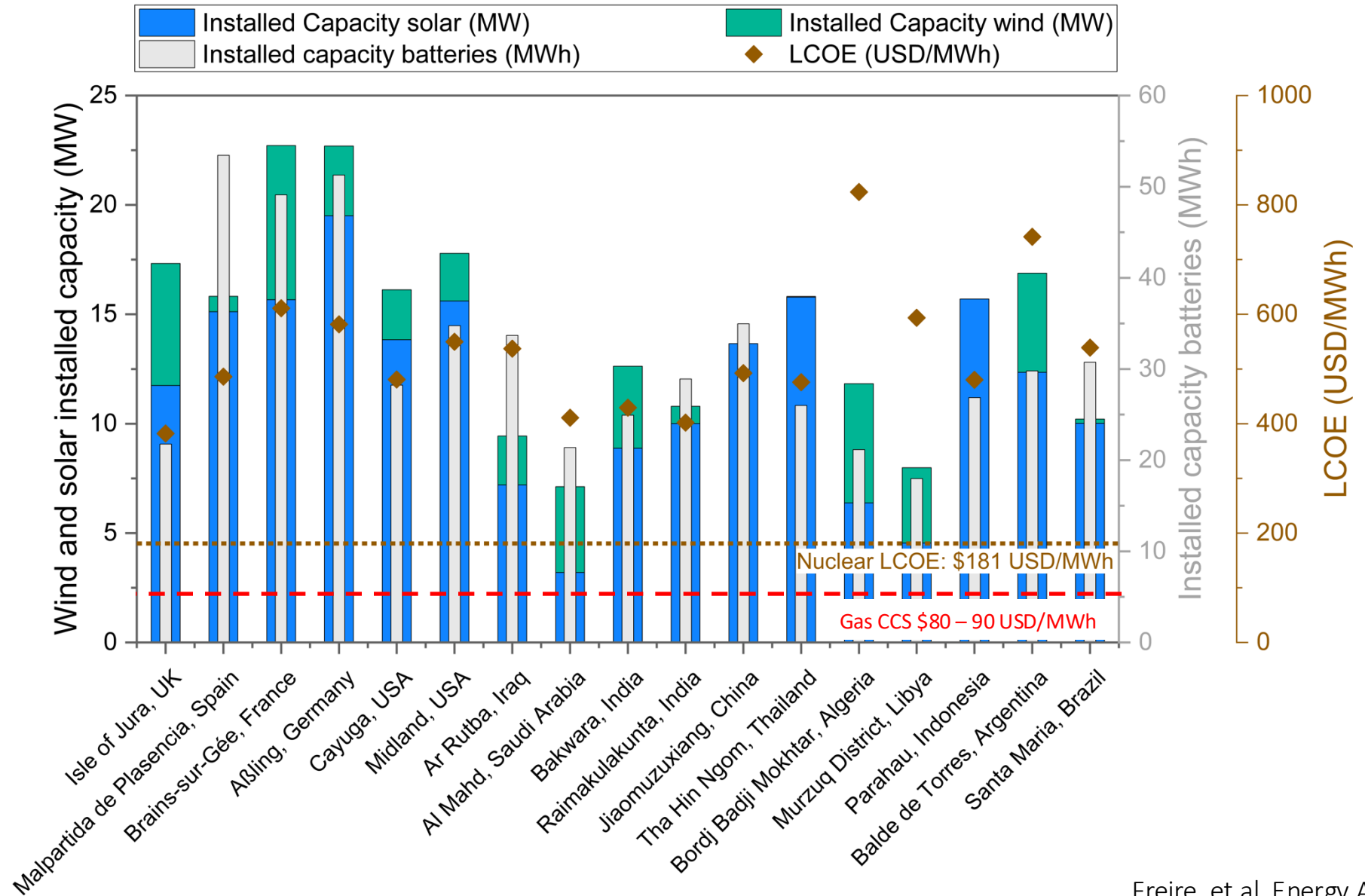


Fatih Birol

# Cost of intermittency

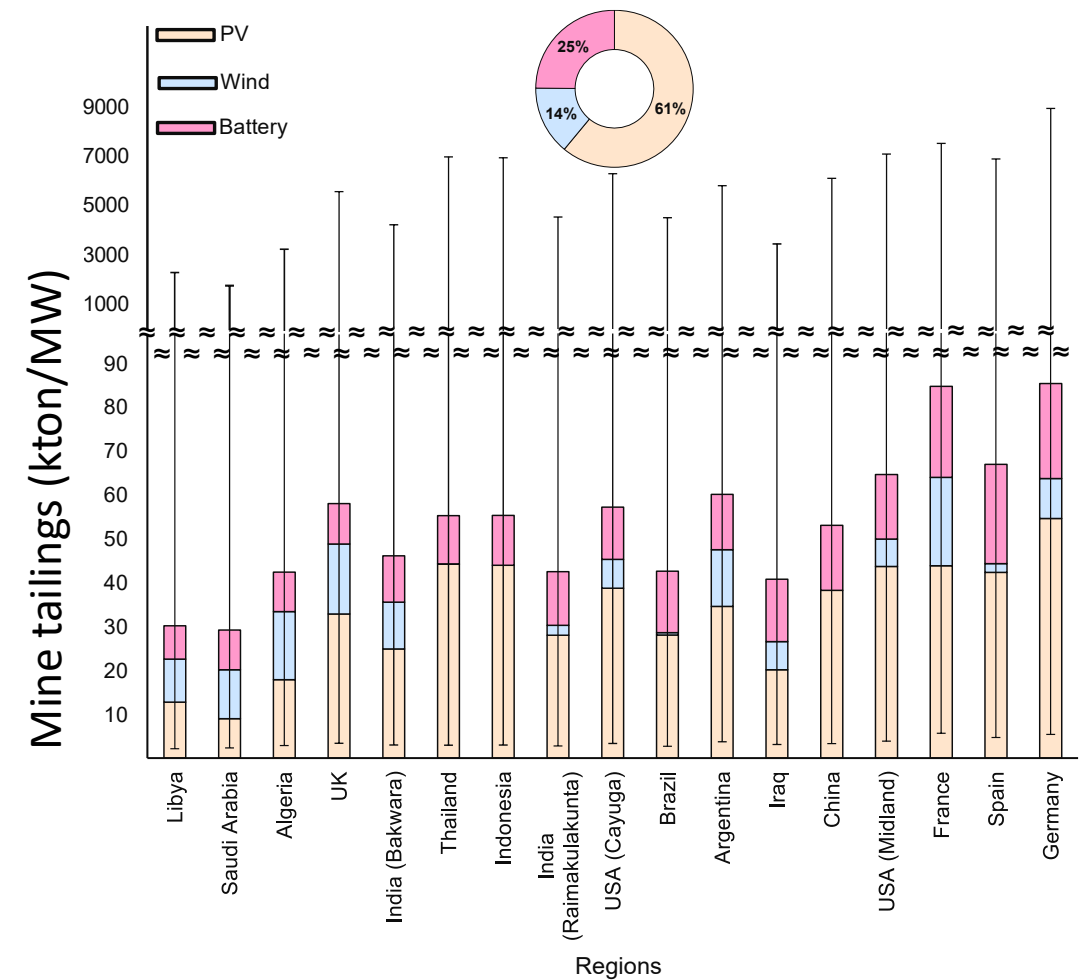
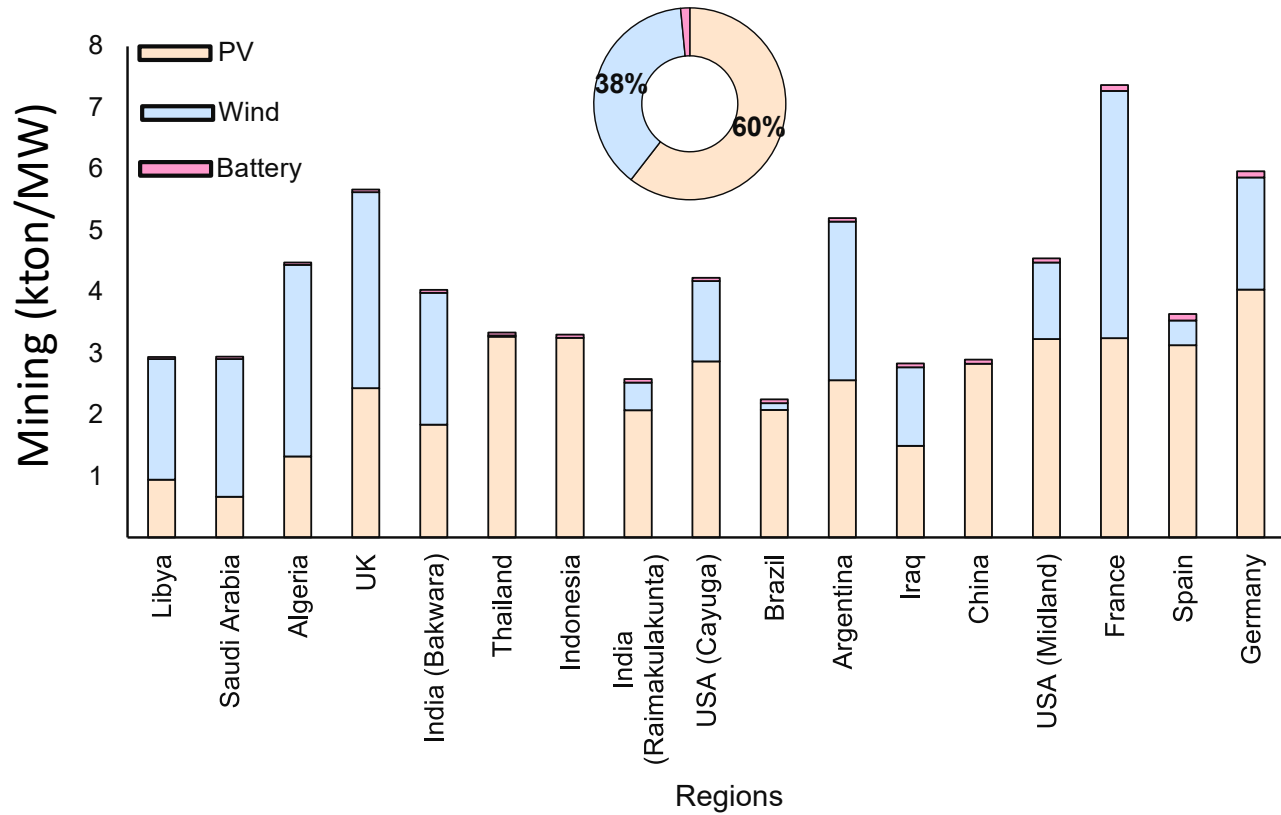


# MWh ≠ MW



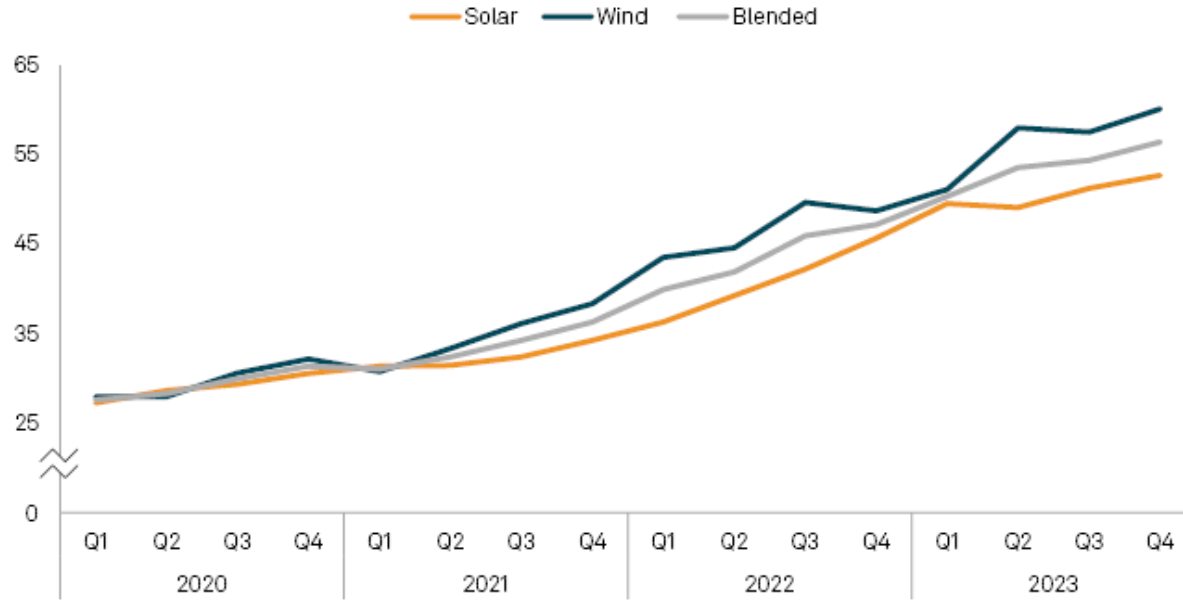


# “Big oil” becomes “big mining”?



# Renewable energy is getting cheaper...

Wind, solar PPA prices have risen dramatically in recent years (\$/MWh)



Data accessed Jan. 30, 2024.

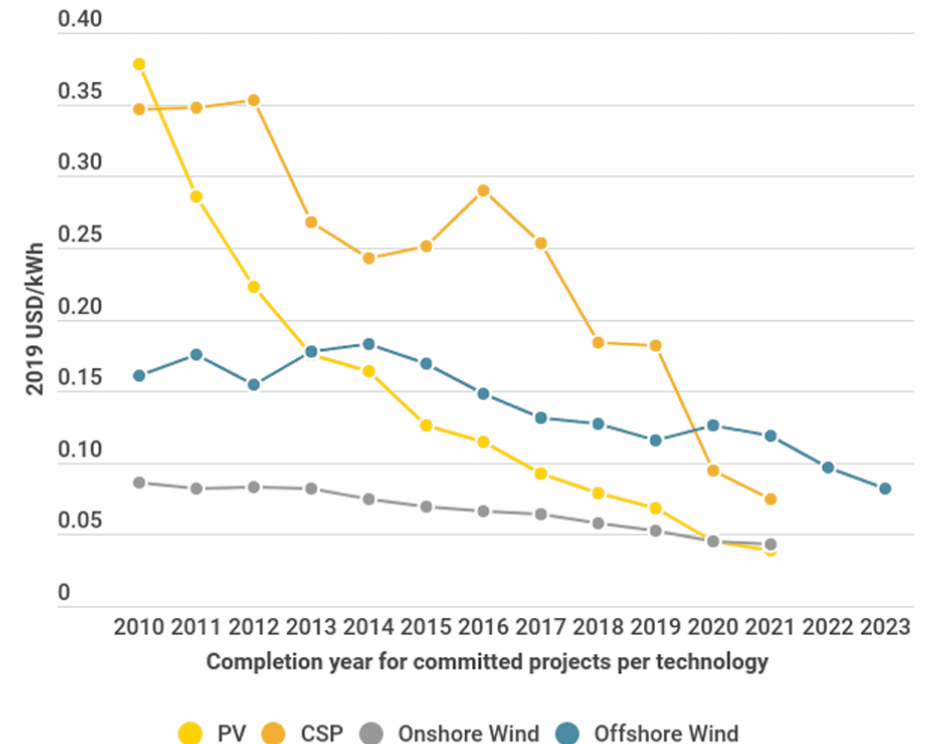
PPA = power purchase agreement.

Shows lowest 25% of PPA offers across six wholesale energy markets in US and Canada for each technology. "Blended" is an aggregation of the lowest 25% of wind and solar PPA offers.

Source: LevelTen Energy.

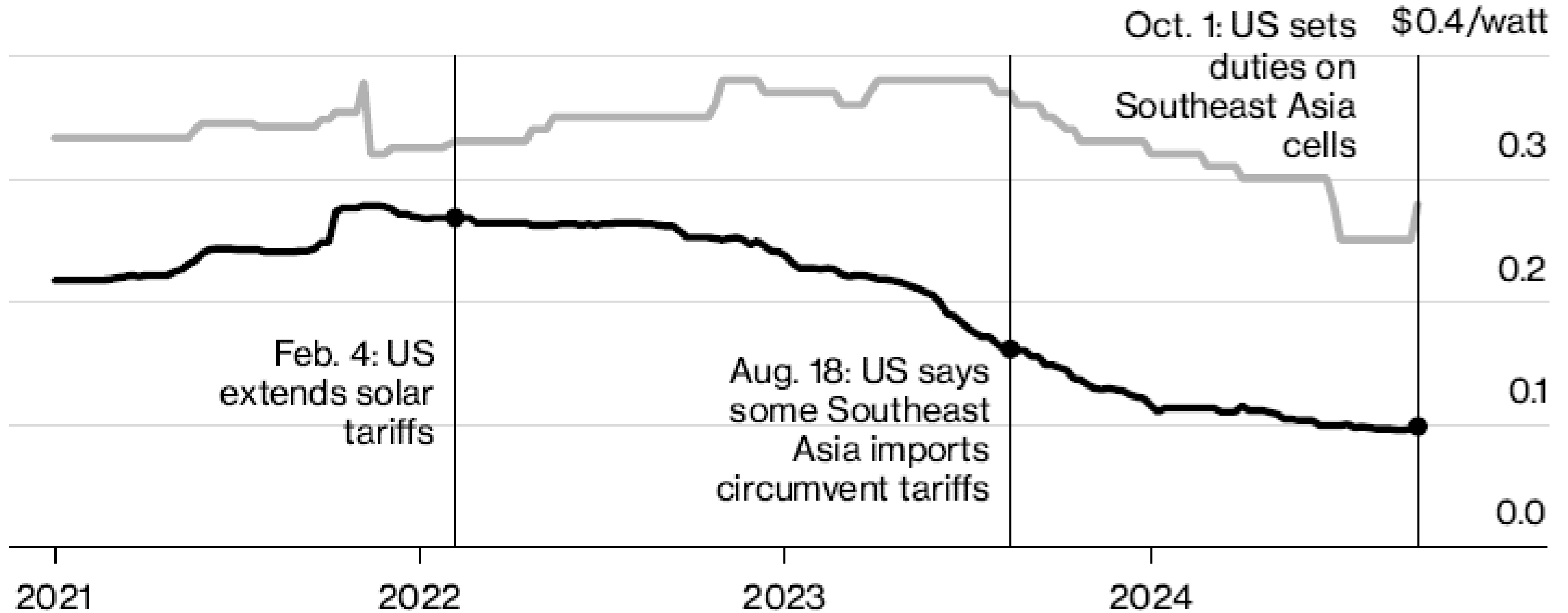
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Costs continue to fall for solar and wind power technologies



# US Solar Import Premium Rising Since 2022 Tariffs

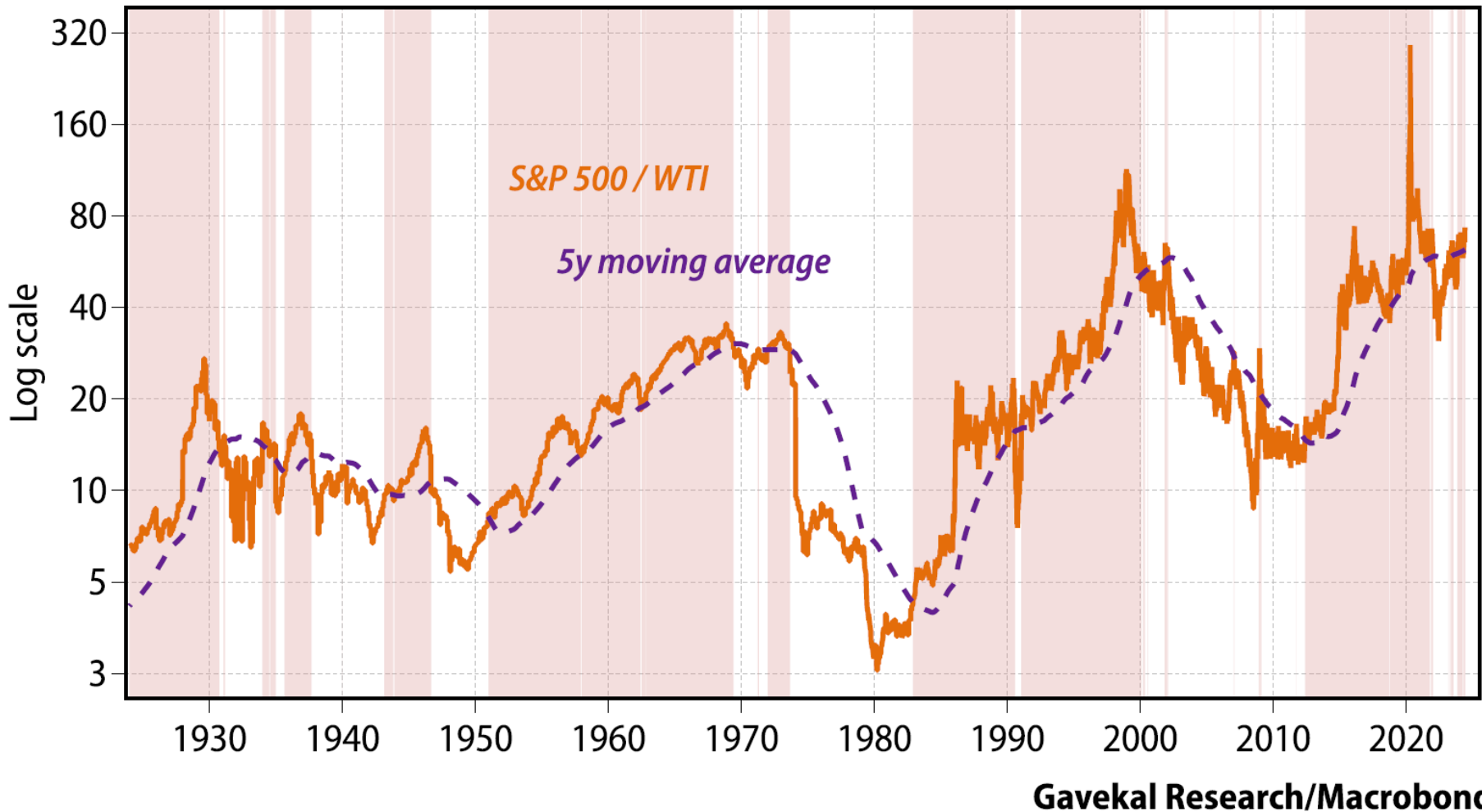
Monocrystalline silicon module's average price / Shipped-to-US average price



Source: PV InfoLink, BloombergNEF

# The economy is simply energy transformed

Pink = S&P 500 / WTI above 5y moving average



- **ALL** major bear markets have been when energy is structurally expensive
- High energy costs are invariably inflationary

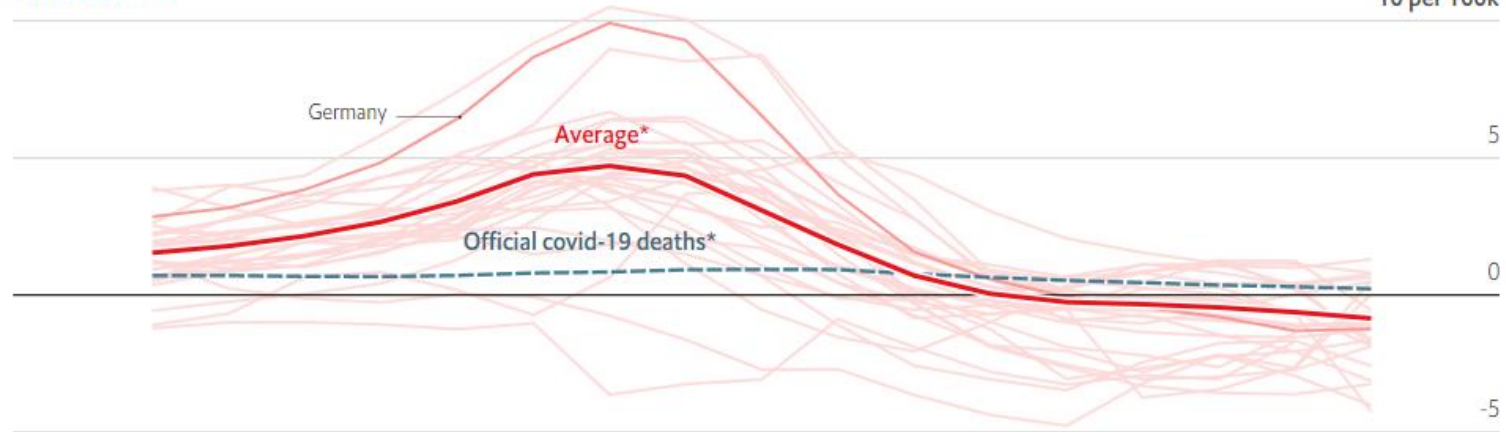




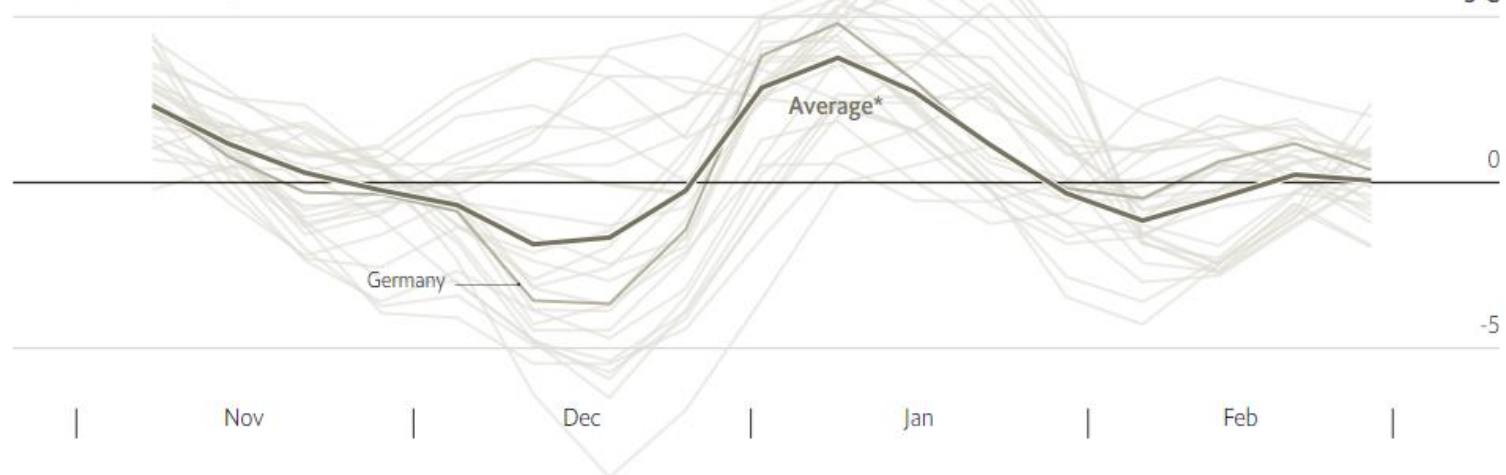
## Europe, excess deaths v average temperatures

Winter 2022-23 compared with 2015-19, three-week moving average

### Excess deaths



### Temperature change



149,000 total excess deaths, explained by:

Rise in energy prices

Covid-19

Other

68,000

59,700

21,500

\*EU-27 (except Malta and Cyprus) plus Britain, Norway and Switzerland

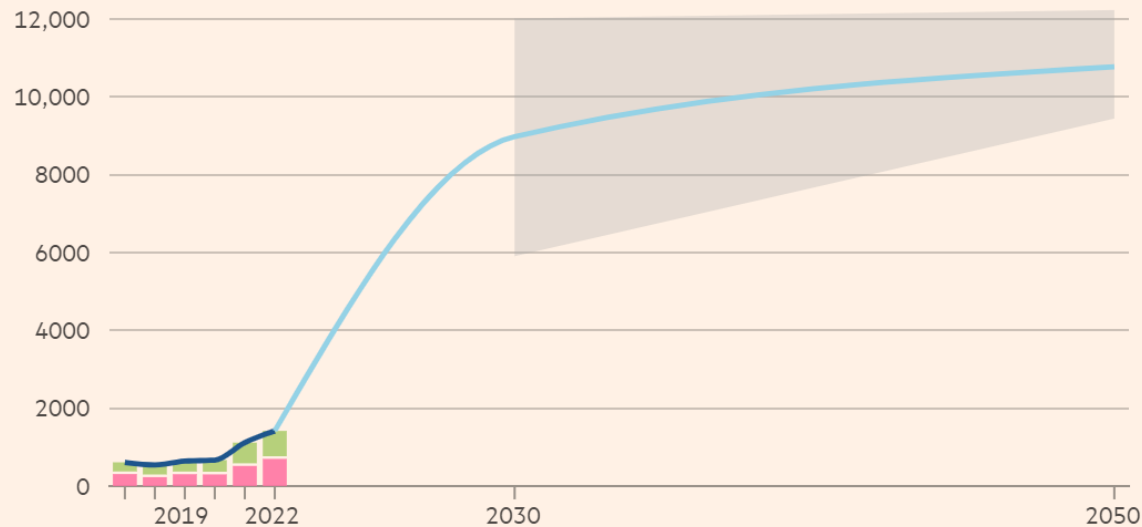
<https://www.economist.com/graphic-detail/2023/05/10/expensive-energy-may-have-killed-more-europeans-than-covid-19-last-winter>

# Energy transition is expensive...and unprofitable...

## The \$9 trillion challenge

Global climate financing (\$bn), with estimated needs in 2030 and 2050 (shaded areas show range of estimates)

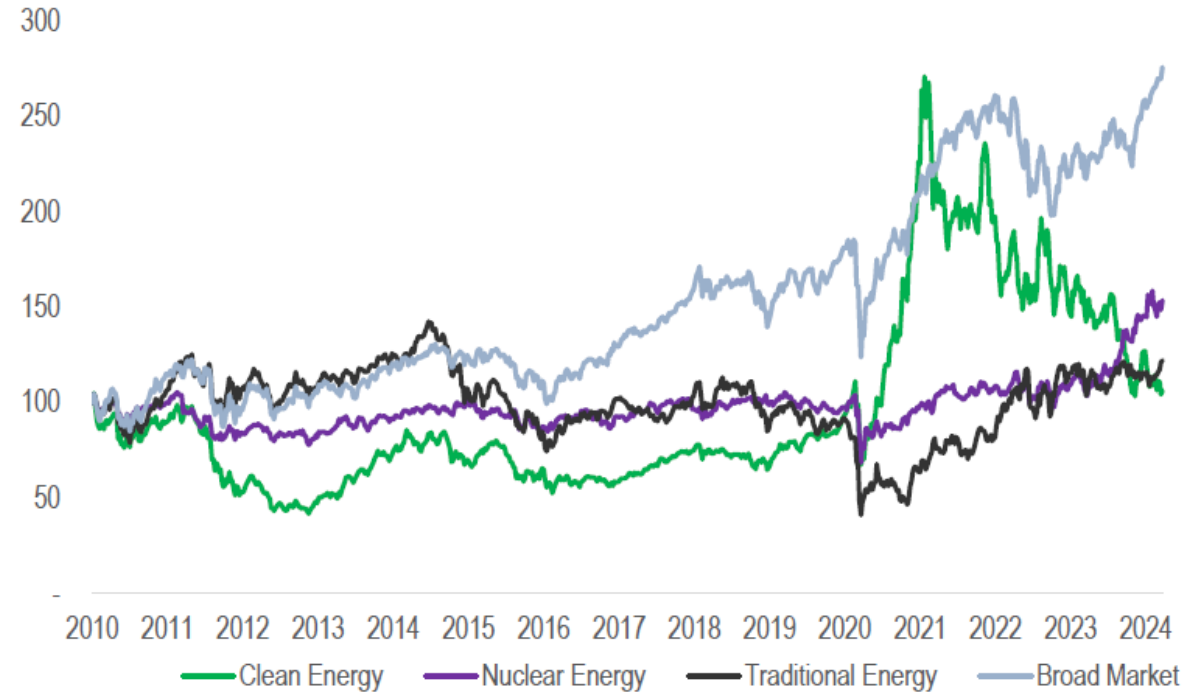
Actual Public Private Needs in the average scenario



FINANCIAL TIMES

Source: Climate Policy Initiative • Climate finance needs for 2030 and 2050 are expressed in constant 2022 dollars

performance, rebased 1.1.2010=100

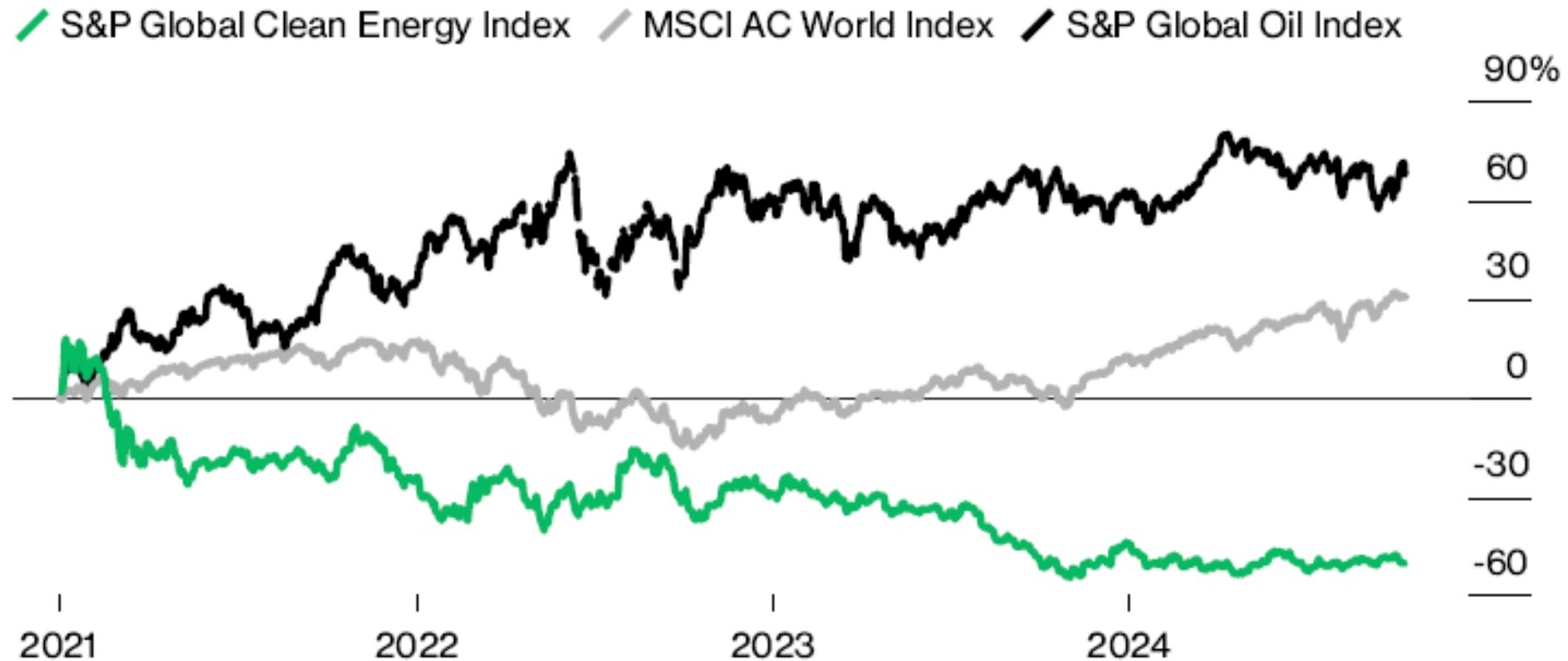


Source: Bloomberg Finance L.P. and J.P. Morgan Global Energy Strategy. Clean energy is average of: NASDAQ Clean Edge (CELS), WilderHill Clean Energy (ECO), FTSE Env/ Ren/Alt. energy (EORE), and S&P Clean Energy (SPGTCED) indices; Nuclear energy refers to MVIS Nuclear (MVNLR) index; Traditional energy is average of XLE and SXEP and broad market is average of SPX and SXXP.

# Energy transition is expensive...and unprofitable...

## Clean Energy Shares Have Lagged Oil, Global Stocks

Change since January 2021

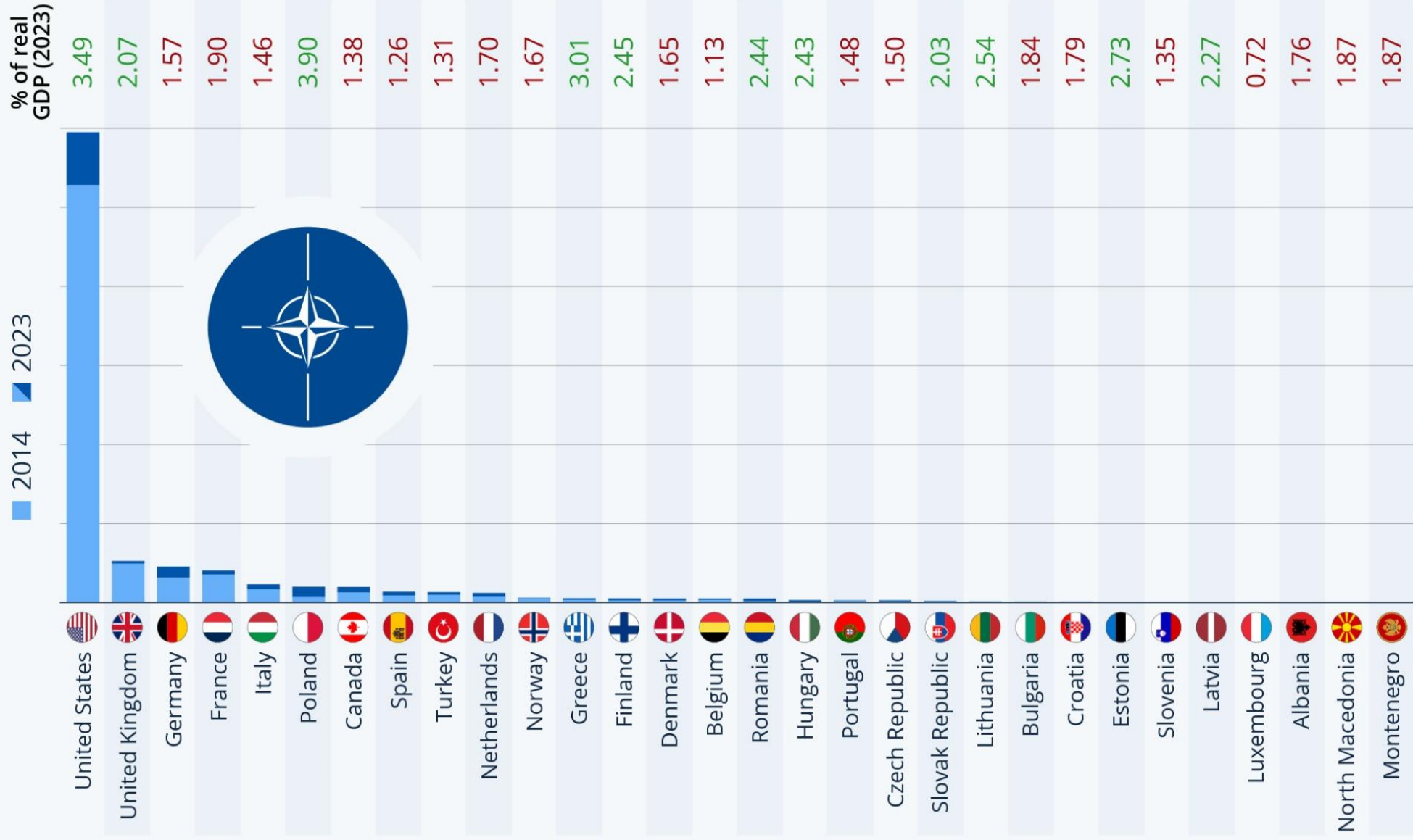


Source: Bloomberg

<https://www.bloomberg.com/graphics/2024-hedge-funds-climate-change-green-energy-stocks/>

# Where NATO Defense Expenditure Stands

Estimated military spending of NATO countries in 2014 and 2023 (in billion constant 2015 U.S. dollars) and share of GDP

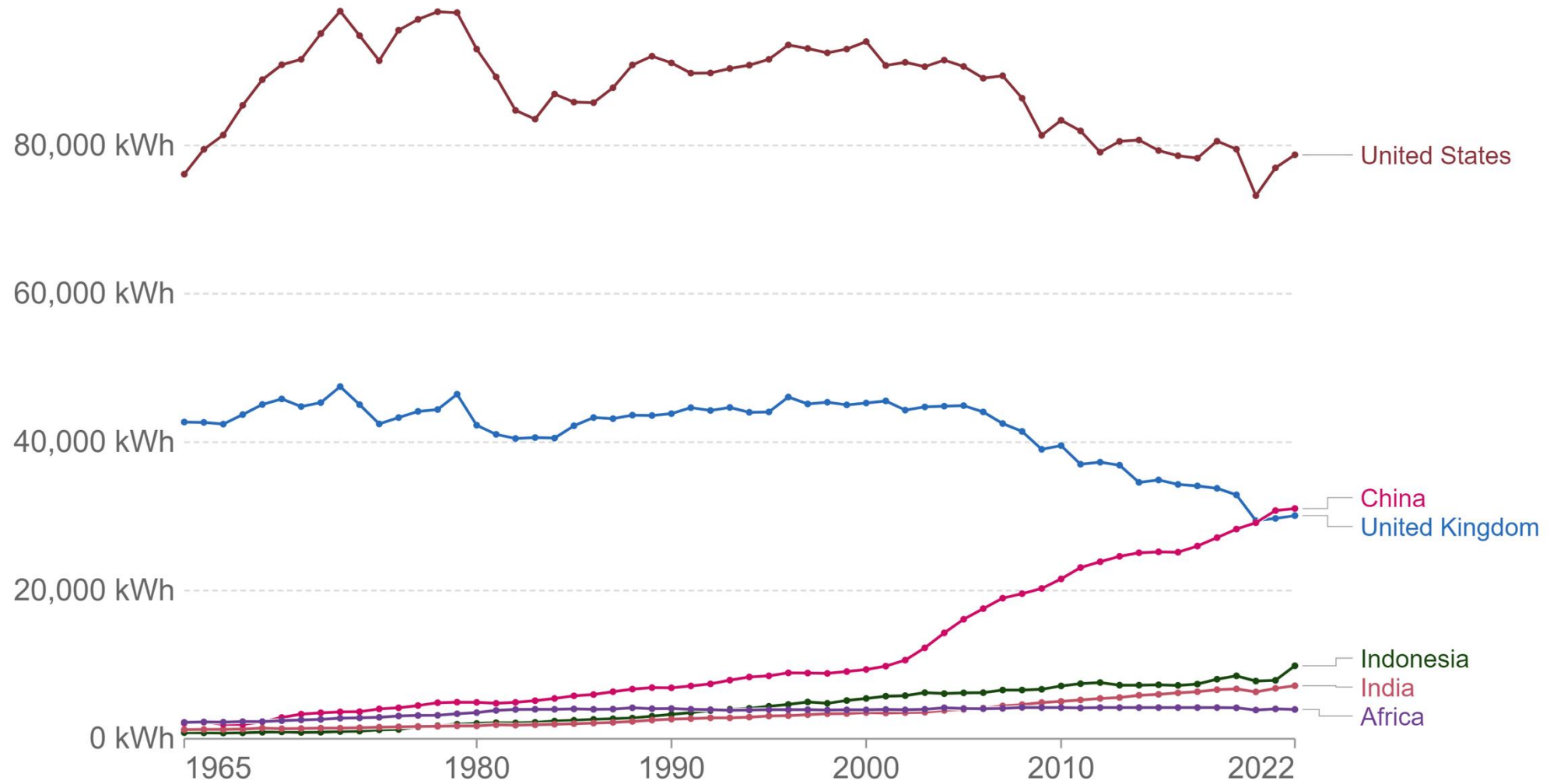


NATO member Iceland has no armed forces. Estimates as of mid-year  
Source: NATO



# Energy use per person

Energy use not only includes electricity, but also other areas of consumption including transport, heating and cooking.



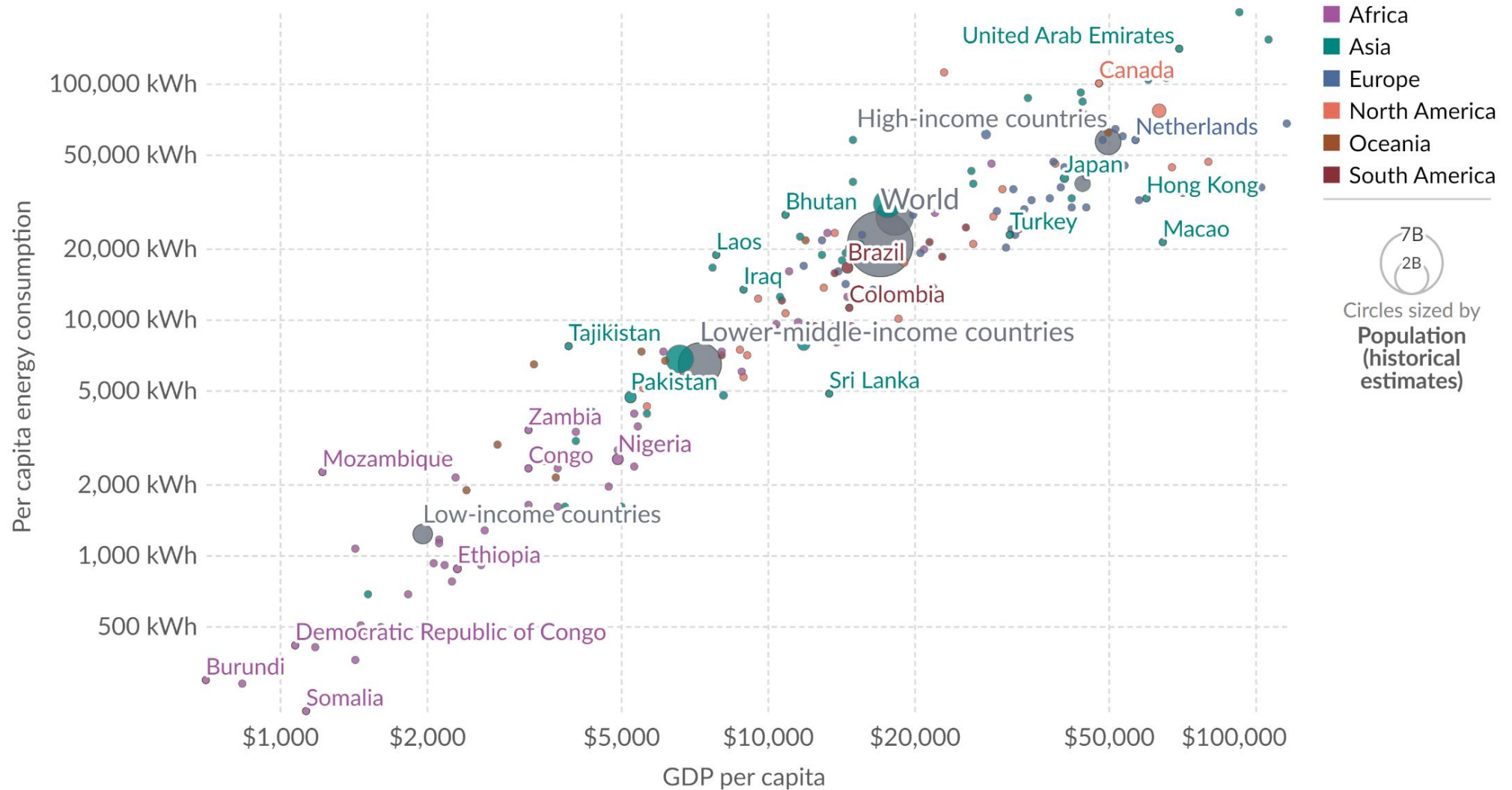
**Data source:** U.S. Energy Information Administration (EIA); Energy Institute Statistical Review of World Energy (2023)

**Note:** Energy refers to primary energy – the energy input before the transformation to forms of energy for end-use (such as electricity or petrol for transport).



# Energy use per person vs. GDP per capita, 2021

Energy refers to primary energy<sup>1</sup>, measured in kilowatt-hours<sup>2</sup> per person, using the substitution method<sup>3</sup>. Gross domestic product (GDP) is adjusted for inflation and differences in the cost of living between countries.



Data source: U.S. Energy Information Administration (2023) and other sources

Note: GDP data is expressed in international-\$<sup>4</sup> at 2017 prices.

OurWorldInData.org/energy | CC BY

# “Justice”

2022 data	(US, EU, CAN, JPN, AU, NZ)	The 1.4 Billion People Club			
	The Lucky 1 Billion	China	India	SE Asia	Africa
Population (millions)	1,124	1,426	1,417	1,307	1,427
Oil:					
Demand (mn b/d)	40.9	14.6	5.3	11.4	4.2
Demand (bbls) per capita	13.3	3.7	1.4	3.2	1.1
Supply (mn b/d)	26.9	4.1	0.7	2.0	7.0
Net imports (mn b/d)	(14.0)	(10.5)	(4.6)	(9.4)	2.9
Natural Gas:					
Demand (Bcf/d)	159.4	36.8	5.6	31.2	15.7
Demand per capita	51.8	9.4	1.4	8.7	4.0
Supply (Bcf/d)	148.7	21.5	2.9	26.8	24.1
Net imports (Bcf/d)	(10.7)	(15.3)	(2.7)	(4.5)	8.4



# Uganda condemns EU resolution slamming oil pipeline

## JOINT linked

14.9.2022 - (20

pursuant to Ru  
replacing the fo  
[B9-0409/2022](#)  
[B9-0410/2022](#)  
[B9-0412/2022](#)

Tomáš Zdecho  
Sandra Kalniet  
Andrey Kovatc  
on behalf of the  
Pedro Marques  
on behalf of the  
Katalin Cseh, F  
Ștefănuță, Ram  
on behalf of the  
Beata Kempa,



zania

stian Sagartz,  
omana Tomc,

Nicolae



# Climate change and national sovereignty

FP

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## Europe to Africa: Gas for Me but Not for Thee

Europe is ramping up its use of the dirtiest fuels—but keeps pressing Africa to stick to draconian green goals.

By [W. Gyude Moore](#), a senior policy fellow at the Center for Global Development, and [Todd Moss](#), the executive director of the Energy for Growth Hub.



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# Anwar Ibrahim, Prime Minister of Malaysia



“The need for transition must be balanced against our need to survive, to ensure that our present policies eliminating poverty in providing education, health and basic infrastructure are not frustrated because of the dictates of others that do not place adequate consideration on what we have to face.”

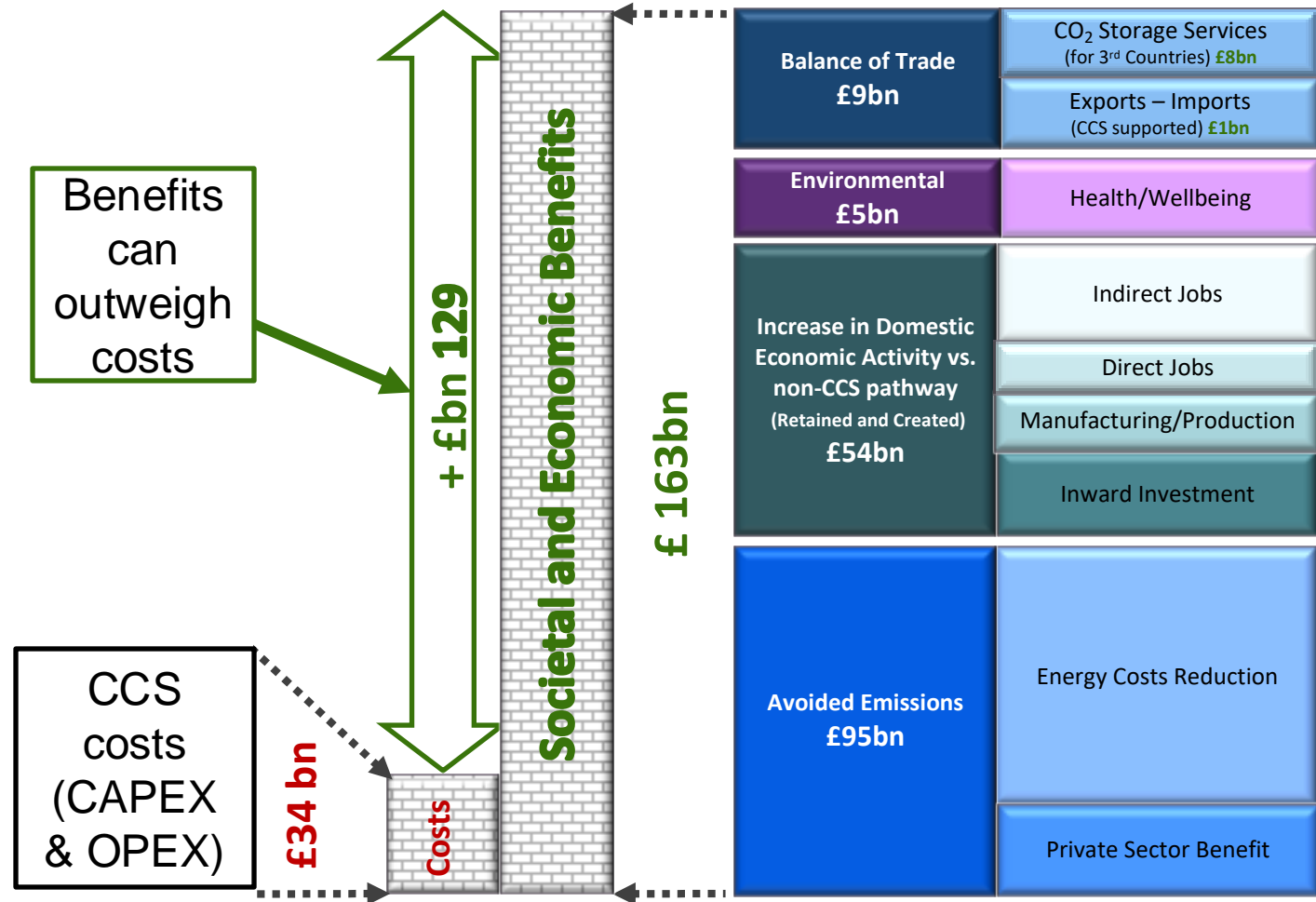


# Need to shift the conversation to value creation

Policy and decision makers are looking for tangible benefits rather than technical detail, e.g., GDP growth and employment.

Need to demonstrate the societal value of CCS/CCUS.

Every £1 invested for CCS results in £4.8 of societal & economic benefit.



# Some conclusions...

- Awareness of the anthropogenic nature of climate change is not new
- Humanity faces an energy hierarchy, not an energy trilemma
- Pragmatism is key; the world of 2025 is vastly different to that of 2015
- National security and geopolitics will trump climate considerations
- Taxpayers, consumers, and investors all have a role to play
- Respecting the national sovereignty of individual countries is a must
- Meeting growing energy demand will require every “tool in the shed”
- Need to focus on economic growth and value creation
- Presenting climate change mitigation as a set of binary choices is a fundamental mistake

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