

Thoughts on the Energy Transition

Julien Jomaux

September 2023

Check out my work on energy here: <https://gemenergyanalytics.substack.com/>

Julien Jomaux



- **Engineer, specialized in electricity and energy systems**
- **Work experiences in Belgium, Rwanda, and Albania**
- **Passionate about electricity, energy, and sustainability**
- **Family with three kids**



Agenda

1. **A brief history of emissions**
2. **Energy Transitions?**
3. **Two different issues: energy poverty and emissions**
4. **Hopeful developments**
5. **Focus on particular countries**
6. **The great challenges**
7. **What could we do?**

Three main greenhouse gases

CO2 is 75%, CH4 17%, N2O 6%: all growing

Global greenhouse gas emissions by gas

Greenhouse gas emissions are converted to carbon dioxide-equivalents (CO₂eq) by multiplying each gas by its 100-year 'global warming potential' value: the amount of warming one tonne of the gas would create relative to one tonne of CO₂ over a 100-year timescale. This breakdown is shown for 2016.



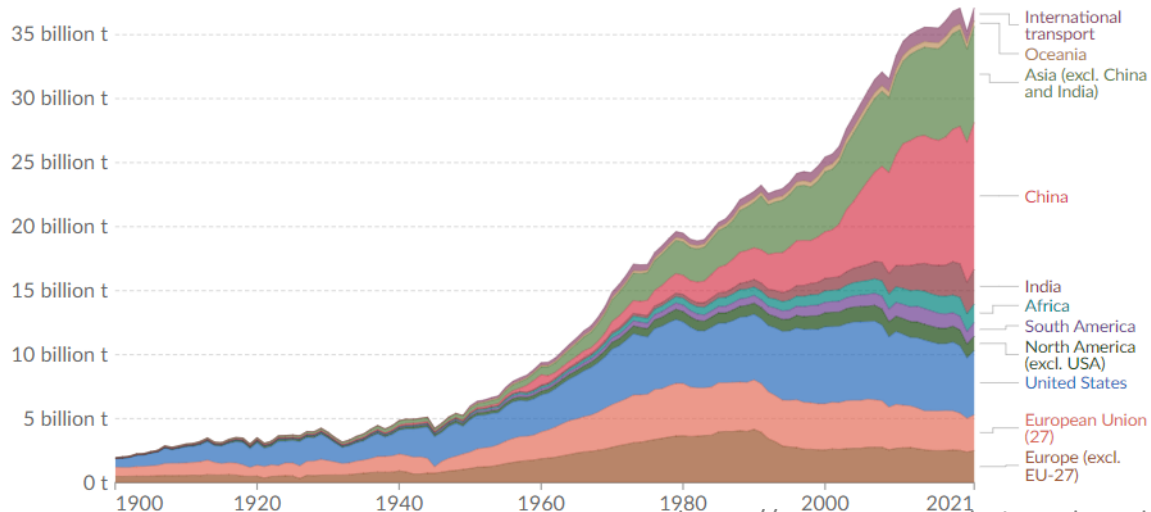
OurWorldInData.org - Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).

Licensed under CC-BY by the author Hannah Ritchie.

Annual CO₂ emissions by world region

This measures fossil fuel and industry emissions. Land use change is not included.

All together Relative



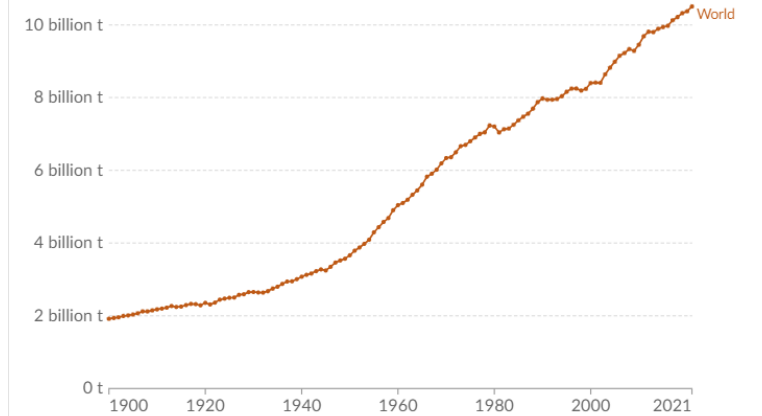
<https://gemenergyanalytics.substack.com>

Julien Jomiaux

Methane emissions

Methane (CH₄) emissions are measured in tonnes of carbon dioxide-equivalents. Includes methane emissions from fossil fuels, industry and agricultural sources.

+ Add country or region



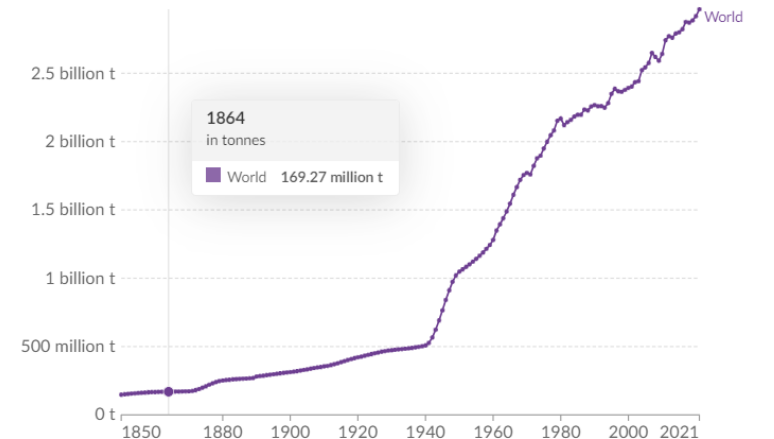
Source: Gütschow and Pflüger (2023)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

Nitrous oxide emissions

Nitrous oxide (N₂O) emissions are measured in tonnes of carbon dioxide-equivalents.

+ Add country or region



Source: Gütschow and Pflüger (2023)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

Unequal distribution of emissions across the world

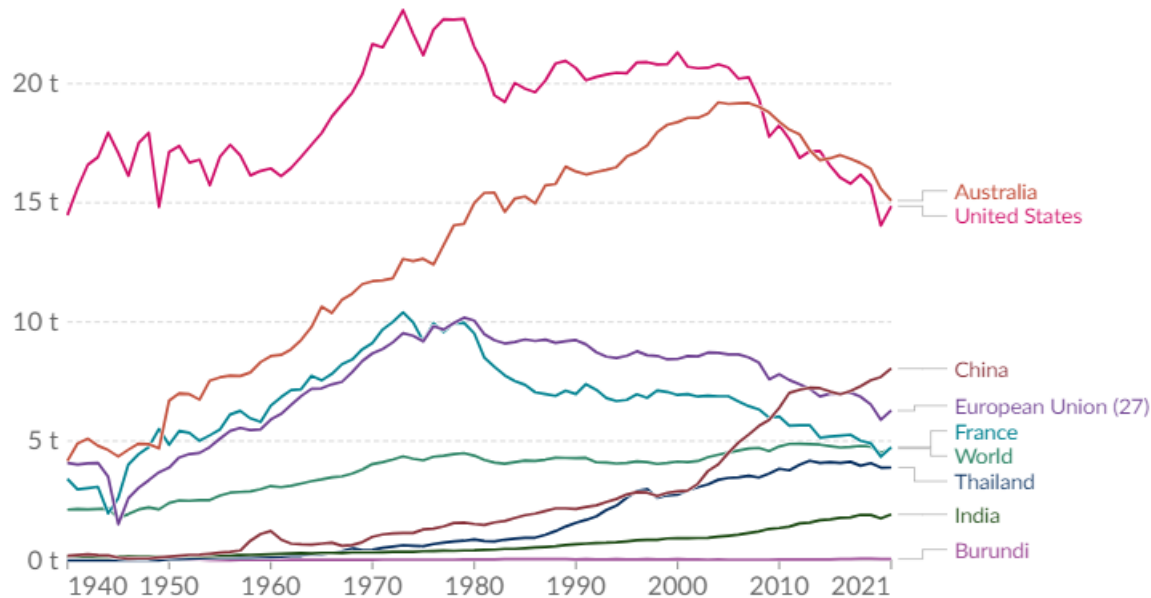
From 0.06 T in Burundi to 15.09 T in Australia

Per capita CO₂ emissions

Carbon dioxide (CO₂) emissions from fossil fuels and industry. Land use change is not included.



[+ Add country or region](#) All together Relative change



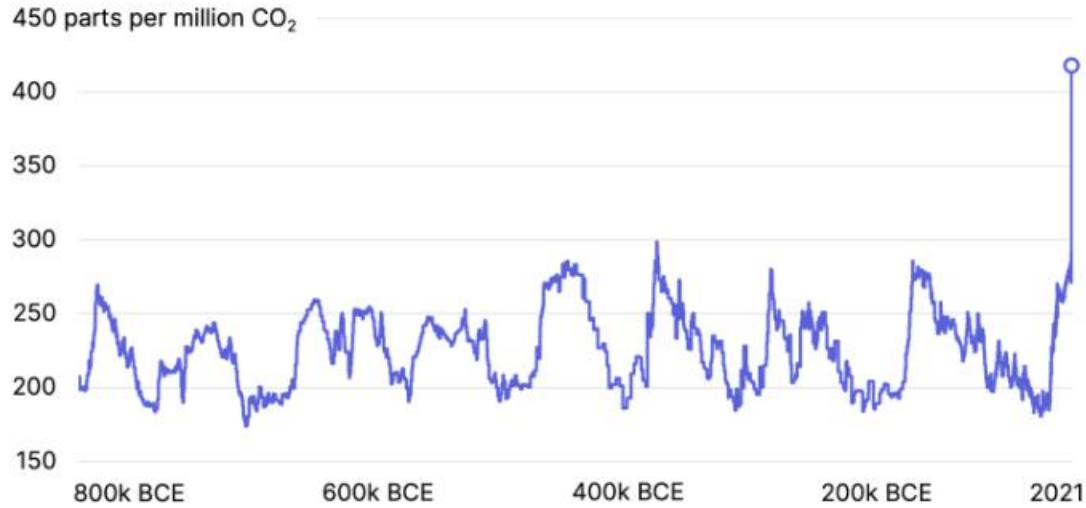
Source: Global Carbon Budget (2022); Gapminder (2022); UN (2022); HYDE (2017); Gapminder (Systema Globalis) OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

2021 in tonnes per capita

Australia	15.09 t
United States	14.86 t
China	8.05 t
European Union (27)	6.28 t
France	4.74 t
World	4.69 t
Thailand	3.89 t
India	1.93 t
Burundi	0.06 t

CO2 is at an unprecedented level in human history

And global temperatures are rising

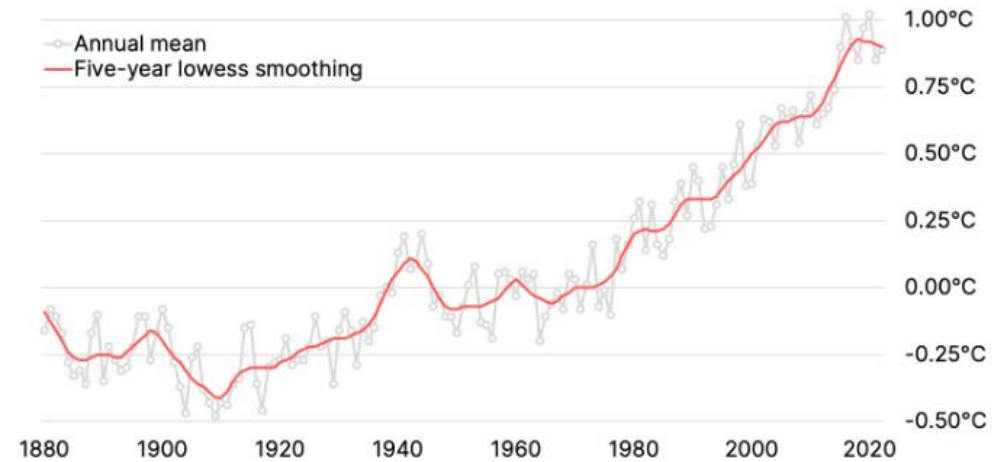


January 2023

<https://www.nathanielbullard.com/>

Temperatures have risen 1°C

Temperatures are one degree Celsius above the long-term average



January 2023

Source:
NASA

Note:
Land-ocean
temperature
index
(base period
1951-80)



NAT BULLARD

<https://gemenergyanalytics.substack.com>

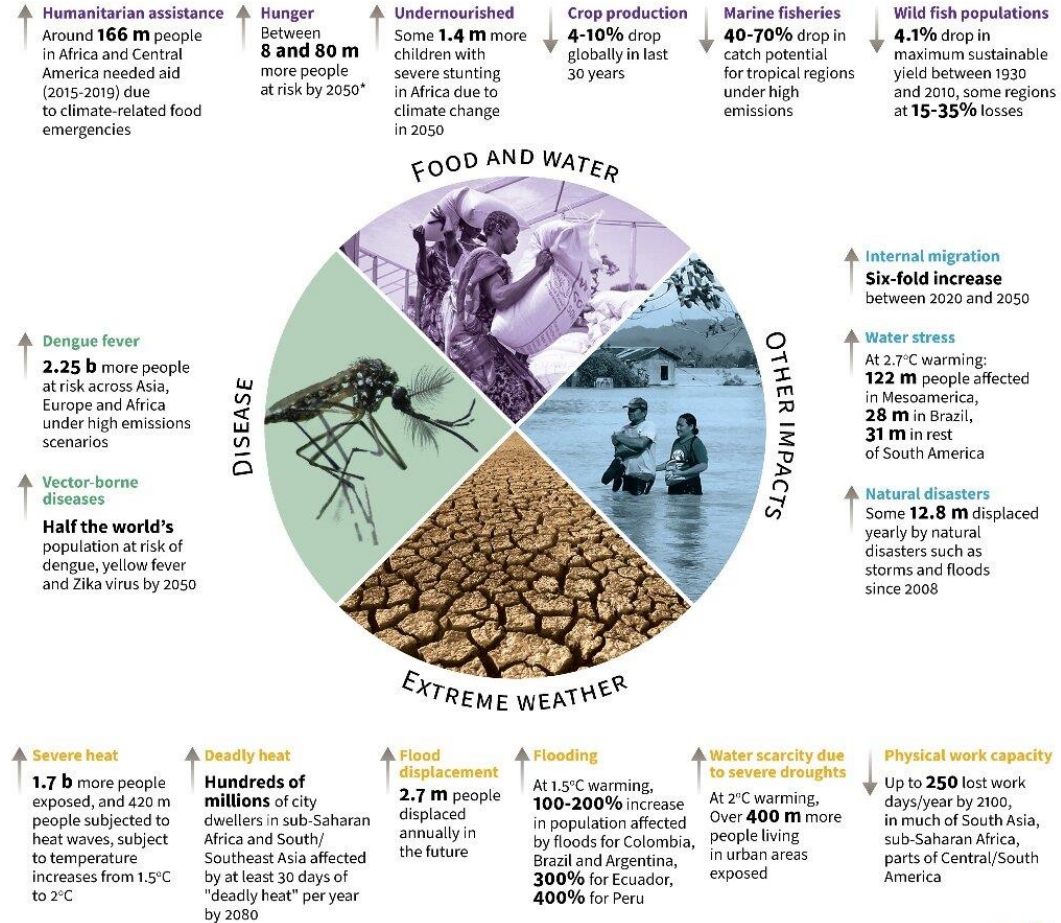
Julien Jomaux

Climate change is real

And it will have a broad range of impacts

Climate change: the impact on humanity

Highlights of a landmark Intergovernmental Panel on Climate Change (IPCC) draft report on the effects of a warming planet on people



Source: IPCC, WGI, Sixth Assessment Report / AFP Photos *depends on levels of emissions/extent of development

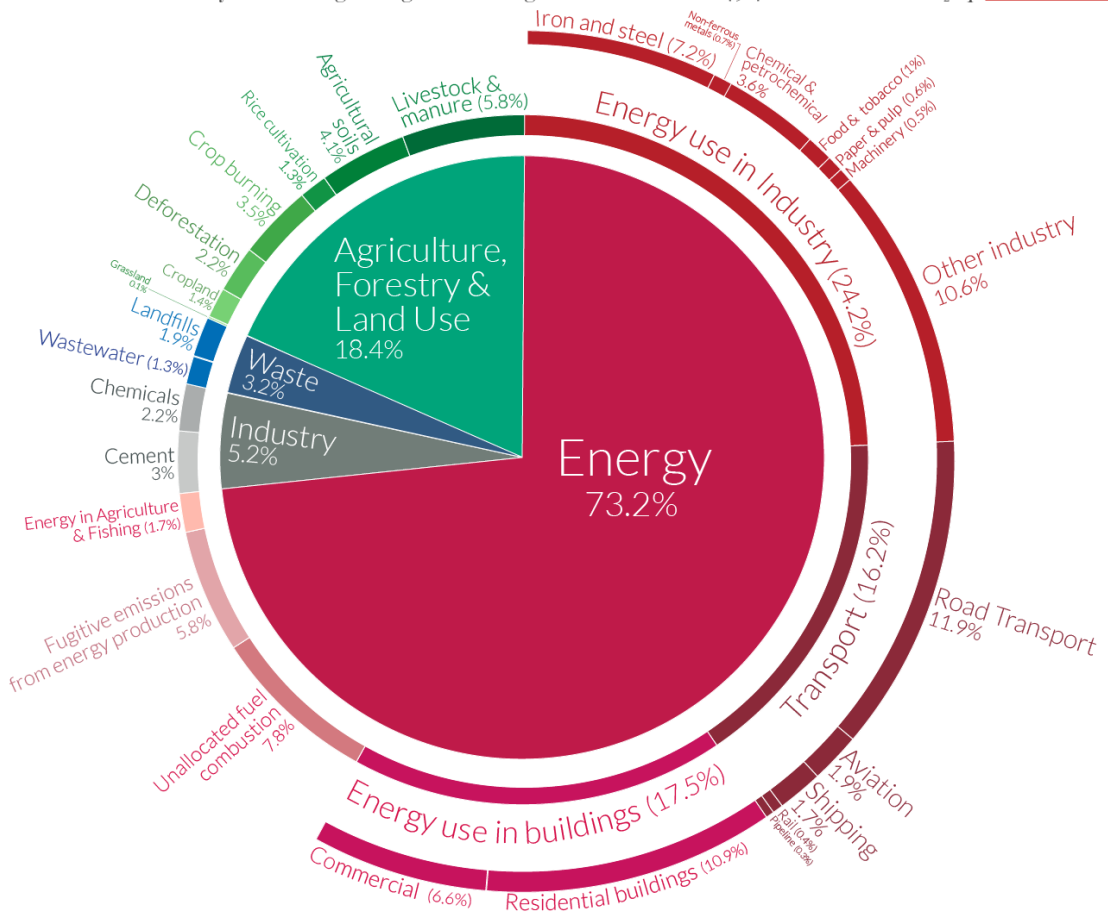


The different sources of emissions

Energy represents 3 quarters of all emissions

Global greenhouse gas emissions by sector

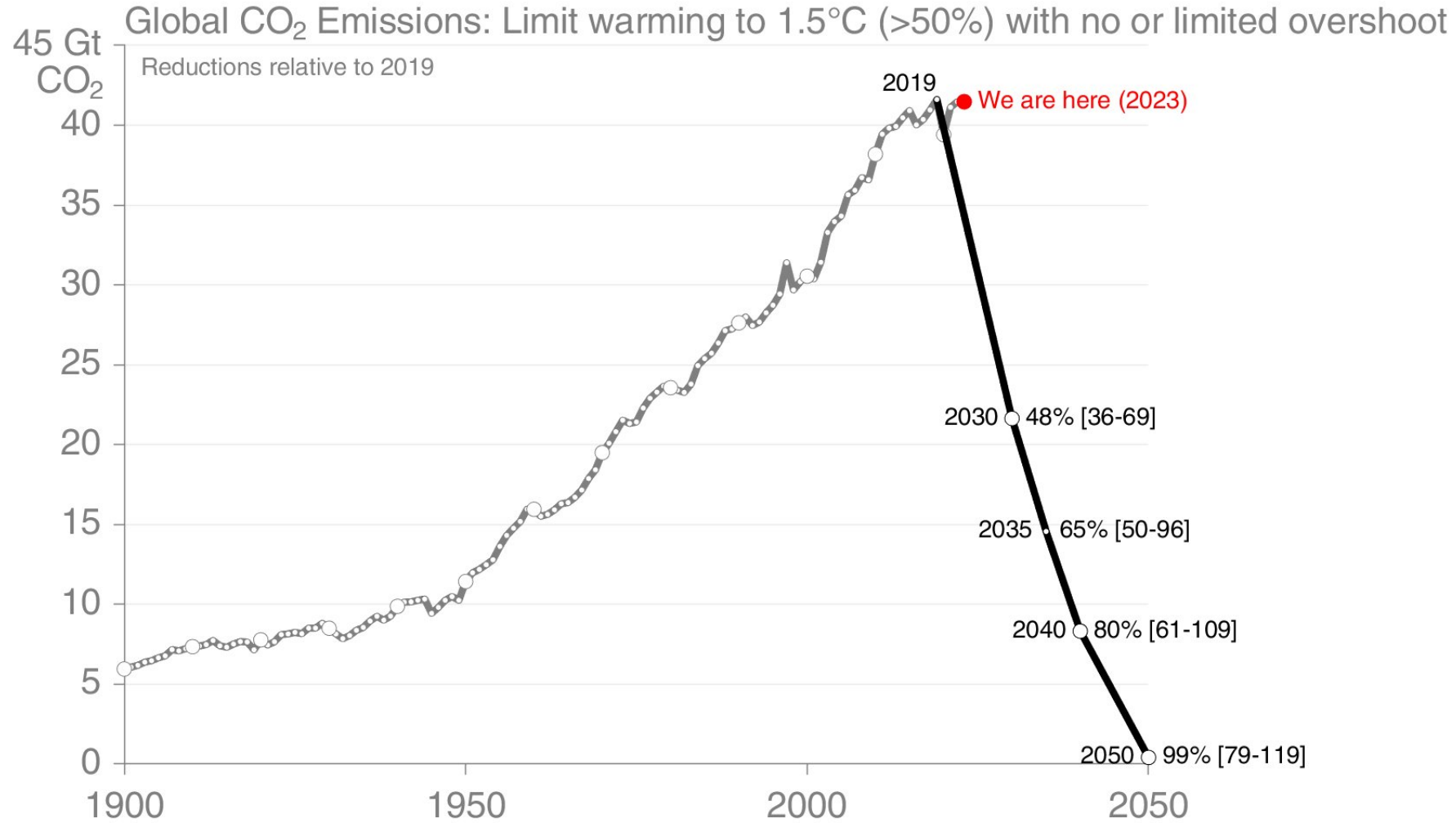
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



OurWorldinData.org – Research and data to make progress against the world’s largest problems.
 Source: Climate Watch, the World Resources Institute (2020). Licensed under CC-BY by the author Hannah Ritchie (2020).

Limiting to 1.5 degrees

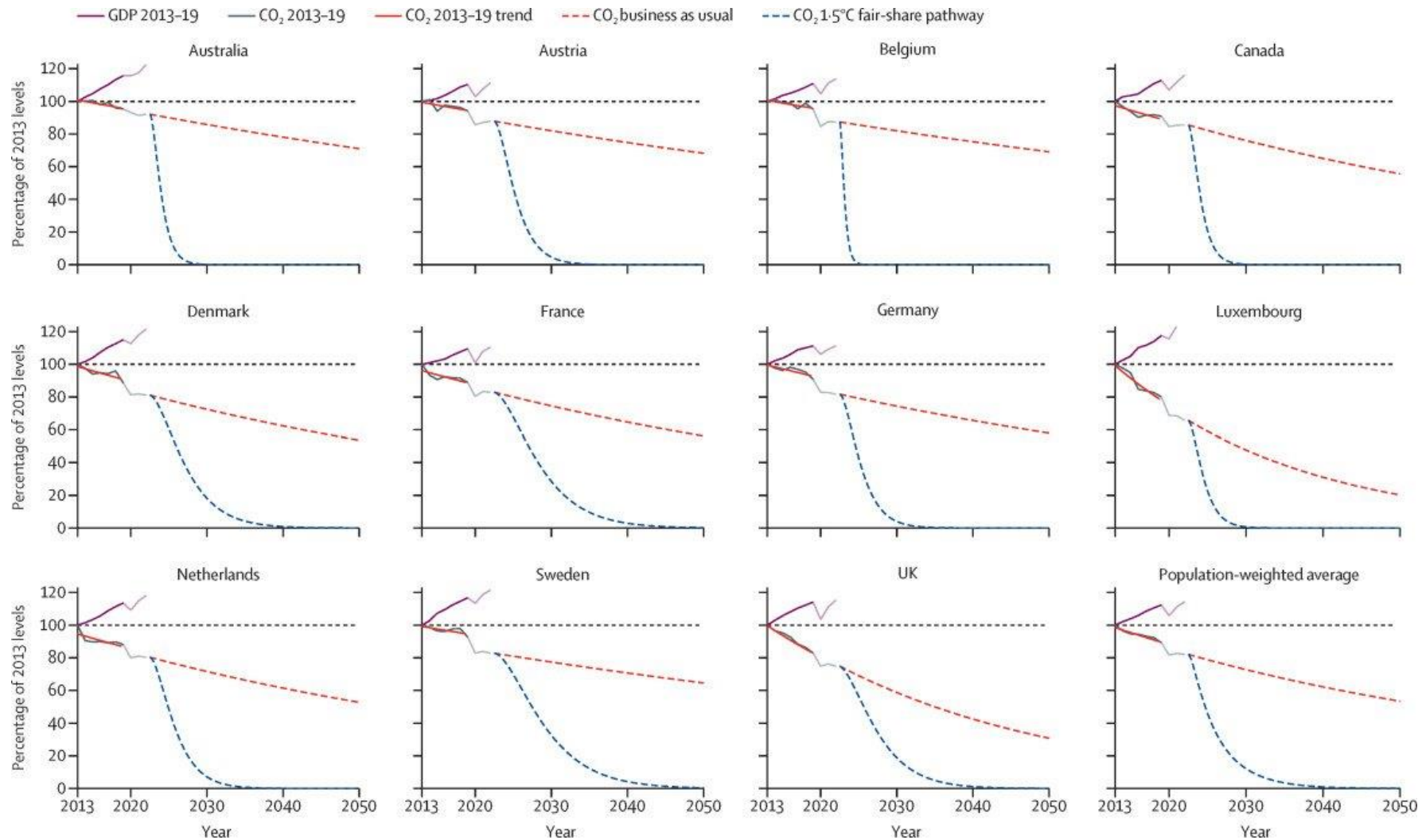
Is it still possible ?



©@Peters_Glen • Data: Global Carbon Budget (2022); IPCC SYR Table SPM.1

Limiting to 1.5 degrees

Decoupling GDP and emissions is possible but it is extremely slow



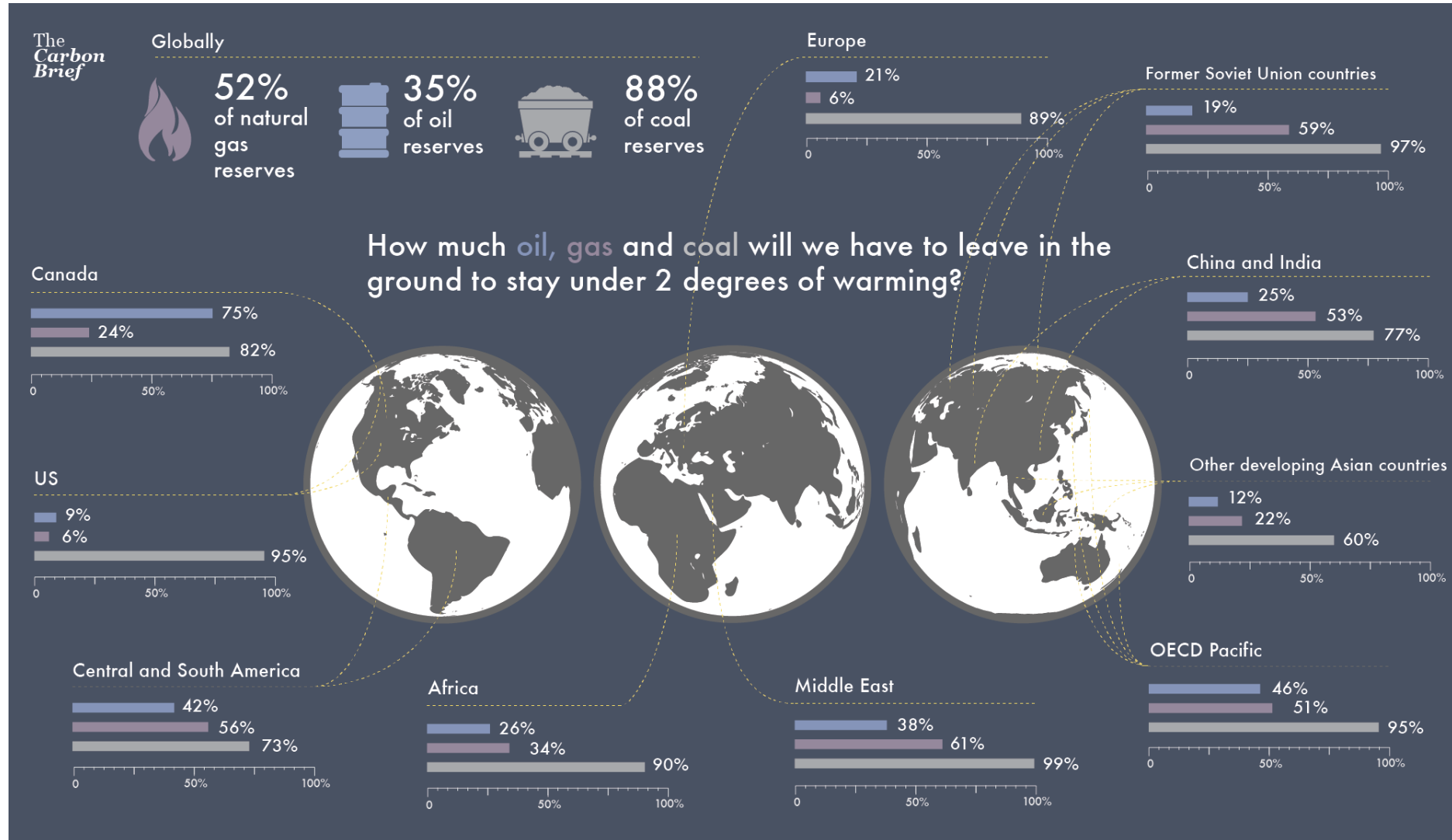
[https://www.thelancet.com/journals/lanph/article/PIIS2542-5196\(23\)00174-2/fulltext](https://www.thelancet.com/journals/lanph/article/PIIS2542-5196(23)00174-2/fulltext)

<https://gemenergyanalytics.substack.com>

Julien Jomaux

Fossil fuels should stay underground

We cannot burn the known reserves of fossil fuels if we want to stay under 2 degrees.



Always more fossil fuels burned

Consumption of fossil fuels are still increasing

Global oil demand is projected to climb by 2.2 mb/d in 2023 to reach 102.1 mb/d, a new record. However, persistent macroeconomic headwinds, apparent in a deepening manufacturing slump, have led us to revise our 2023 growth estimate lower for the first time this year, by 220 kb/d. Buoyed by surging petrochemical use, China will account for 70% of global gains, while OECD consumption remains anaemic. Growth will slow to 1.1 mb/d in 2024.

We expect coal demand grew by about 1.5% in the first half of 2023 to a total of about 4 665 Mt, backed by both an increase of 1% in power generation and 2% in non-power. We observed continued increases in China, India and Indonesia, which more than offset declines in the United States, the European Union and Japan.

Global gas consumption in 2023 set to increase by 1% on year: GECF

Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

The energy transition

A common view on the past and future energy transitions

Video AREVA:

<https://www.youtube.com/watch?v=GPDoWxtwSoY>

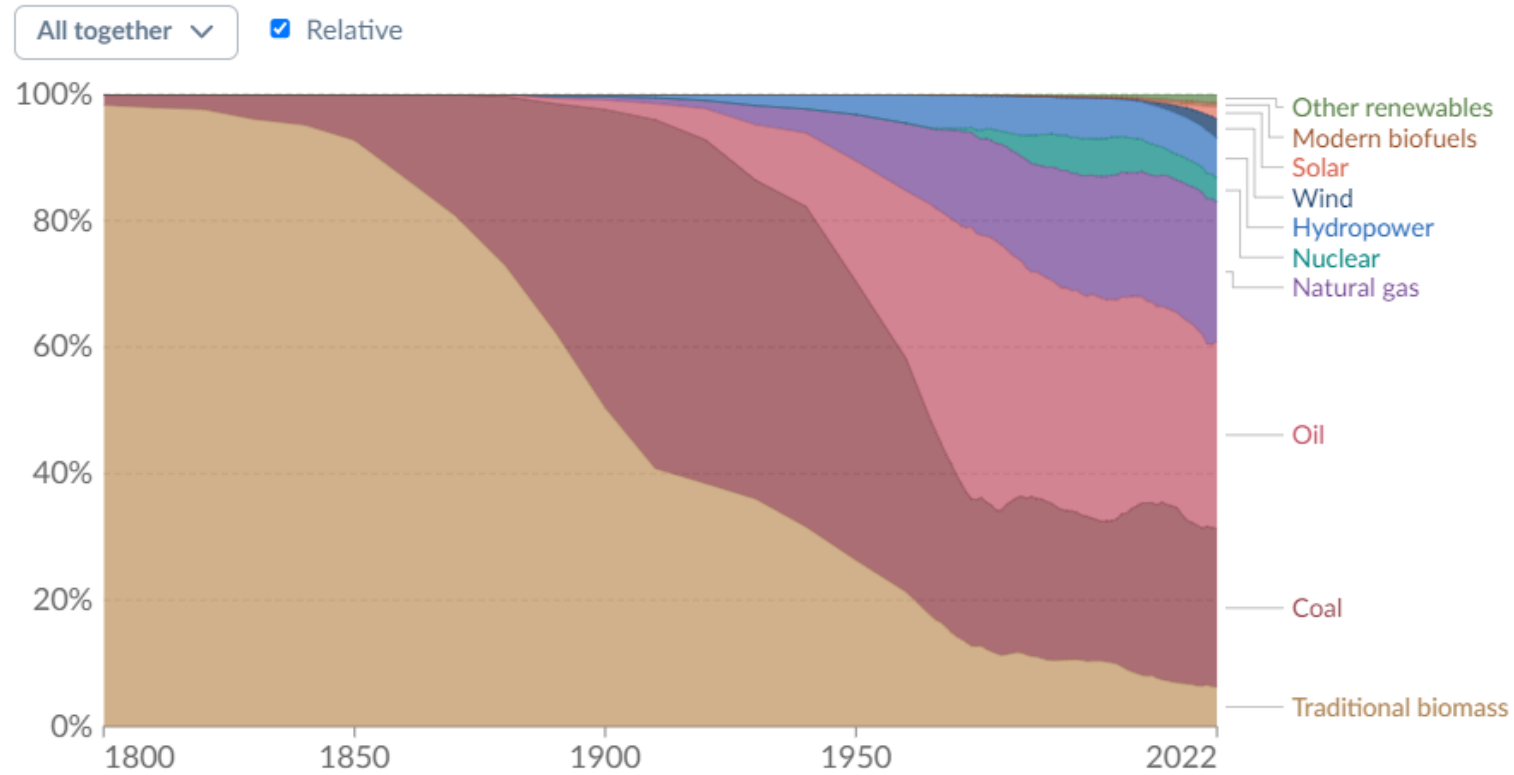
For a great view on the energy transition: Jean-Baptiste Fressoz, French historian

The past energy transitions

From biomass to coal to oil to natural gas... in route to sources with low emissions?

Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



Source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)
OurWorldInData.org/energy • CC BY



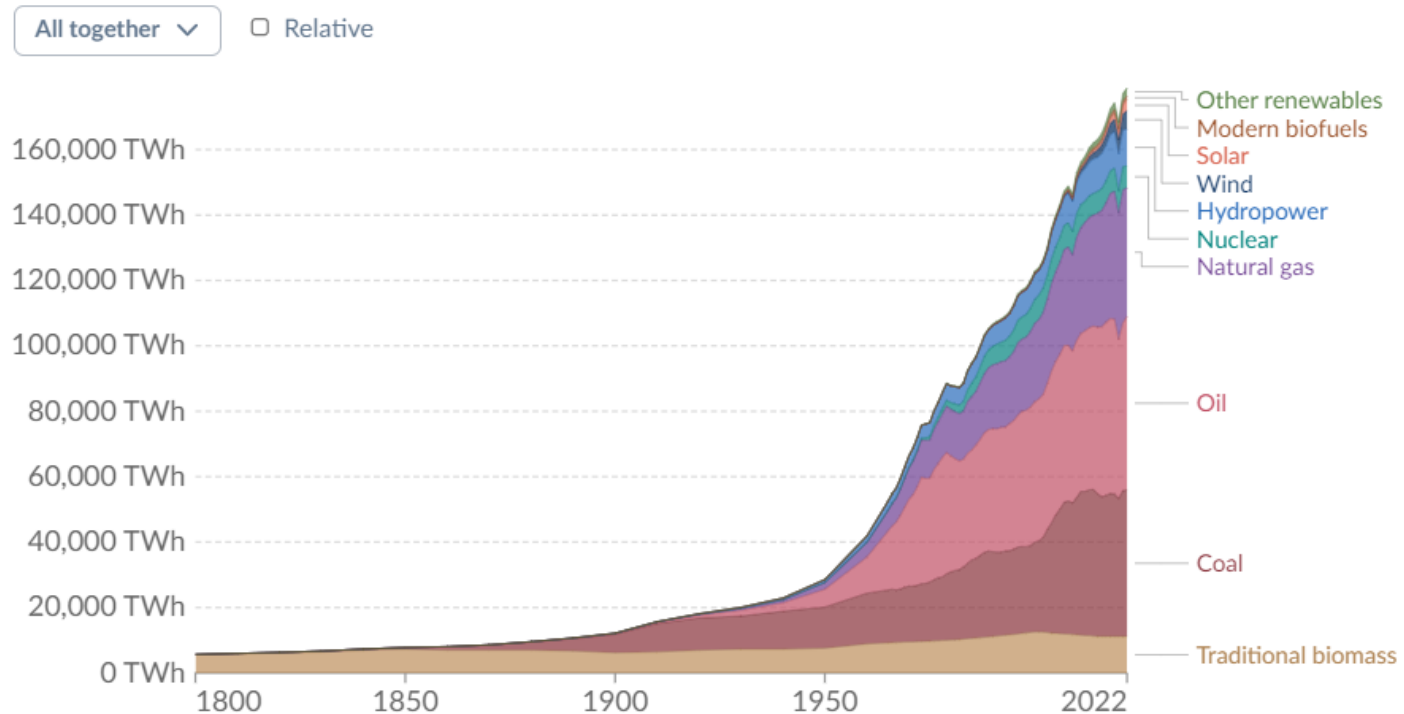
Or the different additions?

It seems that energy has been added on top of each other

Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

Our World
in Data



Source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)
OurWorldInData.org/energy • CC BY



Or even symbiosis / mutual reinforcement

The case with the automobile industry



Oil made cars possible



Cars need steel, which requires coal



Or even symbiosis / mutual reinforcement

Would it be the same with renewables?

Norway: World's biggest floating wind farm will power oil and gas platforms

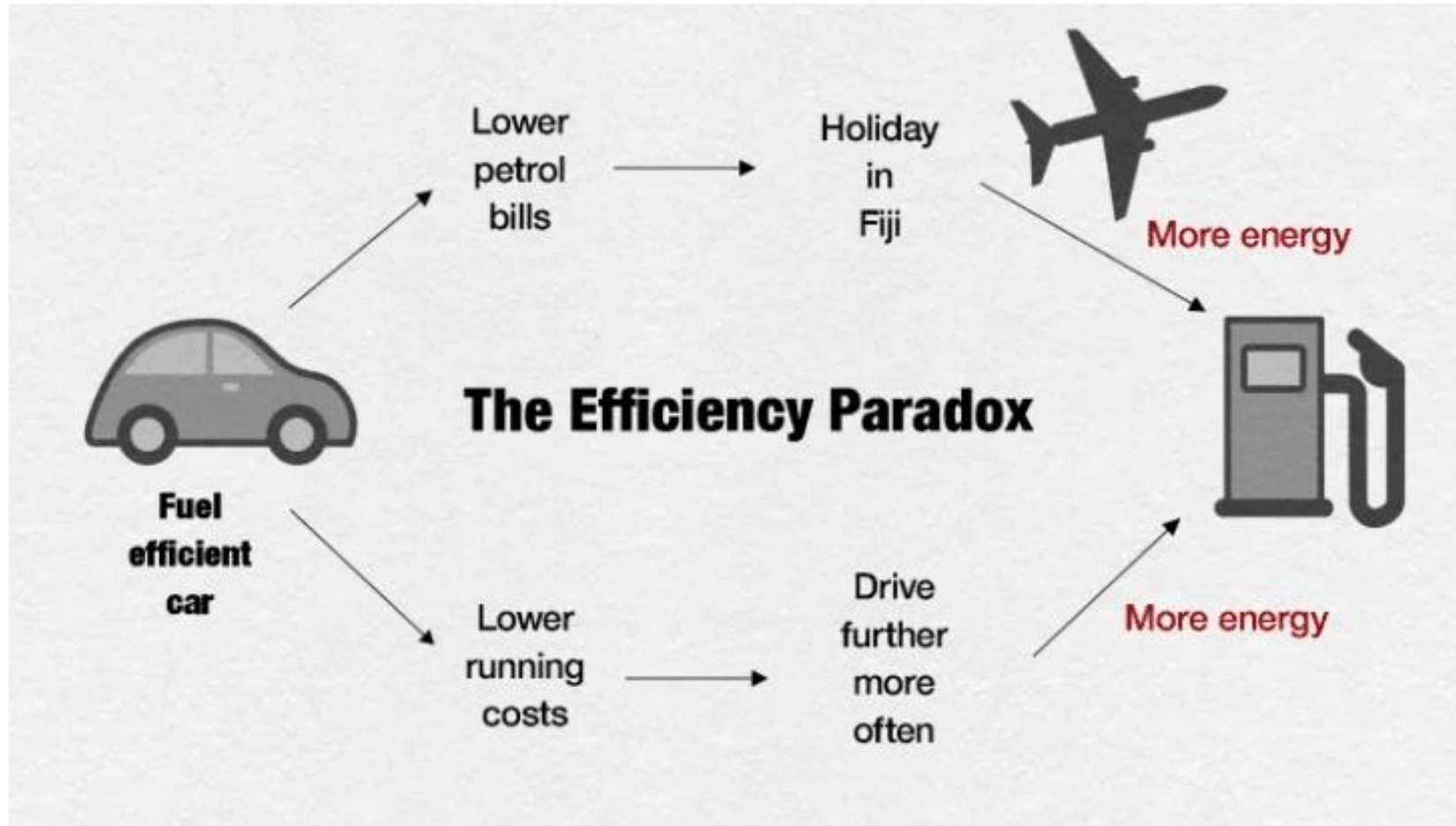


By [Lottie Limb](#) with Reuters

Published on 23/08/2023 - 18:00 • Updated 25/08/2023 - 15:43

The rebound effect / Javons paradox

Efficiency reduces energy cost, which contributes to increasing consumption.
The motor of socioeconomic development



<https://2030.builders/the-hidden-part-of-sustainability-rebound-effect/>

<https://gemenergyanalytics.substack.com>

Julien Jomaux

The rebound effect with renewables?

Renewables might also lead to a rebound effect

The image shows a screenshot of the Octopus Energy mobile application. At the top, there is a dark blue header with a 'Menu' icon on the left, the 'octopusenergy' logo in the center, and an 'Account' icon on the right. The main content area features a smartphone screen on the left displaying a message from Octopus Energy: 'Plunge pricing alert! You'll be paid for any electricity you use between 2:00-3:00am tonight'. A red circle highlights this message. To the right of the phone, a large white text overlay reads 'Introducing Agile Octopus' and 'The 100% green electricity tariff with Plunge Pricing', with a red circle around the latter. At the bottom right, there is a 'Works with IFTTT' logo and a 'Find out more' link.

Menu

octopusenergy

Account

16:00
Tuesday 20 February

MESSAGES

Octopus Energy
Plunge pricing alert!

You'll be paid for any electricity you use
between 2:00-3:00am tonight

Introducing Agile
Octopus

The 100% green electricity tariff with
Plunge Pricing

Works with
IFTTT

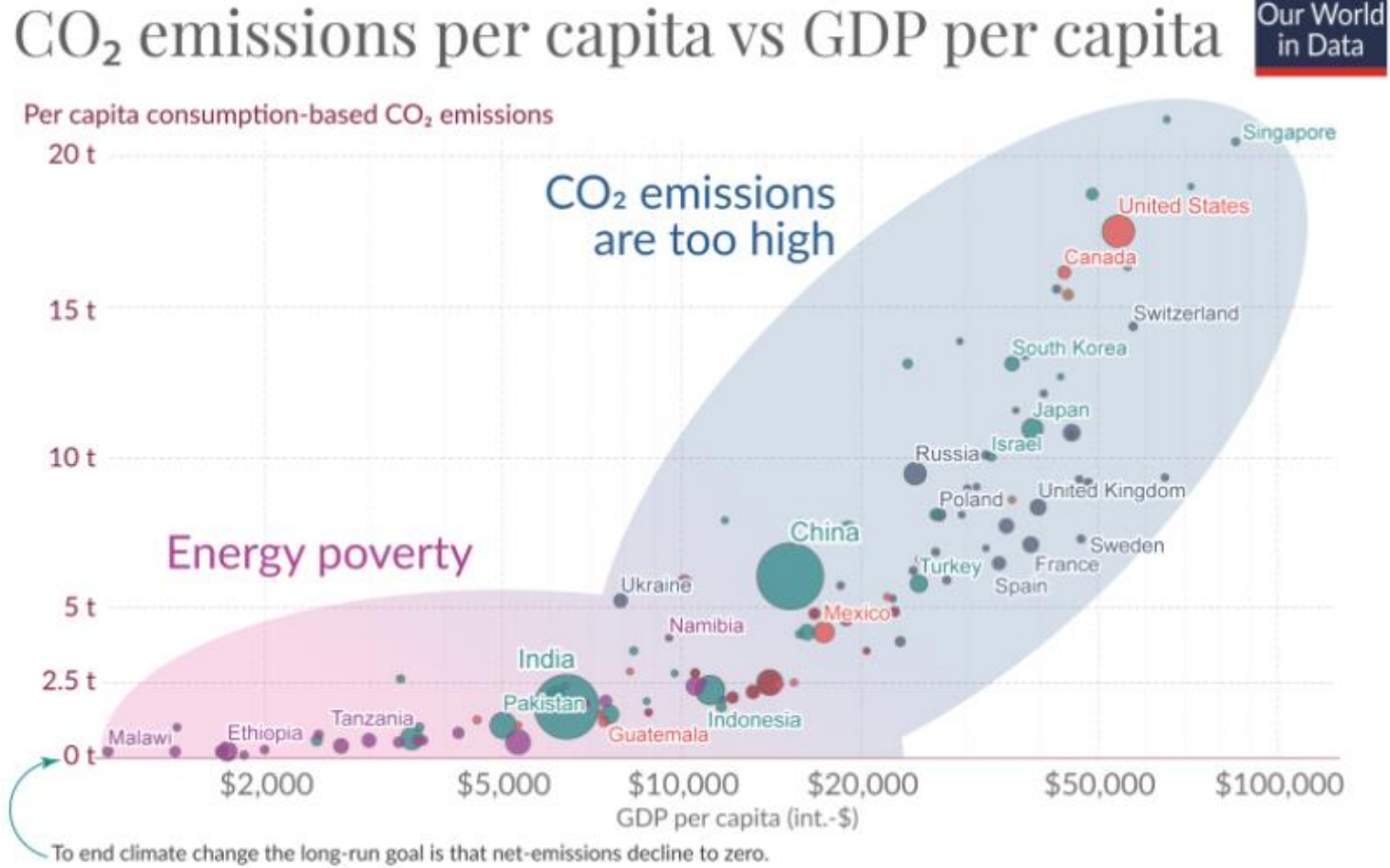
[Find out more](#)

Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

Two different issues

Energy poverty is still very much an issue



Data for 2017: Global Carbon Project, UN Population, and World Bank.

OurWorldinData.org - Research and data to make progress against the world's largest problems.

Licensed under CC-BY by the author Max Roser.

The world is unequal

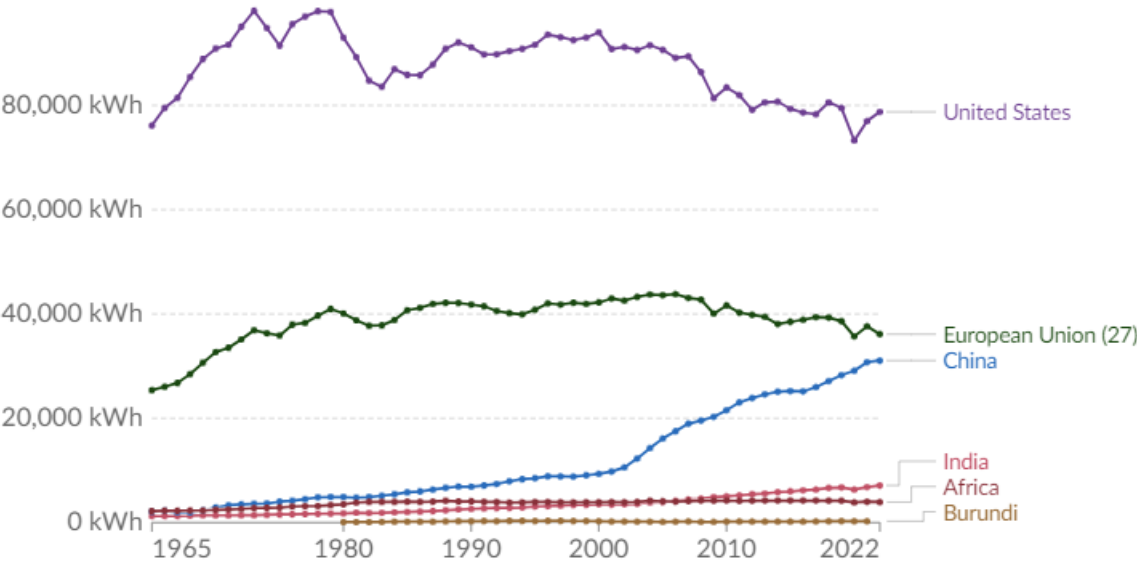
A person in the USA consumes 262 times more than one in Burundi

Energy use per person

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



+ Add country or region All together



2021 in kilowatt-hours per capita

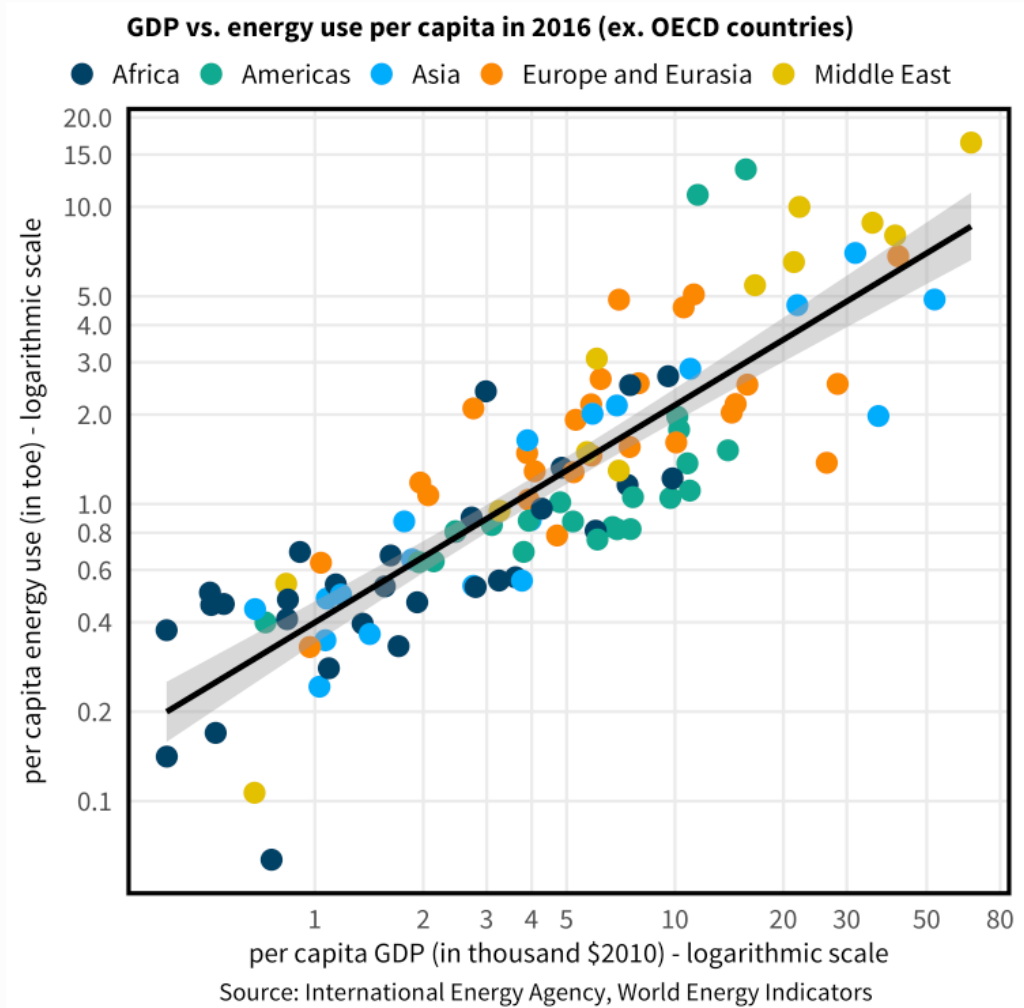
United States	76,989 kWh
European Union (27)	37,624 kWh
China	30,769 kWh
India	6,810 kWh
Africa	4,027 kWh
Burundi	294 kWh

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).
OurWorldInData.org/energy • CC BY



GDP vs Energy Use

The link is very strong



<https://www.csis.org/analysis/energy-and-growth-exploring-nuanced-relationship>

Energy Poverty

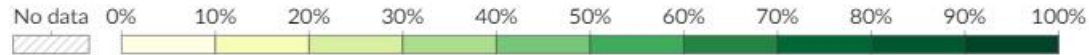
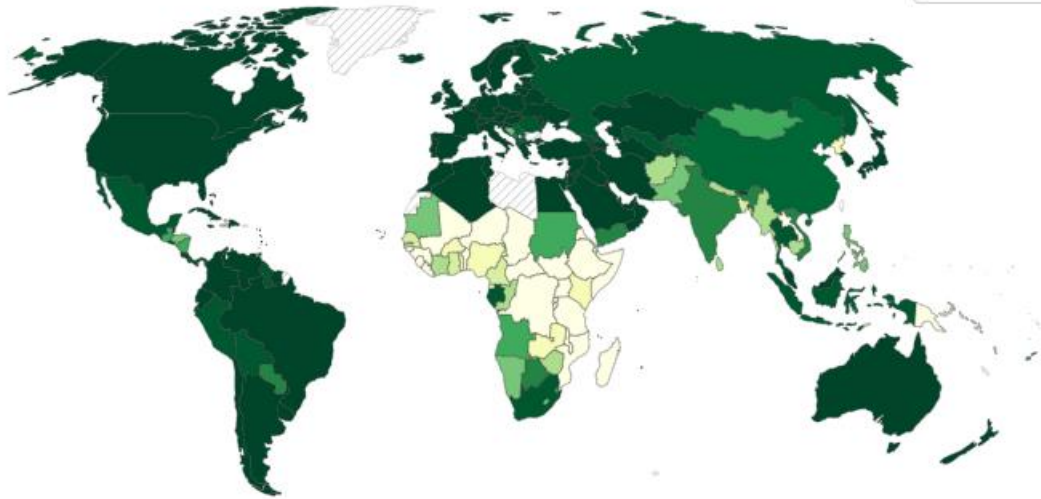
Access to electricity and clean cooking

Share of the population with access to clean fuels for cooking, 2020

Access to clean fuels or technologies such as natural gas, electricity, and clean cookstoves reduce exposure to indoor air pollutants, a leading cause of death in low-income households.

Our World in Data

World



Source: WHO, Global Health Observatory (2022)

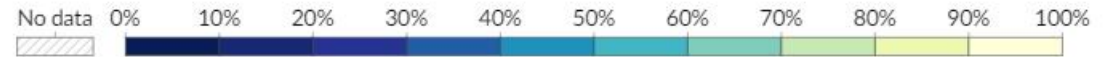
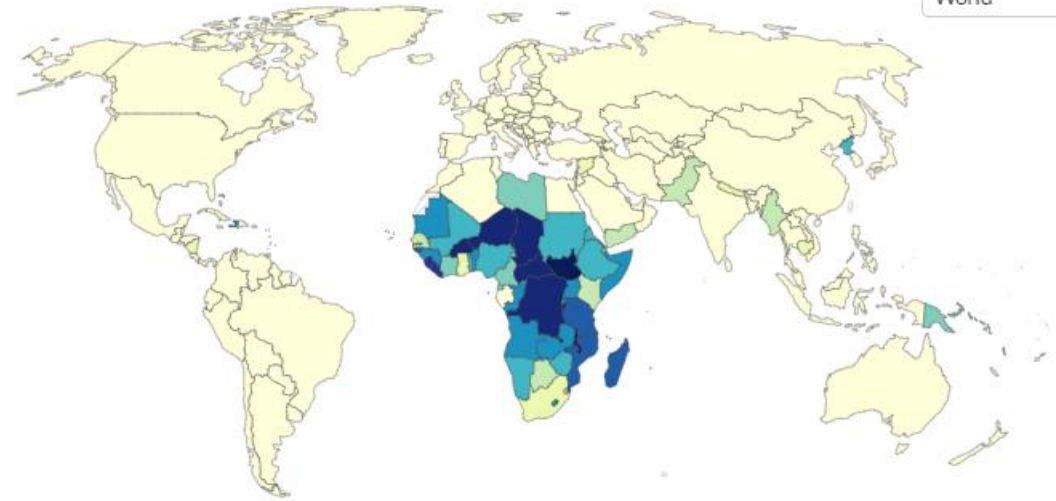
OurWorldInData.org/energy • CC BY

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.

Our World in Data

World



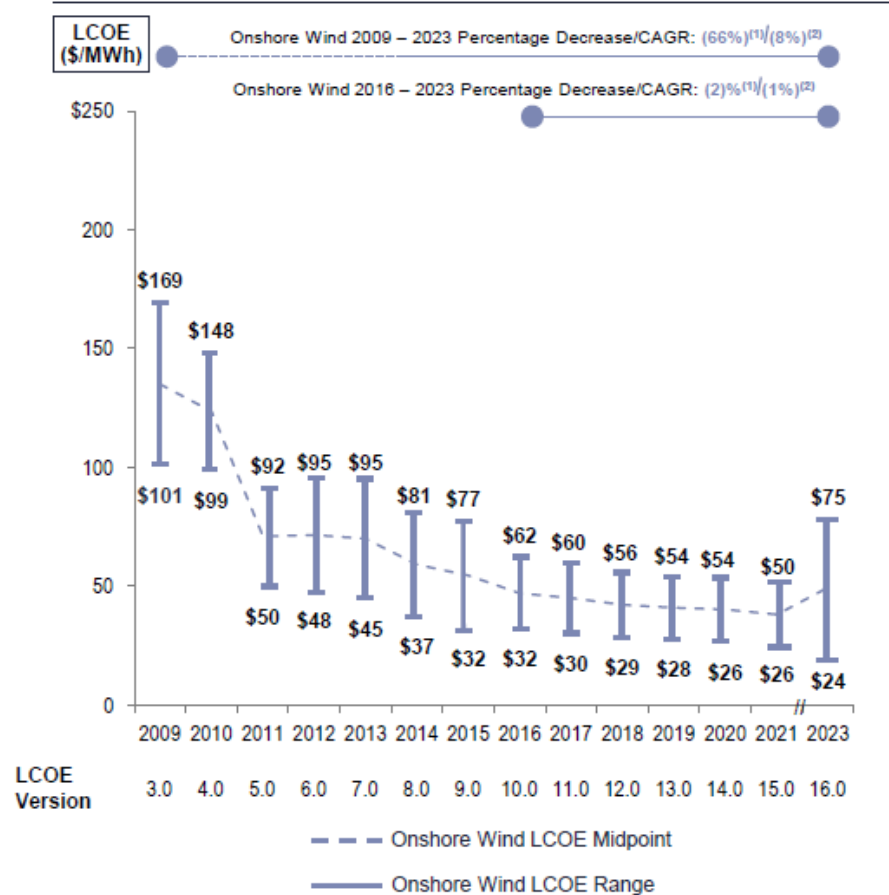
Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

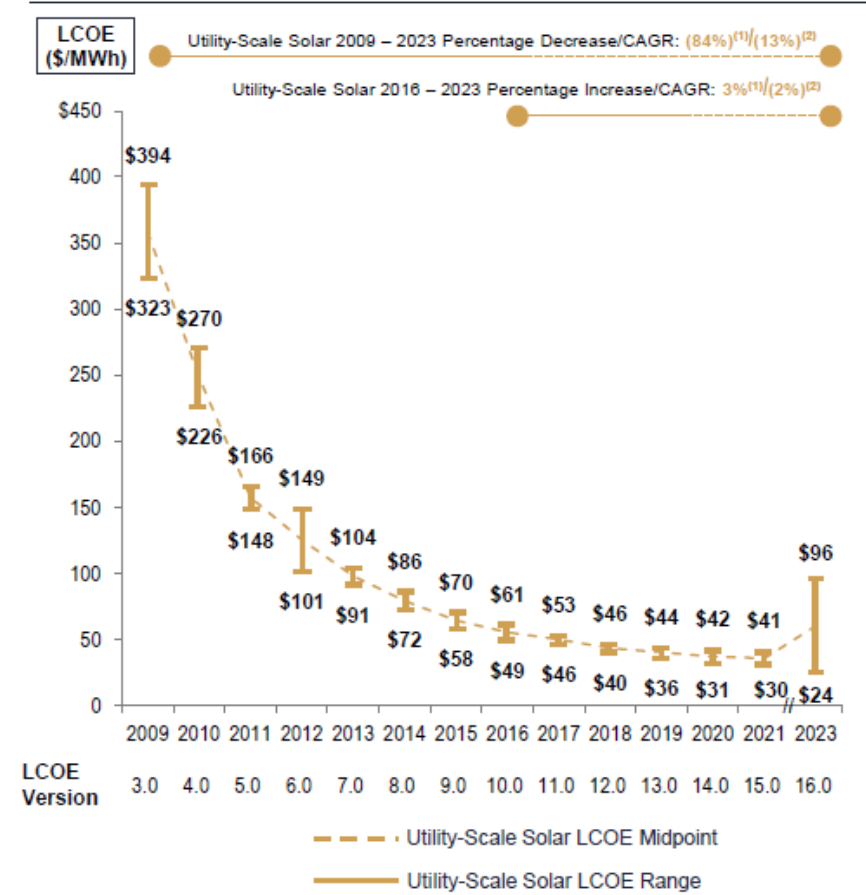
Wind and solar are getting cheaper

Even though there has been a small uptick recently

Unsubsidized Onshore Wind LCOE

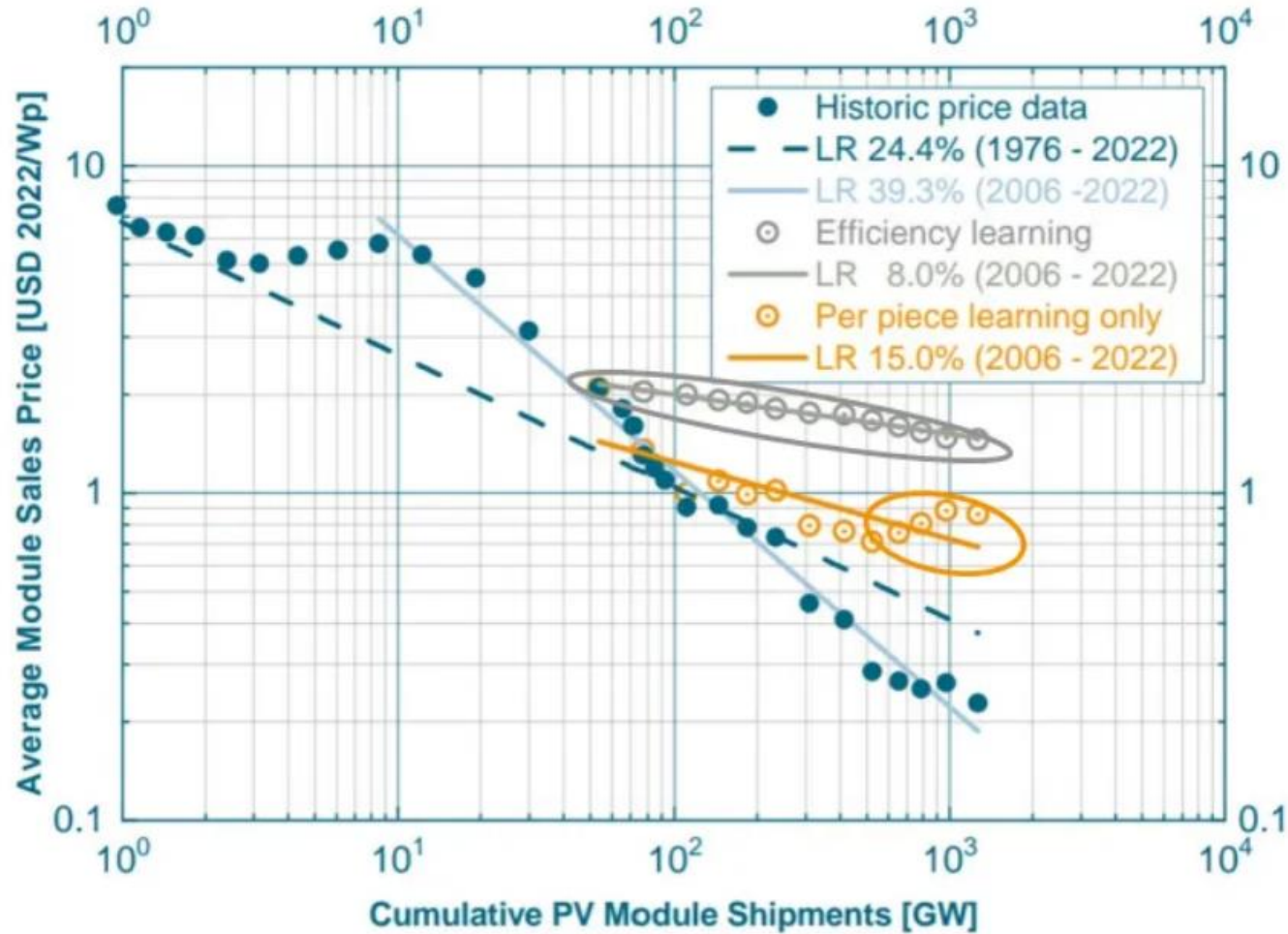


Unsubsidized Solar PV LCOE



Solar is leading

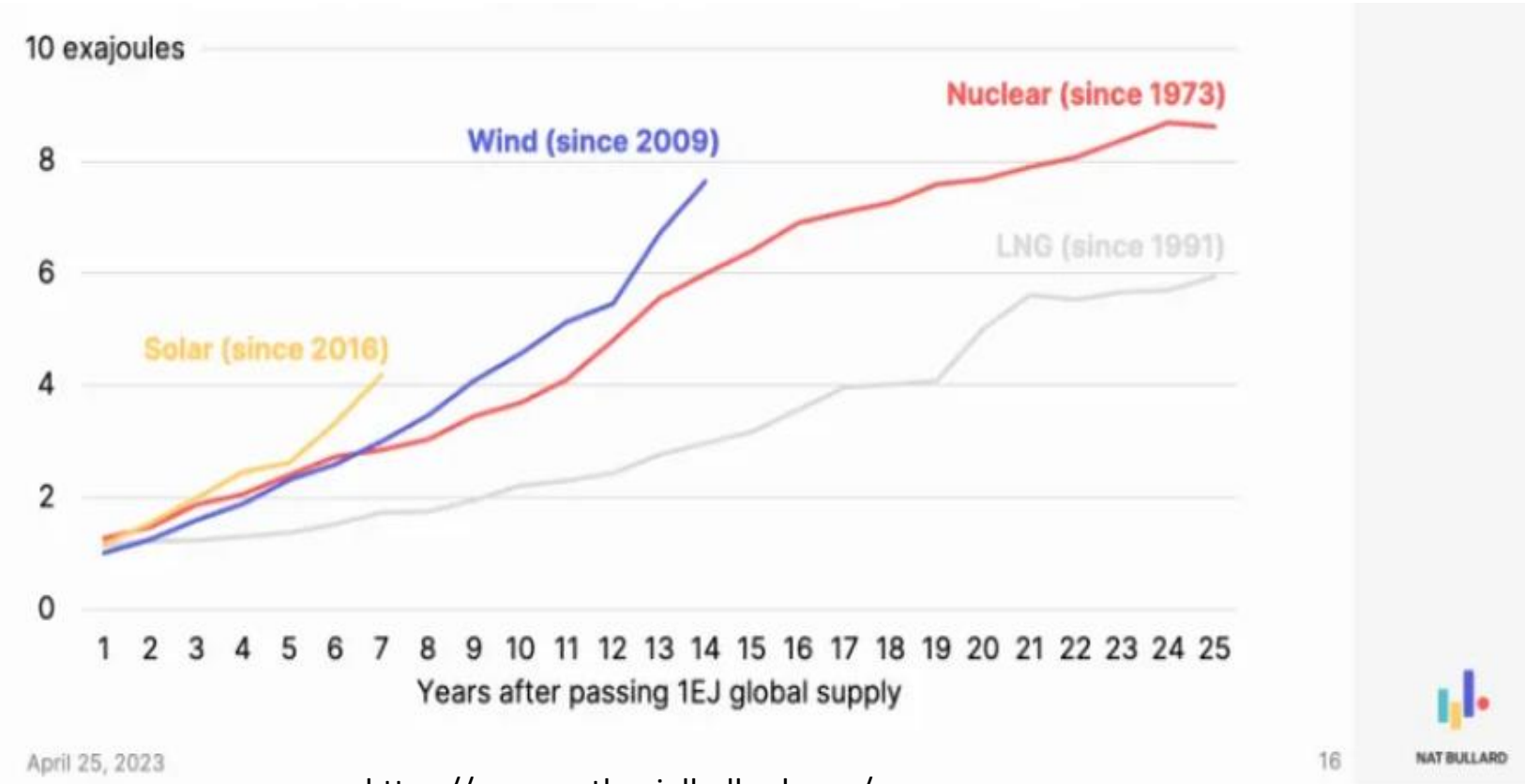
Solar modules cost only 1% of what they used to cost 30 years ago



<https://www.vdma.org/international-technology-roadmap-photovoltaic>

Solar is leading

Solar is being deployed at an unprecedented speed

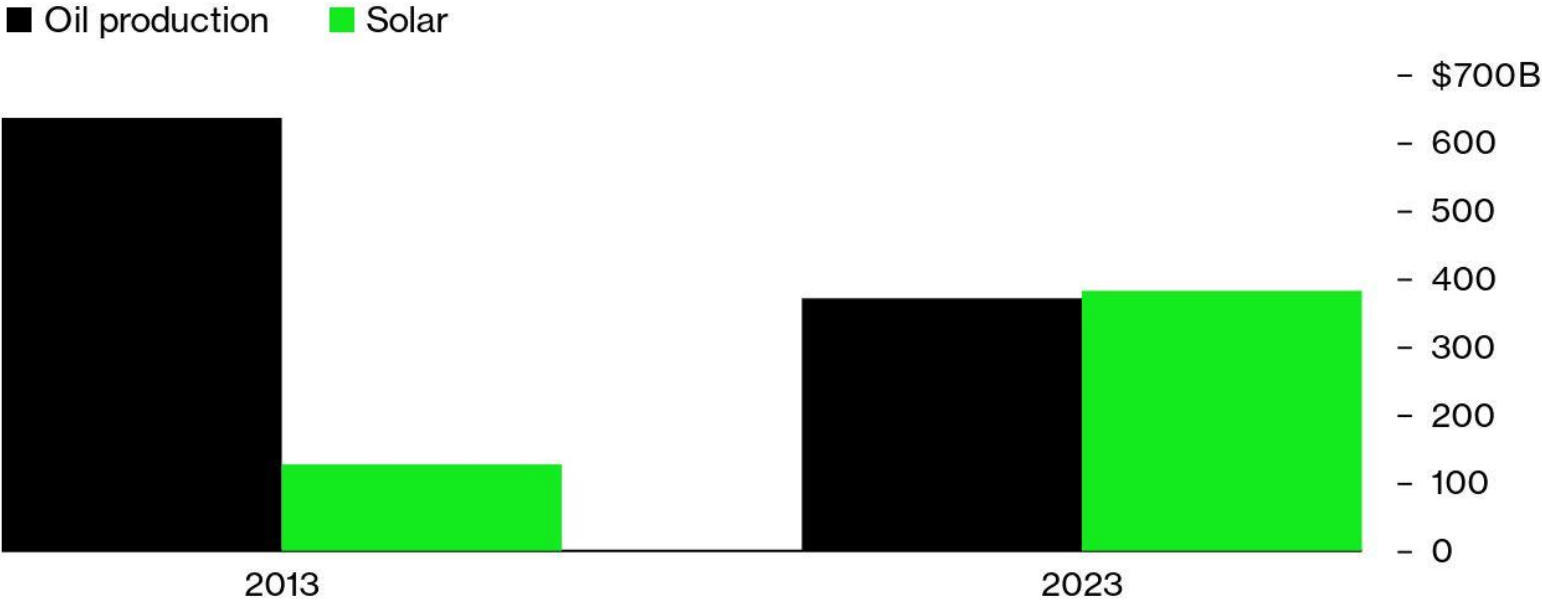


Solar is leading

Investment in solar is overtaking oil production spending in 2023

Solar Investment Will Overtake Oil Production Spending This Year

International Energy Agency data show solar investment surge while oil production spending dropped in the last decade

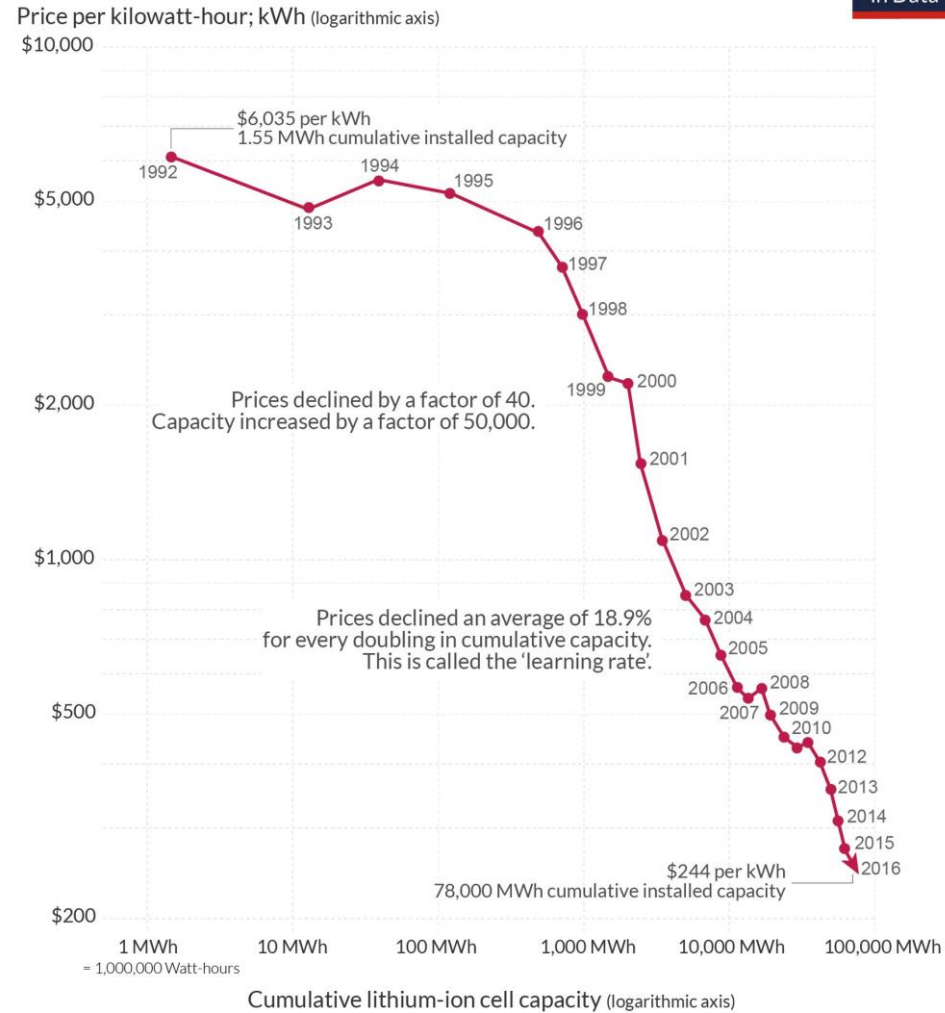


Source: IEA
Note: 2023 data are estimates



Batteries are getting cheaper

Price and market size of lithium-ion batteries since 1992



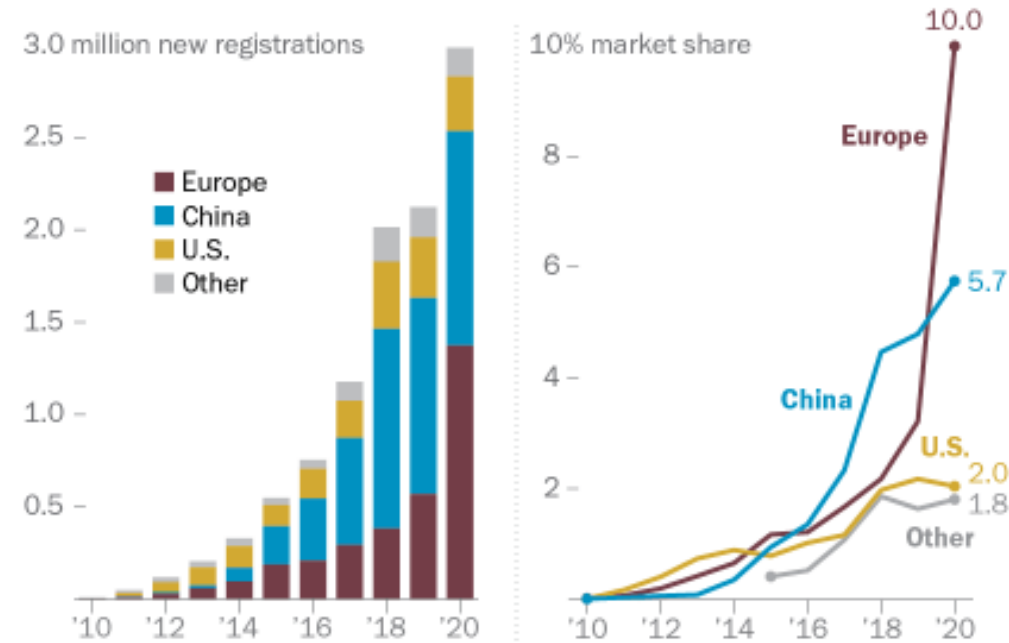
Prices are adjusted for inflation and given in 2018 US-\$ per kilowatt-hour (kWh).
Source: Micah Ziegler and Jessica Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.
OurWorldinData.org - Research and data to make progress against the world's largest problems. Licensed under CC-BY by the author Hannah Ritchie.

Electric Vehicles

More and more on the road

Europe leads the way in new electric vehicle sales

New global electric car registrations and automobile market share, 2010-2020



Note: Electric car totals include all-electric, plug-in hybrid and fuel cell vehicles. "Europe" includes the 27 nations in the EU, plus Iceland, Norway, Switzerland and the UK. "Other" includes Australia, Brazil, Canada, Chile, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, South Africa, South Korea and Thailand. Source: International Energy Agency, "Global EV Outlook 2021."

PEW RESEARCH CENTER

Heat pumps

An important tool for the electrification of heating



<https://notesfrompoland.com/2023/04/28/heat-pumps-boom-in-poland-europes-fastest-growing-market/>

<https://gemenergyanalytics.substack.com>

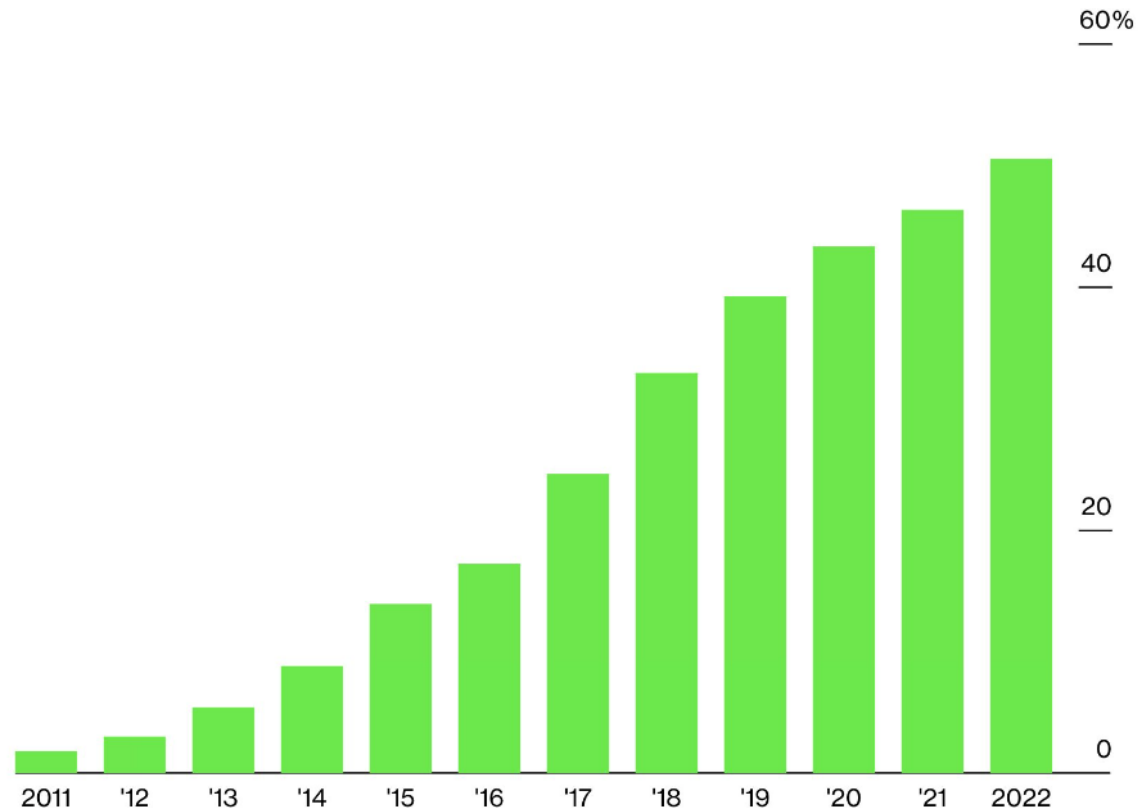
Julien Jomaux

Lighting

We are increasingly using LED for lighting

LED Share of Global Residential Lighting Sales

LEDs accounted for 1% of sales in 2010; they made up more than 50% in 2022



Source: International Energy Agency

<https://www.nathanielbullard.com/>

<https://gemenergyanalytics.substack.com>

Julien Jomaux

Economy is decoupling from CO2

GDP is growing faster than CO2 emissions

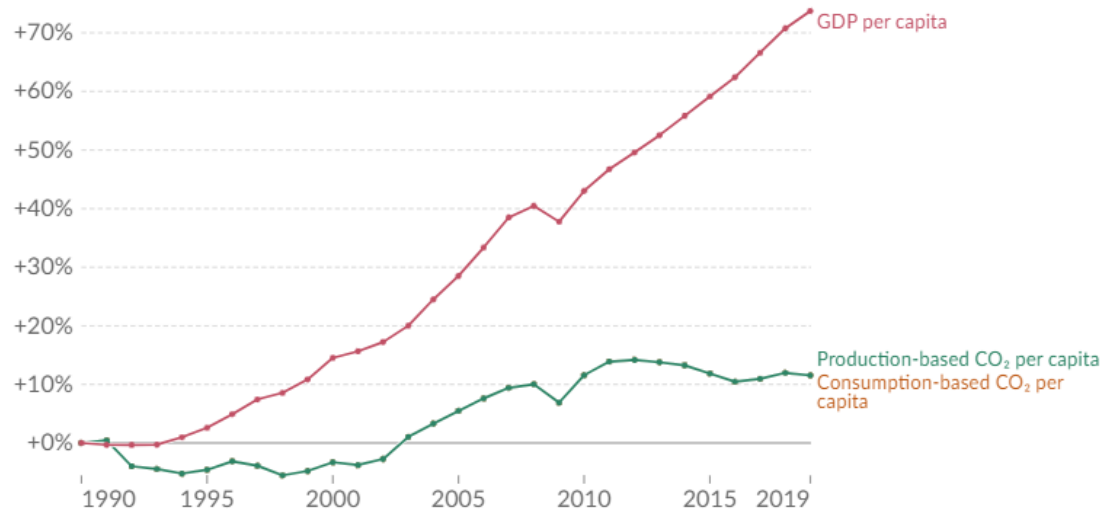
Change in per capita CO2 emissions and GDP, World

Consumption-based emissions are national emissions that have been adjusted for trade. This measures fossil fuel and industry emissions. Land use change is not included.

Our World in Data

↔ Change country or region

All together ▾



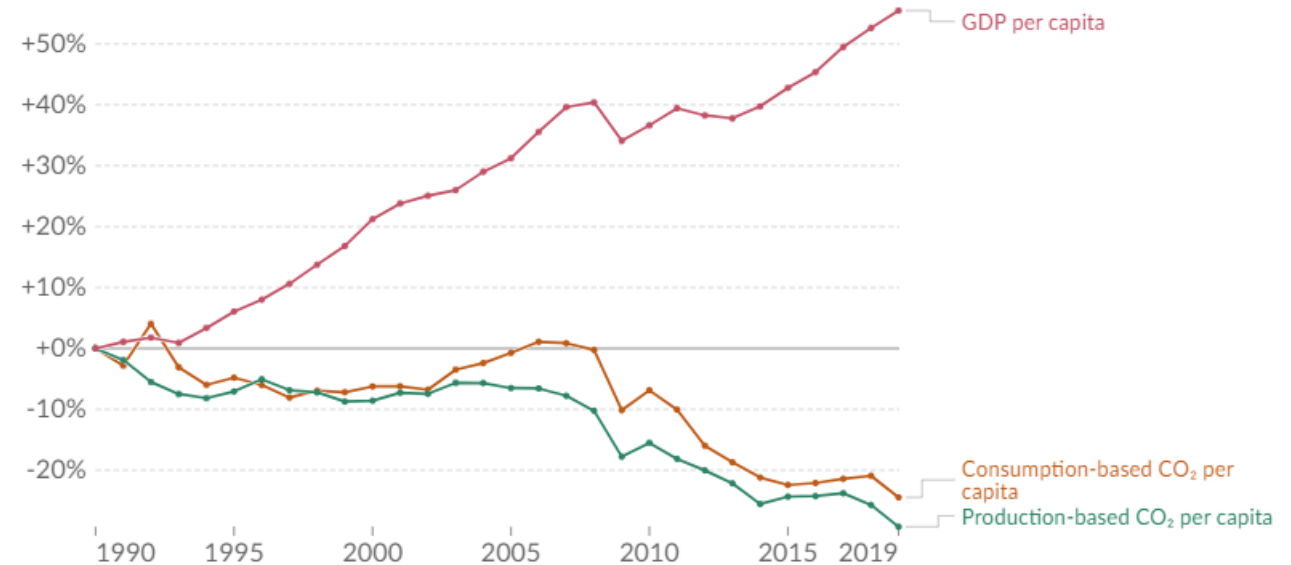
Change in per capita CO2 emissions and GDP, European Union (27)

Consumption-based emissions are national emissions that have been adjusted for trade. This measures fossil fuel and industry emissions. Land use change is not included.

Our World in Data

↔ Change country or region

All together ▾



Source: Data compiled from multiple sources by World Bank, Global Carbon Budget (2022); Gapminder (2022); UN (2022); HYDE (2017); Gapminder (Systema Globalis)

Note: GDP figures are adjusted for inflation.

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

Electricity is the best form of energy

No need to replace all the primary energy

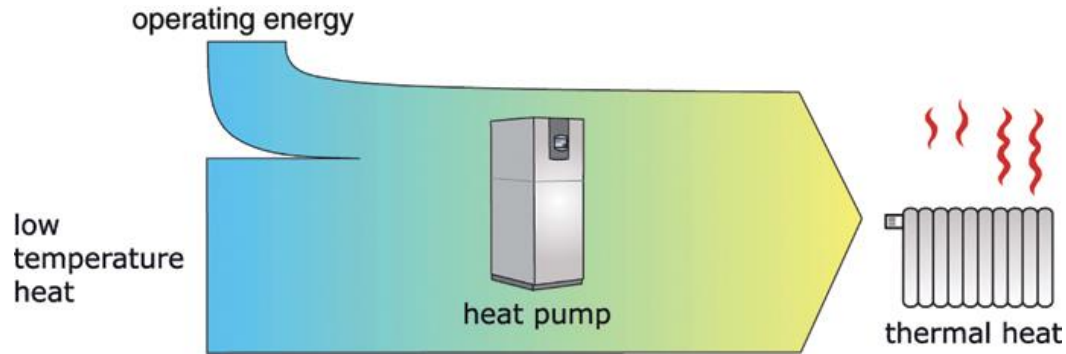
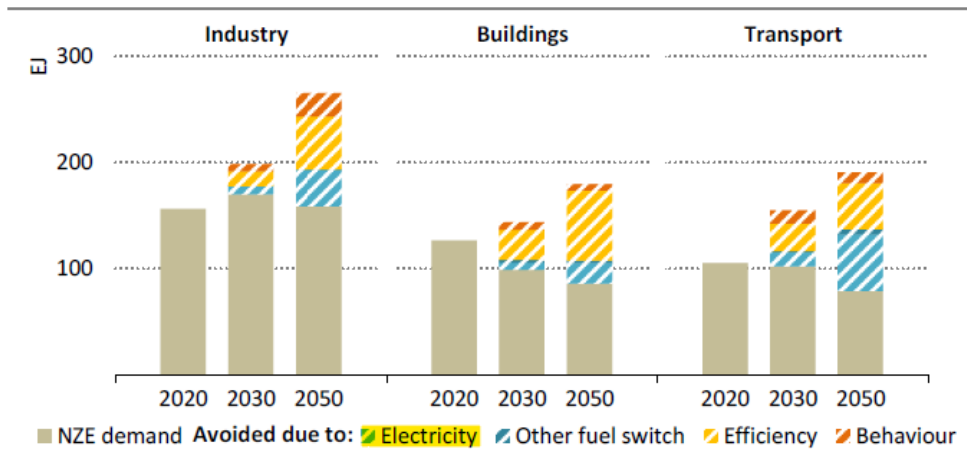
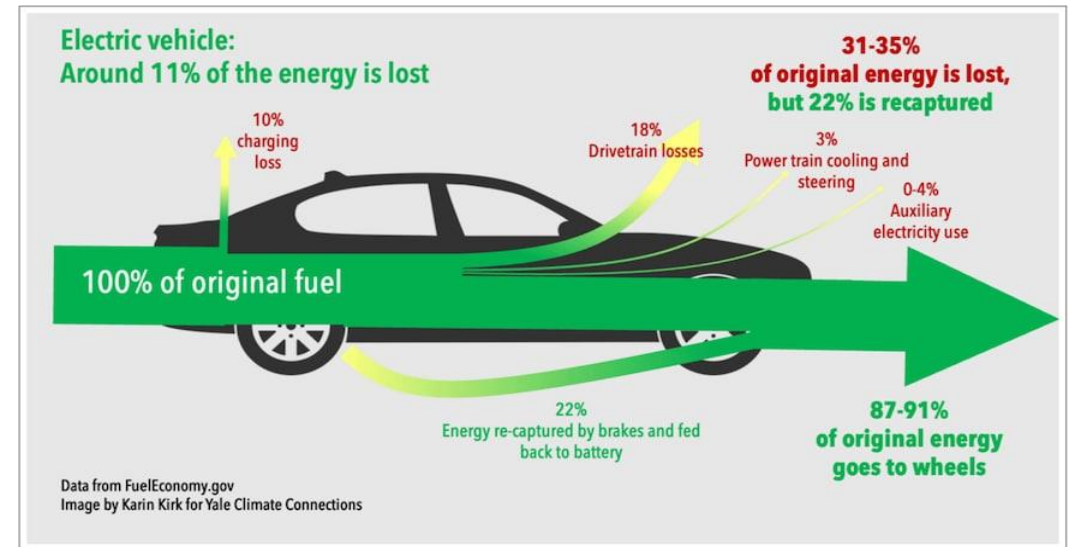
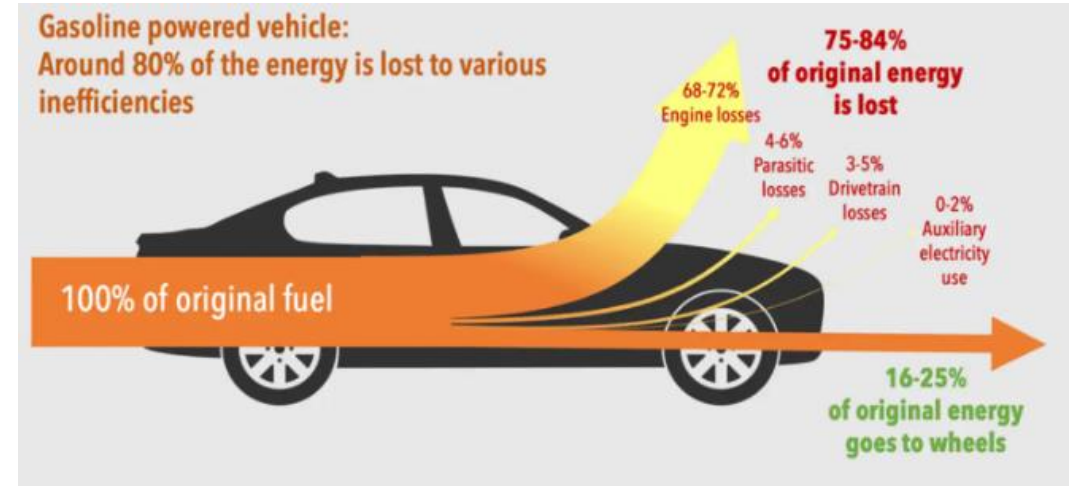


Figure 2.13 ▸ Total final consumption and demand avoided by mitigation measure in the NZE



IEA. All rights reserved.

Energy efficiency plays a key role in reducing energy consumption across end-use sectors



<https://www.motortrend.com/news/evs-more-efficient-than-internal-combustion-engines/>

Behavioural change

People could have an impact

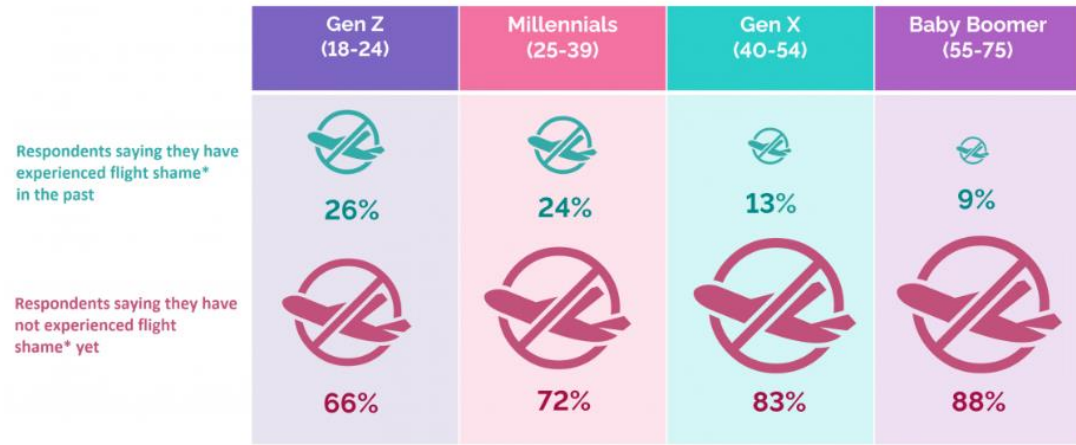


2015
2021

Maastricht, NL
@cars.destroyed.our.cities



Flight shame - media hype or a traveller's reality?

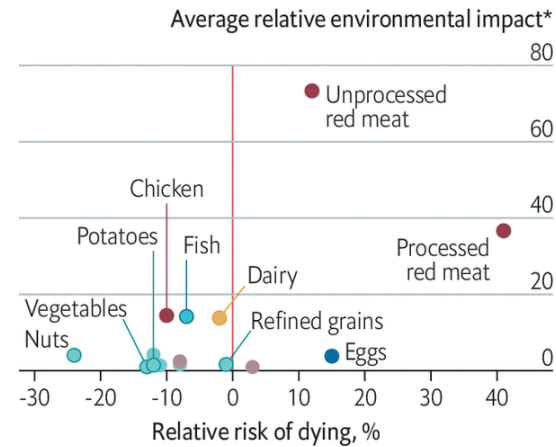


*Flight shame is defined as a feeling of shame for using aeroplanes as a means of transportation, as environmental organisations seek to convince people to avoid flying

<https://www.cleanenergywire.org/news/sustainable-travel-and-flying-shame-growing-concerns-germans-survey>

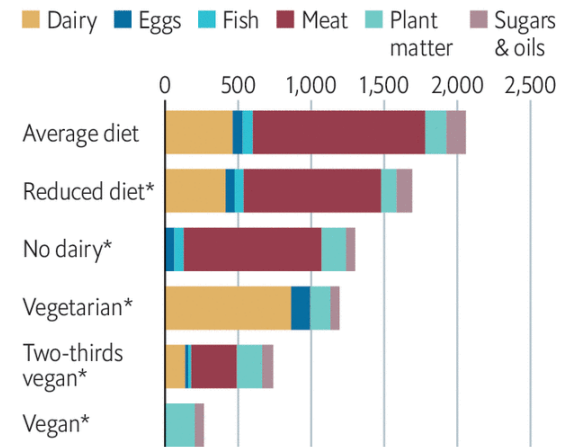
High-steak diets

Health and environmental impact of one extra serving per day



Sources: "Multiple health and environmental impacts of foods", by Clark et al., PNAS; "Country-specific dietary shifts to mitigate climate and water crises", by Kim et al., Global Environmental Change

United States, greenhouse-gas footprint kg of CO₂ equivalent per person per year



*Vegetables=1 †Simulated diet, to reach 2,300 calories per day

The Economist

<https://gemenergyanalytics.substack.com>

Julien Jomiaux

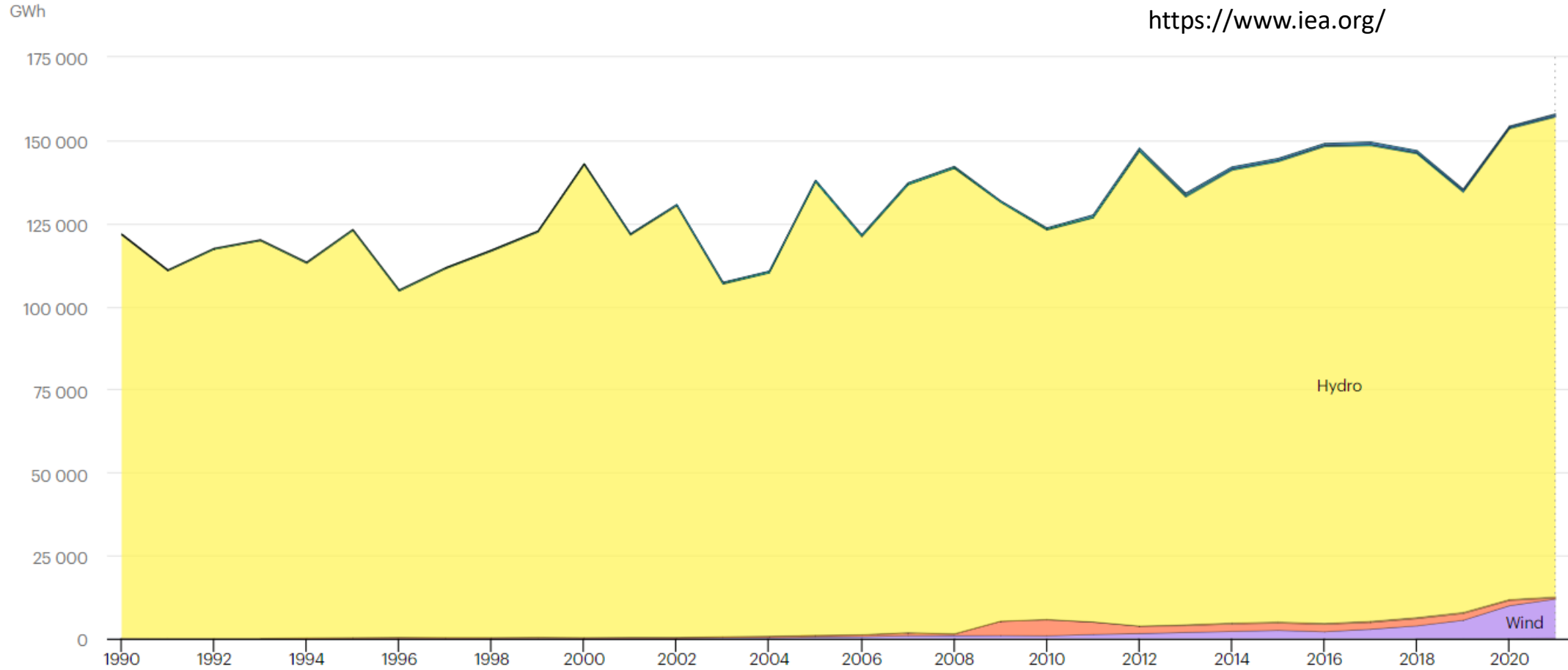
Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

Norway

Hydro country: decarbonized electricity

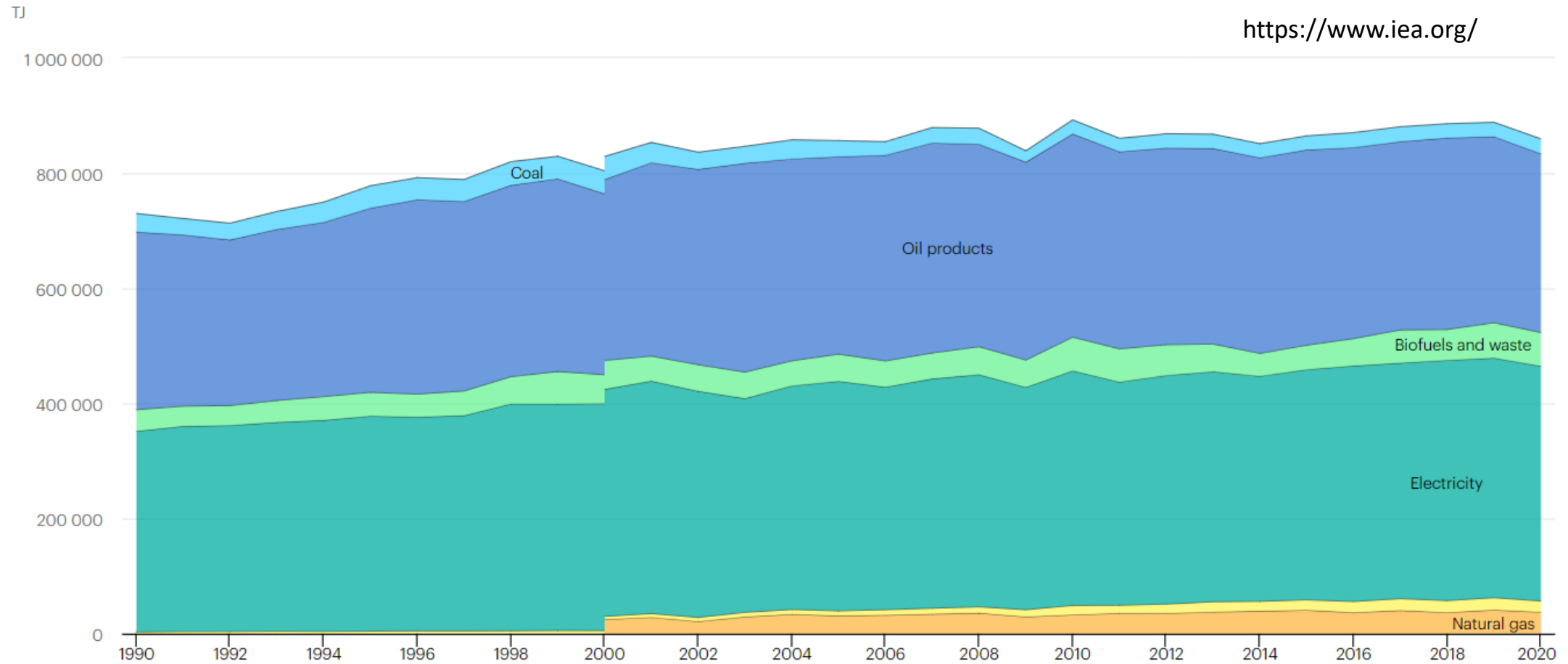
Electricity generation by source, Norway 1990-2021



Norway

Final consumption: still a lot of oil

Total final consumption (TFC) by source, Norway 1990-2020

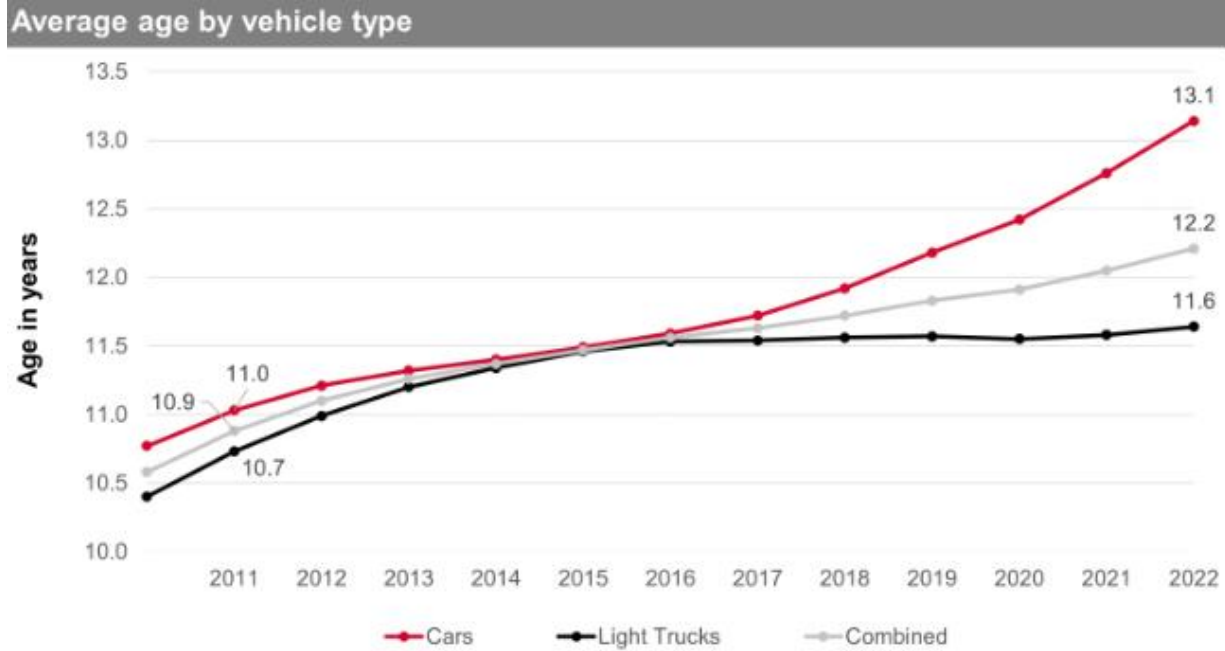


<https://gemenergyanalytics.substack.com>

Julien Jomaux

Norway

Mobility: slow process



Note: Data as on January 1 of each year
Source: S&P Global Mobility

© 2022 S&P Global Mobility

December 13, 2022 05:18 AM

EVs now make up 20% of Norway's cars

EVs now make up 20 percent of Norway's cars after doubling their share in three years.

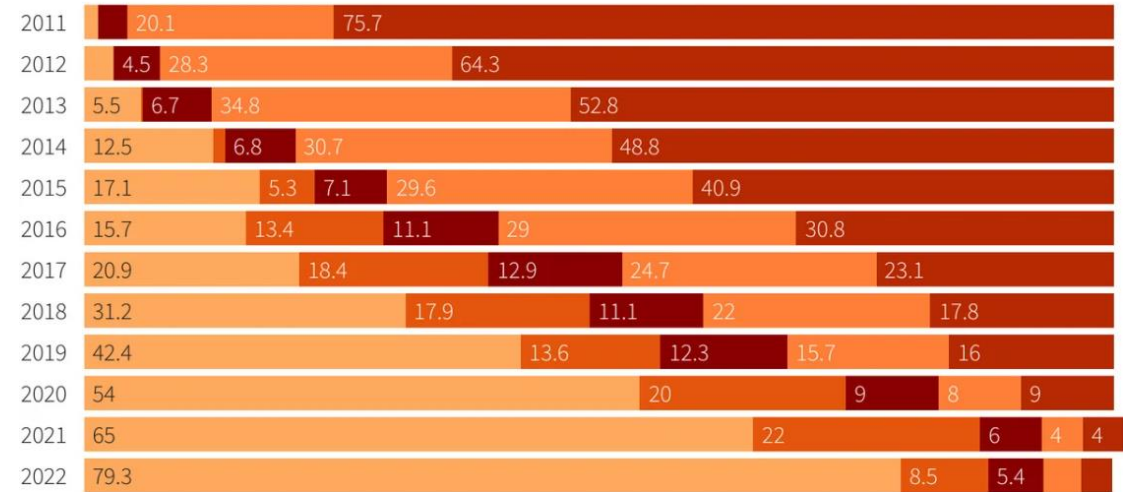
<https://gemenergyanalytics.substack.com>

Julien Jomaux

Norway new car sales

Years 2011-2022 in percentage of market per car type

● Electric ● Plug-in hybrid ● Non-plug hybrid ● Petrol only ● Diesel only

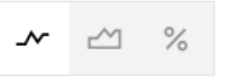


Source: Norwegian Road Federation (OFV) | Reuters, Jan 2, 2022 | By Victoria Klesty

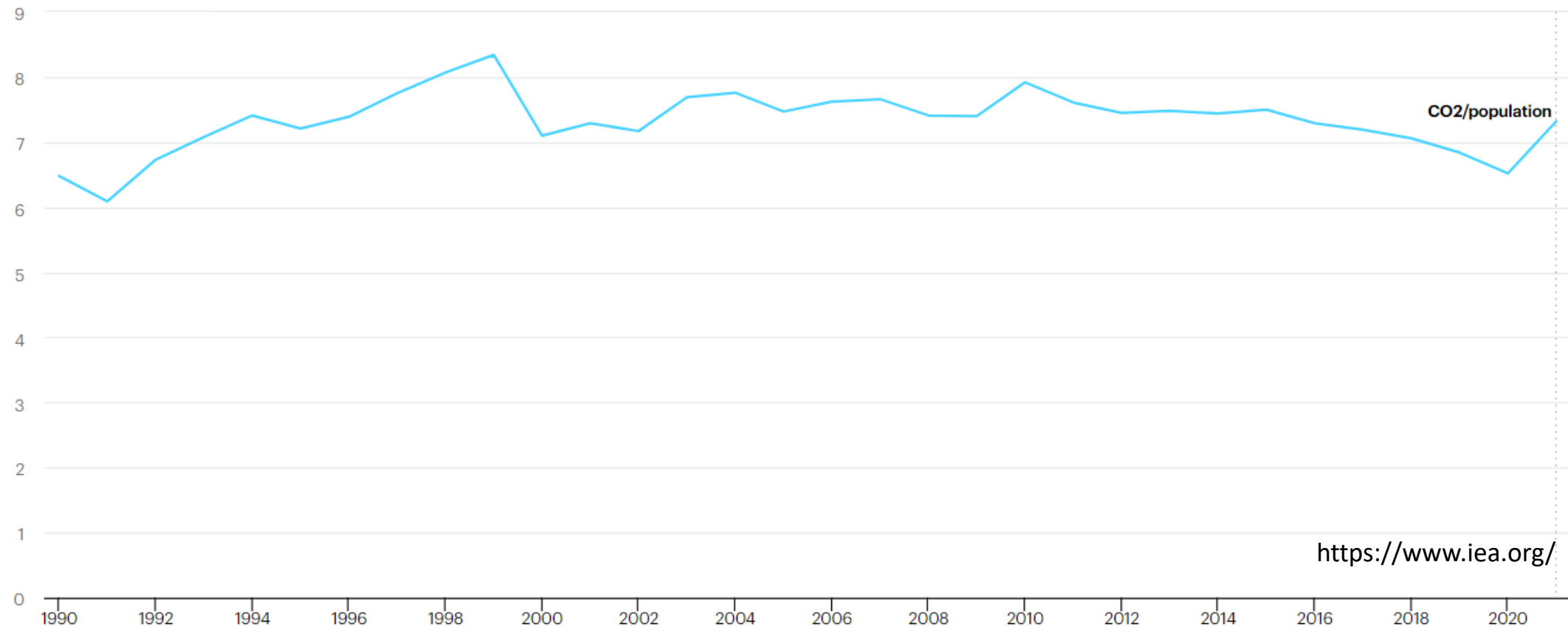
Norway

CO2 emissions per capita: around 7t CO2 (France is at 4.2)

CO2 emissions per capita, Norway 1990-2021



t CO2/capita



<https://www.iea.org/>

Norway

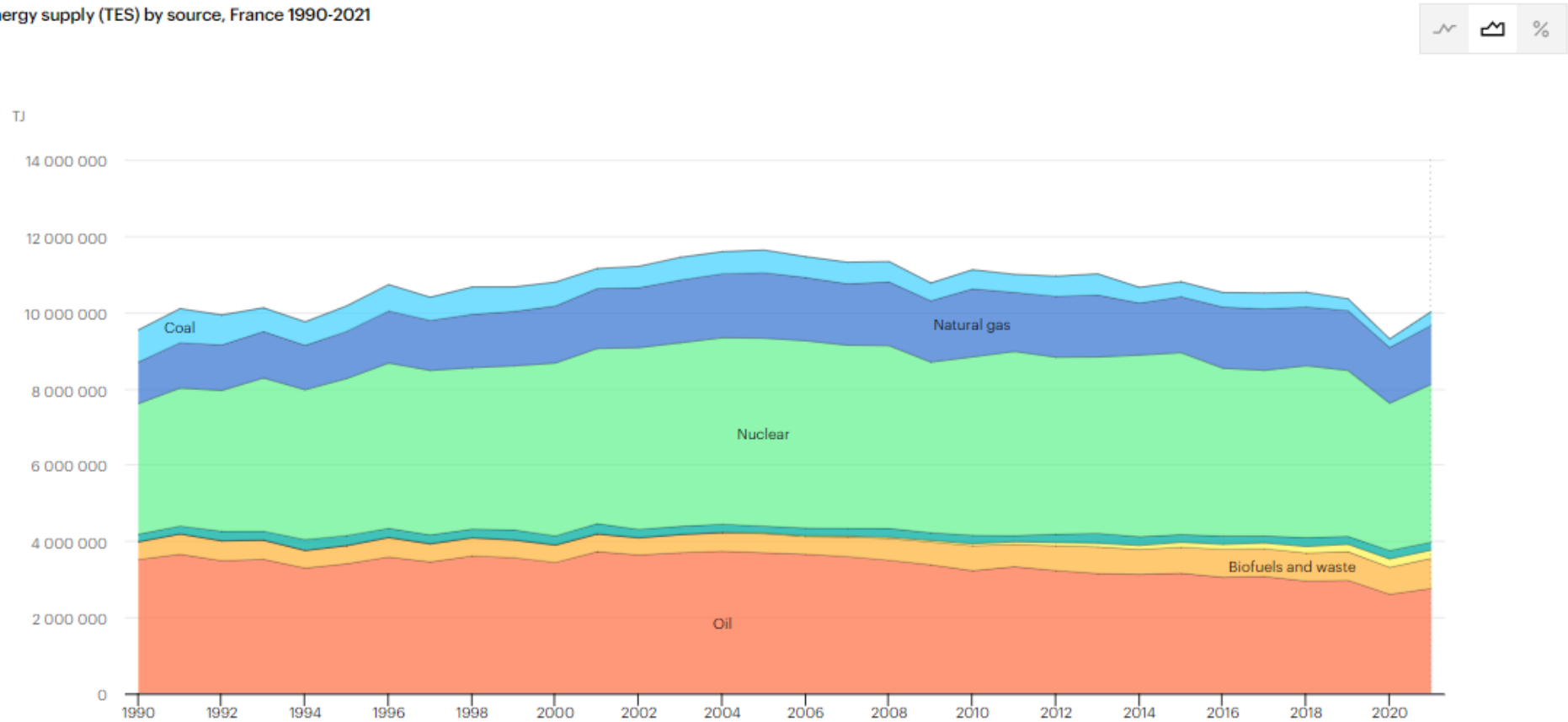
Some conclusions

- Some countries with hydro potential have already decarbonized their electricity grid.
→ Potential for green energy (=geography) plays an important role.
- Decarbonization of the electricity sector is only part of the problem
→ Electricity is the easiest.
- Decarbonization of the transportation sector is relatively slow
→ Major different between the flux (= the sale of EV) and the stock (the fleet).

France

CO2 emissions per capita: around 7t CO2 (France is at 4.2)

Total energy supply (TES) by source, France 1990-2021

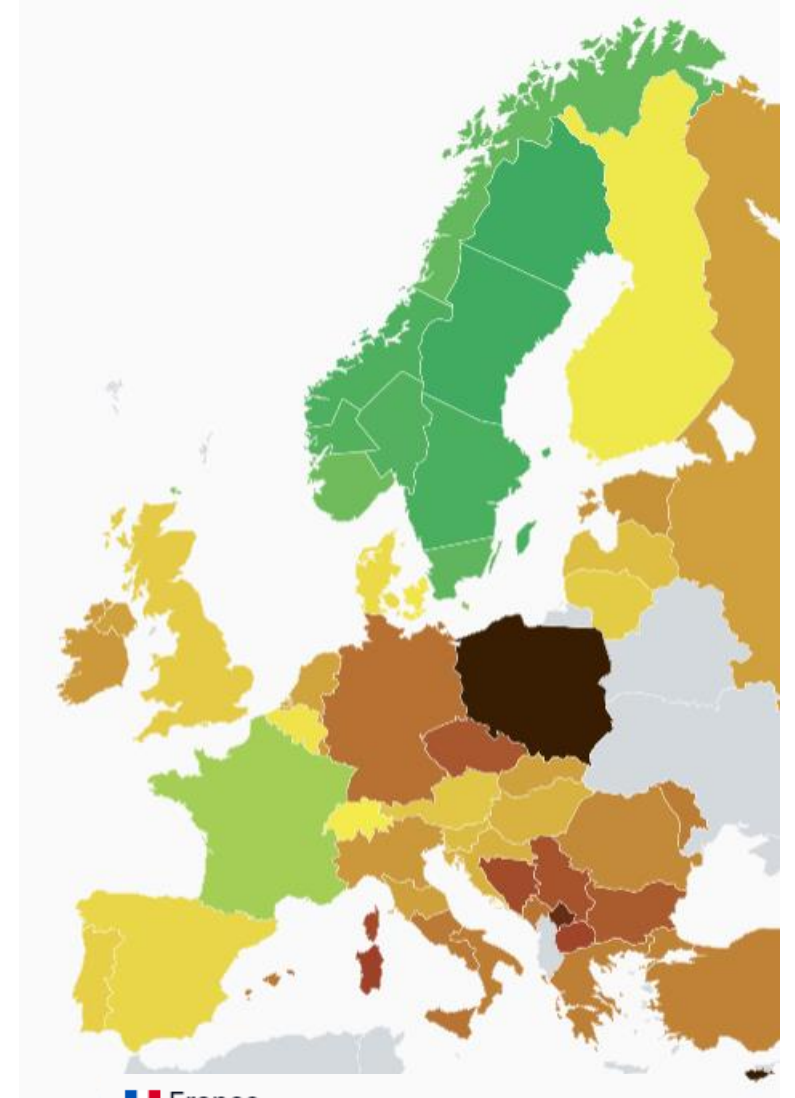
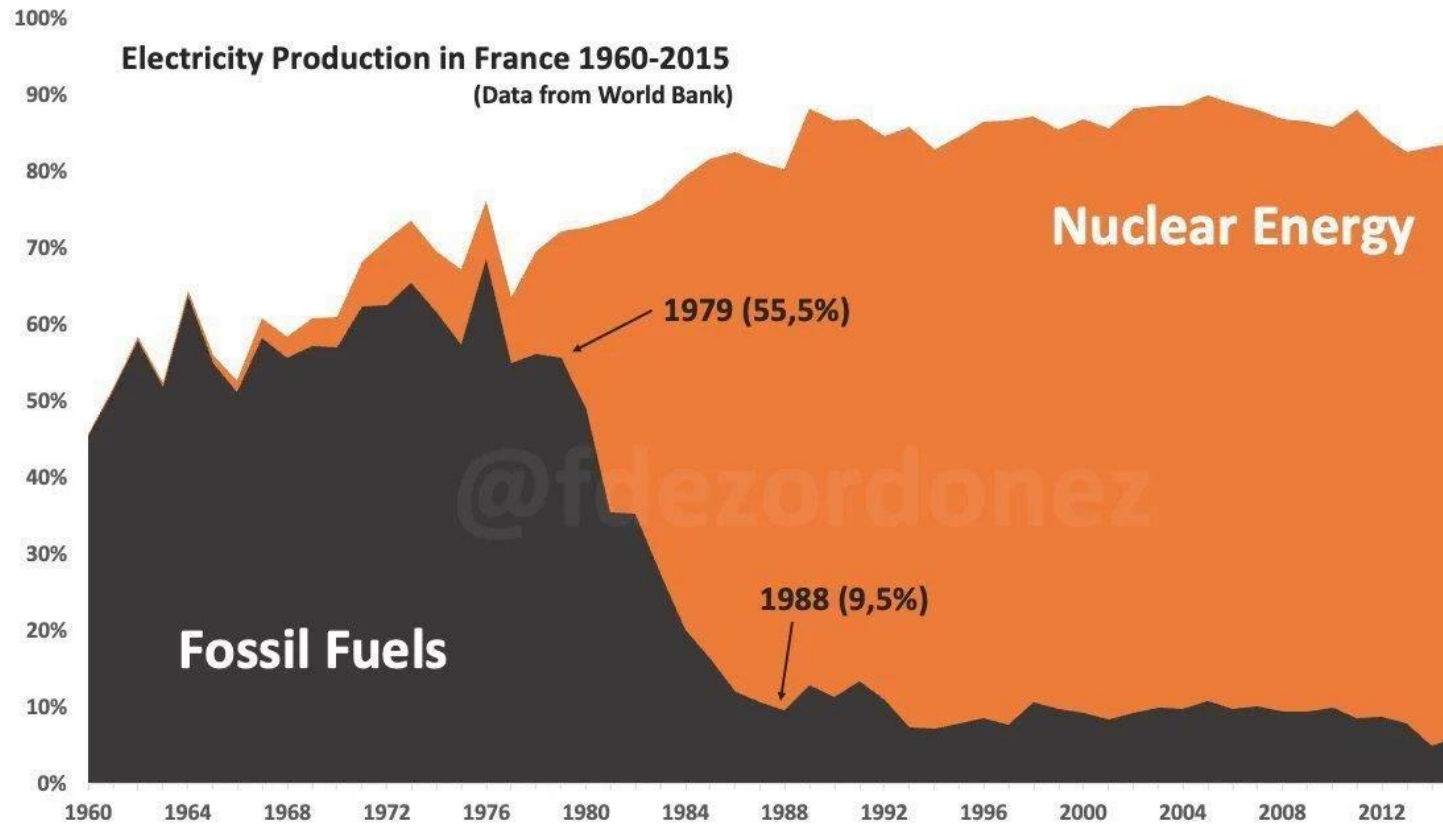


<https://www.iea.org/>

IEA. All rights reserved.

France

Nuclear is low-carbon

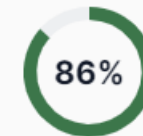


France
2022

<https://app.electricitymaps.com/>



Intensité
carbone



Bas
carbone



Renouvelable

<https://gemenergyanalytics.substack.com>

Julien Jomaux

France

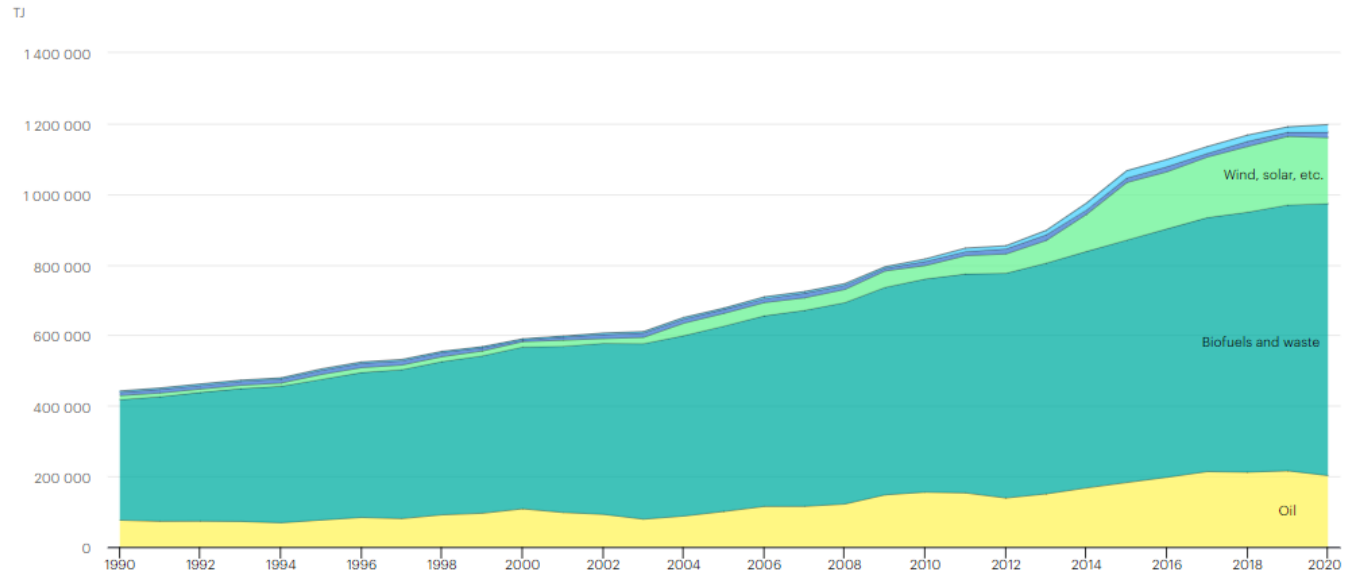
Some conclusions

- Nuclear provides decarbonized power. Of course, nuclear is not cheap.
→ Nuclear could be a way to decarbonize electricity generation.
- Electricity is not energy
→ We consume a lot of fossil fuels directly (cars, heating, industry). Not only as energy but also a feedstock (plastics, fertilizers).

Kenya

Energy supply still dominated by biofuels

Total energy supply (TES) by source, Kenya 1990-2020



IEA. All rights reserved.

● Coal ● Hydro ● Wind, solar, etc. ● Biofuels and waste ● Oil



<https://africa-energy-portal.org/news/role-clean-cooking-sustainable-development>

Kenya

Energy use is still extremely low

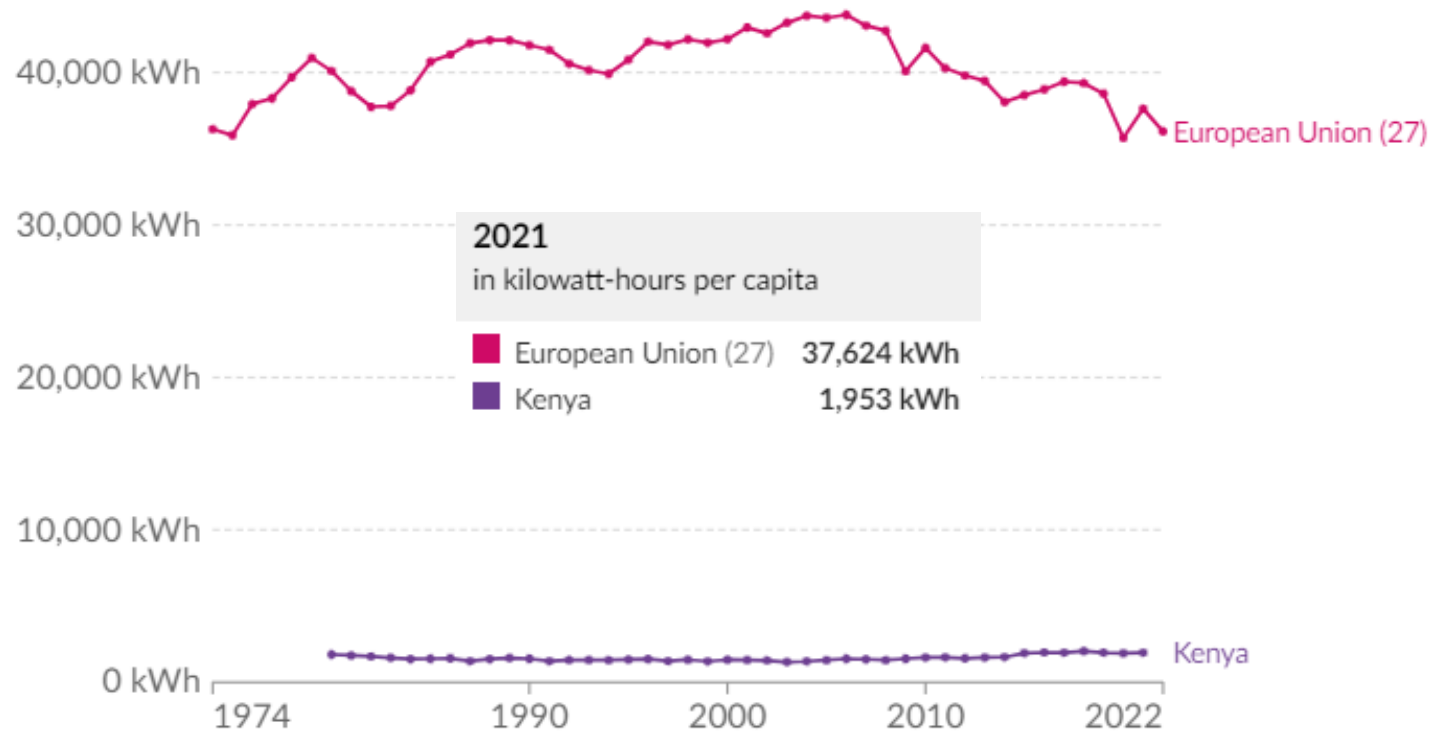
Energy use per person

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

Our World
in Data

+ Add country or region

All together ▾



Kenya

Some conclusions

- Developing nations are in a very different situation.
 - ➔ Some more obvious actions are needed first, like access to clean cooking, electricity, etc.
- Energy use per capita has to increase
 - ➔ The development of the country would need to go through more consumption.
 - ➔ Could it leapfrog directly to renewables only?

Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

Clean Energy Tracker

A lot of red in the IEA list

Energy System Overview

- Energy Efficiency
- Behavioural Changes
- Electrification
- Renewables
- Bioenergy
- Hydrogen
- Carbon Capture, Utilisation and Storage
- Innovation
- International Collaboration
- Digitalisation

Cross-Cutting Technologies & Infrastructure

- CO2 Transport and Storage
- CO2 Capture and Utilisation
- Bioenergy with Carbon Capture and Storage
- Direct Air Capture
- Electrolysers
- District Heating
- Data Centres and Data Transmission Networks

● Electricity

- Coal
- Natural Gas
- Solar PV
- Wind
- Hydroelectricity
- Demand Response
- Nuclear Power
- Grid-scale Storage
- Smart Grids

● Oil & Natural Gas Supply

- Methane Abatement
- Gas Flaring

● Low-Emission Fuels

- Biofuels

● Transport

- Cars and Vans
- Trucks and Buses
- Rail
- Aviation
- International Shipping
- Electric Vehicles

<https://www.iea.org/reports/tracking-clean-energy-progress-2023>

● Industry

- Steel
- Chemicals
- Cement
- Aluminium
- Paper
- Light Industry

● Buildings

- Heating
- Space Cooling
- Lighting
- Appliances and Equipment
- Building Envelopes
- Heat Pumps

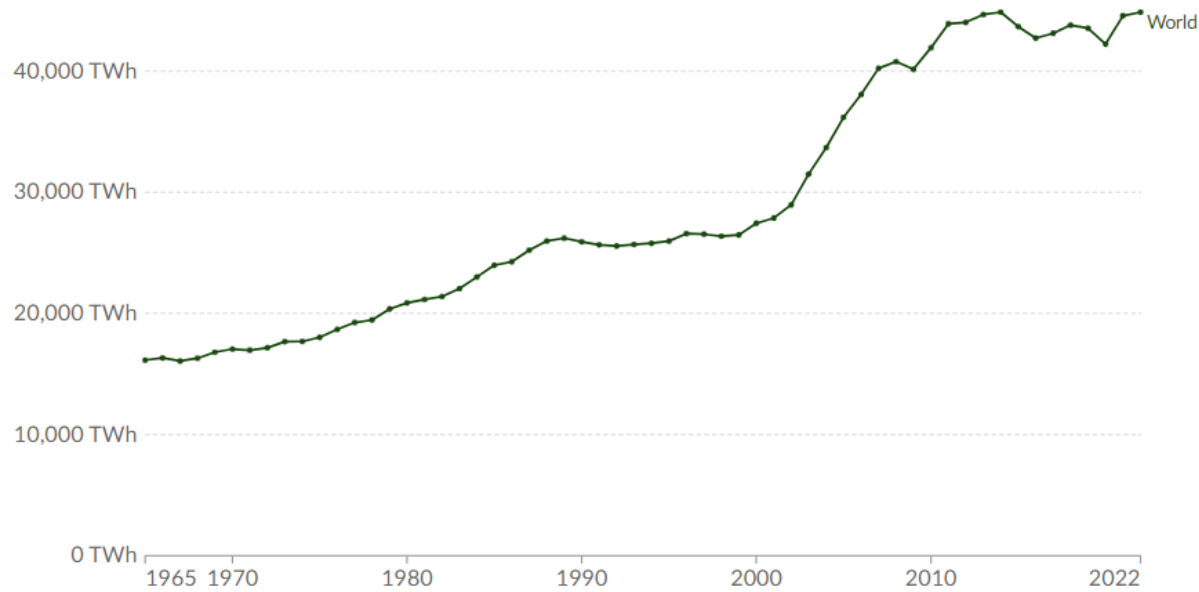
Coal in electricity

Coal is dirty but cheap and easy

Coal consumption

Coal consumption by country or region, measured in terawatt-hours (TWh).

[+ Add country or region](#)



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

OurWorldInData.org/fossil-fuels • CC BY

Our World
in Data


#	Country	Yearly Coal Consumption (MMcf)	World Share	Cubic Feet Per Capita
18	Serbia	43,189,608,110	0.5 %	5,763.77
10	Australia	129,642,679,100	1.5 %	5,358.09
23	Bulgaria	35,234,236,840	0.4 %	4,862.59
13	Kazakhstan	86,633,849,830	1.0 %	4,792.08
17	Czech Republic (Czechia)	49,418,771,720	0.6 %	4,694.21
73	New Caledonia	1,155,220,880	0.0 %	4,071.29
9	Poland	148,799,901,400	1.7 %	3,861.71
7	South Africa	202,298,474,200	2.4 %	3,585.44
22	Greece	38,077,094,330	0.4 %	3,542.14
4	Germany	257,488,592,900	3.0 %	3,127.46
1	China	4,319,921,826,000	50.5 %	3,081.50
14	Taiwan	72,649,581,410	0.8 %	3,079.09
8	South Korea	157,124,158,500	1.8 %	3,062.25

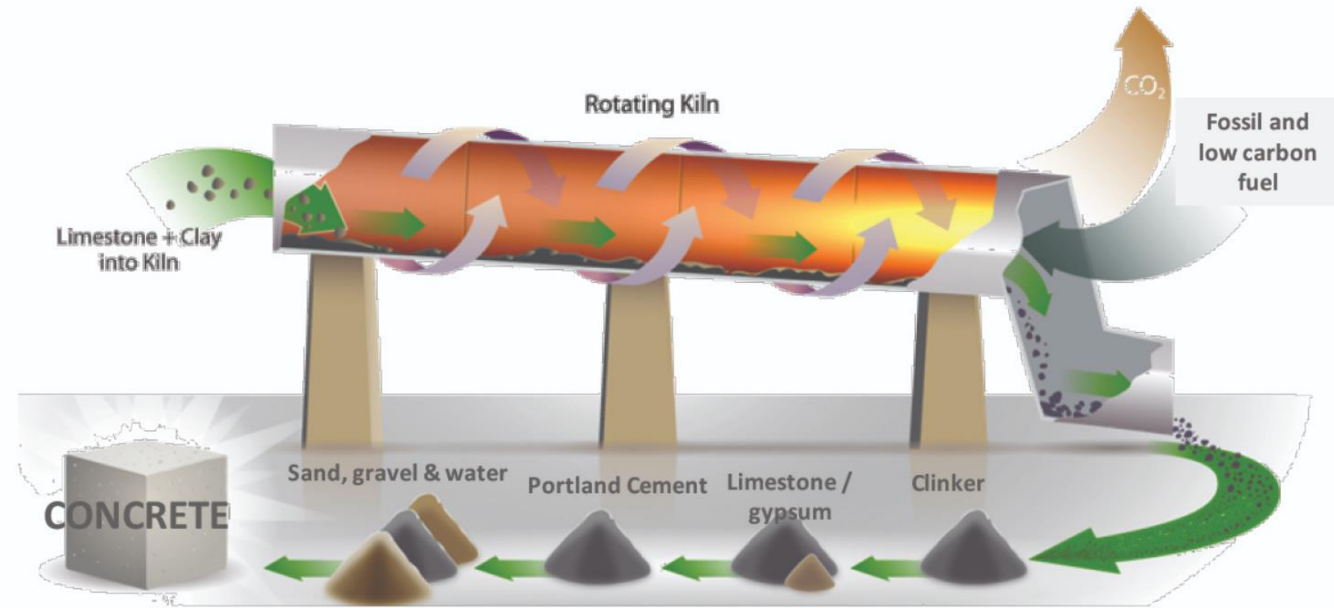
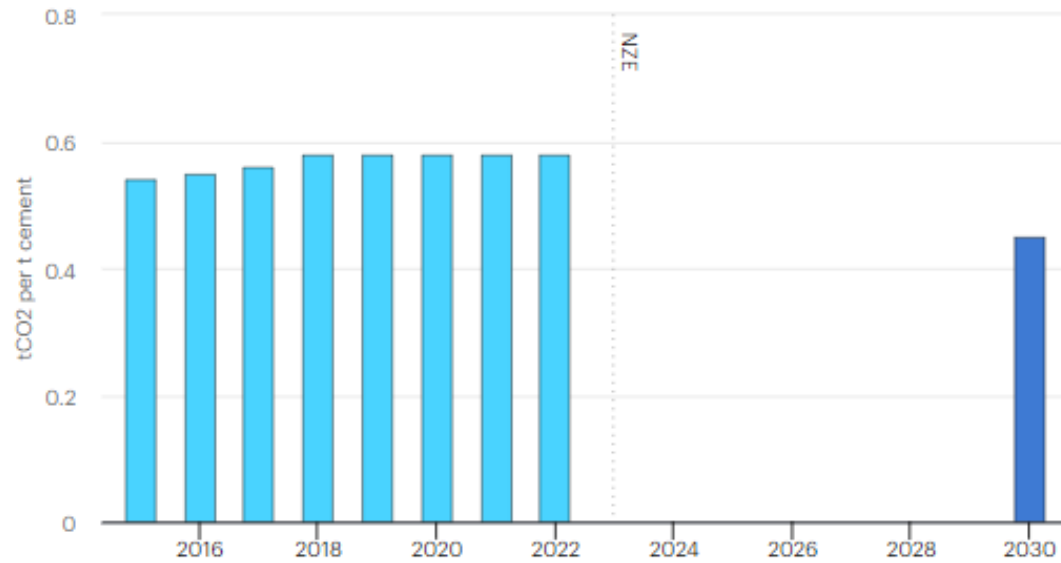
<https://www.worldometers.info/>

Industry - Cement

No progress

Direct emissions intensity of cement production in the Net Zero Scenario, 2015-2030

Open 




<https://www.toppr.com/ask/en-bt/question/how-portland-cement-is-manufactured/>

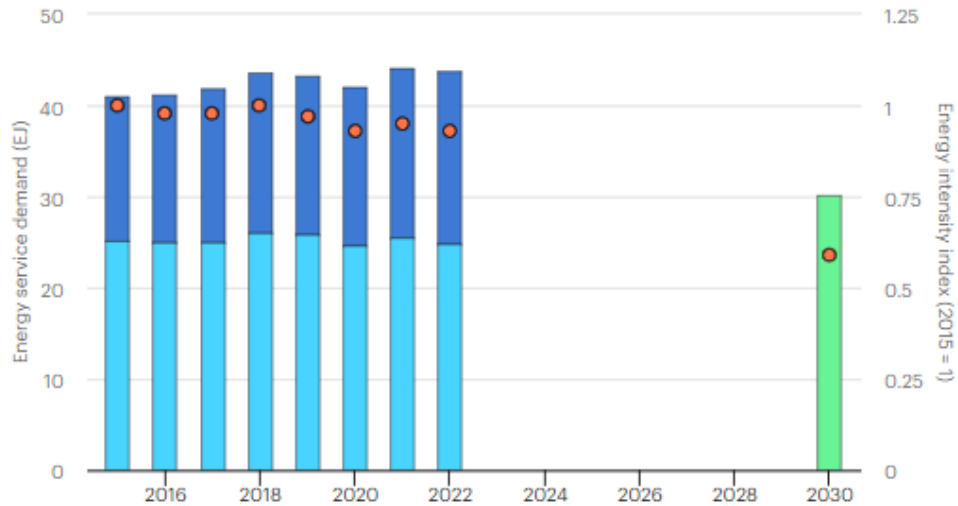
IEA. Licence: CC BY 4.0

Building Envelopes

Building renovation is really slow and deep ones are almost inexistant

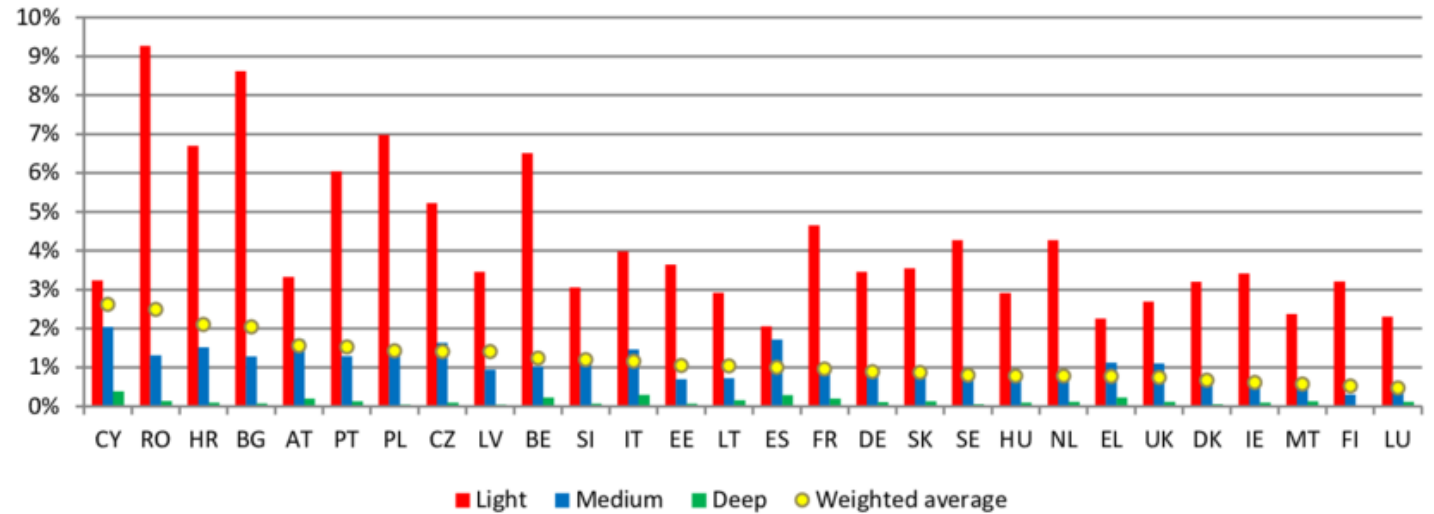
Energy service demand for space heating and energy intensity index in the Net Zero Scenario, 2015-2030

Open 



IEA. Licence: CC BY 4.0

- Advanced economies
- Emerging market and developing economies
- World
- Energy intensity index



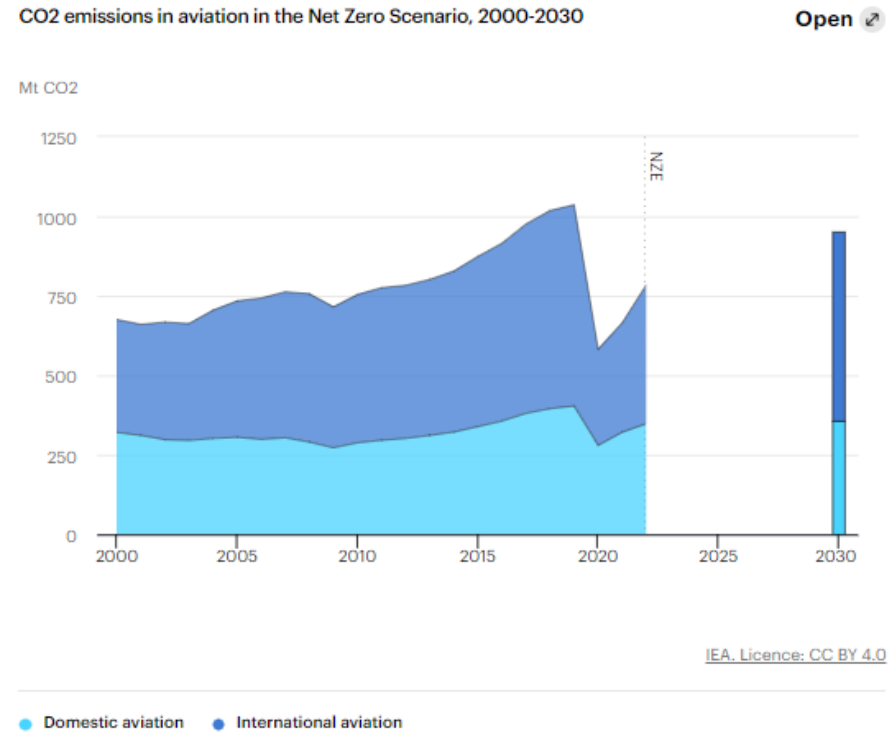
https://www.researchgate.net/figure/Renovation-rates-in-residential-buildings-in-the-EU28-Member-States-by-renovation-level_fig2_366030623

Aviation

Only a tiny fraction of the world is actually contributing

One percent of the world's population accounts for more than half of flying emissions

Published 19 November 2020



Agenda

1. A brief history of emissions
2. Energy Transitions?
3. Two different issues: energy poverty and emissions
4. Hopeful developments
5. Focus on particular countries
6. The great challenges
7. What could we do?

Energy poverty is still very much an issue

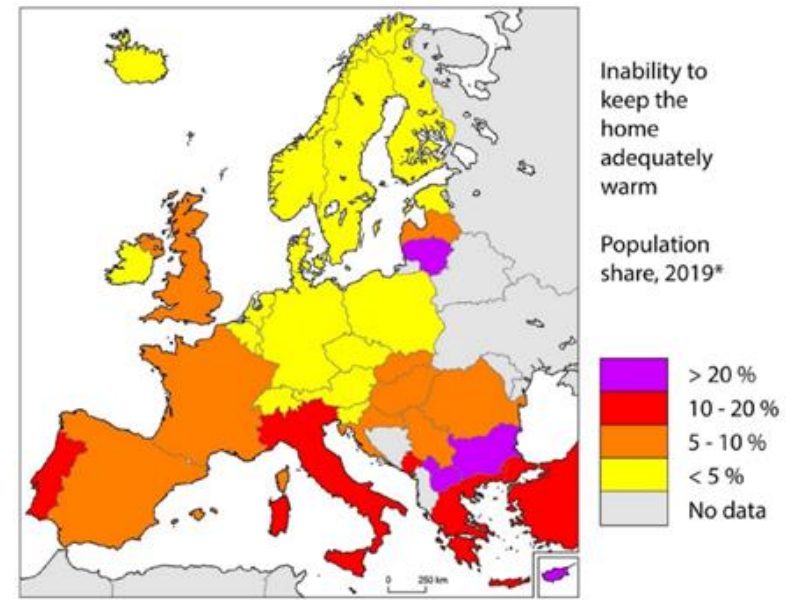
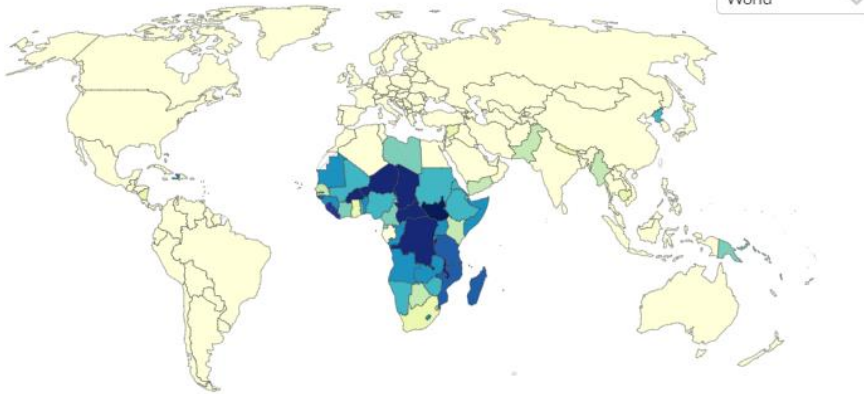
Important to note that many countries are still lacking proper energy

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.

Our World in Data

World



* Kosovo*, UK, and Iceland data from 2018.

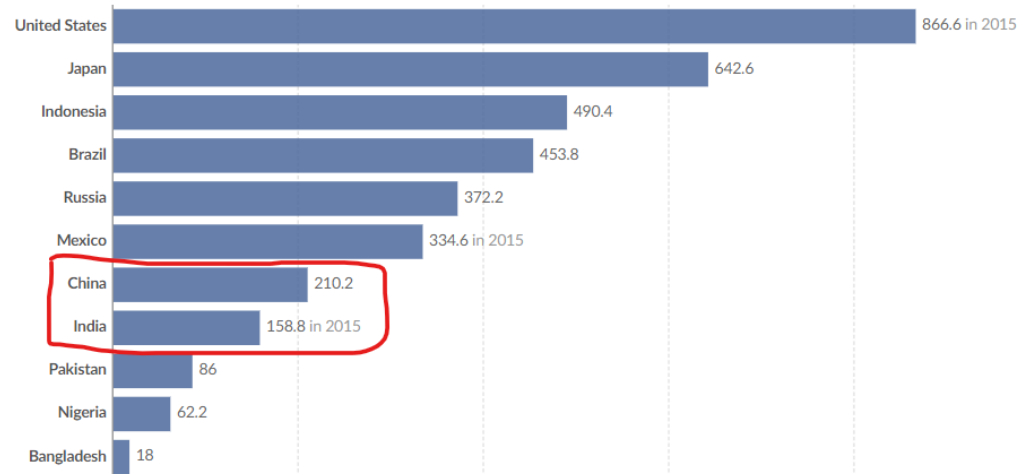
From knowledge to warm home” project -Croatia

Registered vehicles per 1,000 people, 2016

The total number of registered vehicles (i.e. vehicles reported to a government agency and given some form of registration) per 1,000 people in each country.

Our World in Data

+ Add country or region



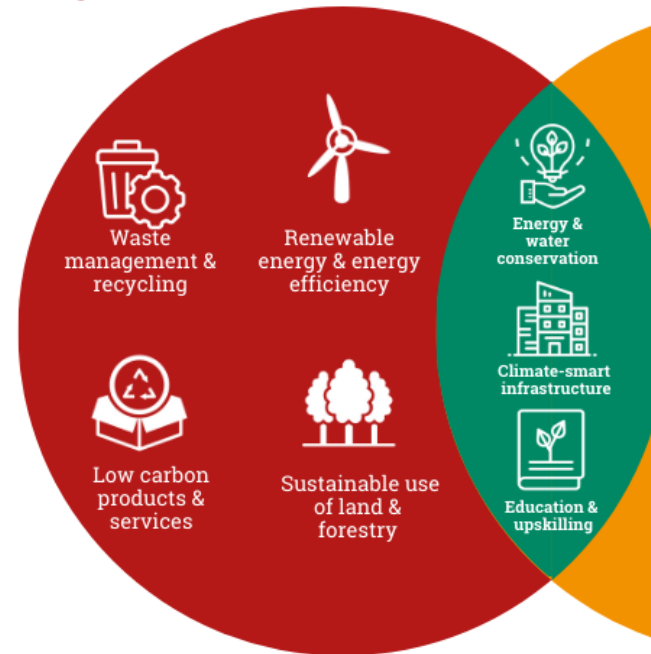
Adaptation and Resilience

For local population (especially the ones not responsible), adaptation is key

Climate Change Mitigation

Actions to avoid and/or reduce greenhouse gas emissions

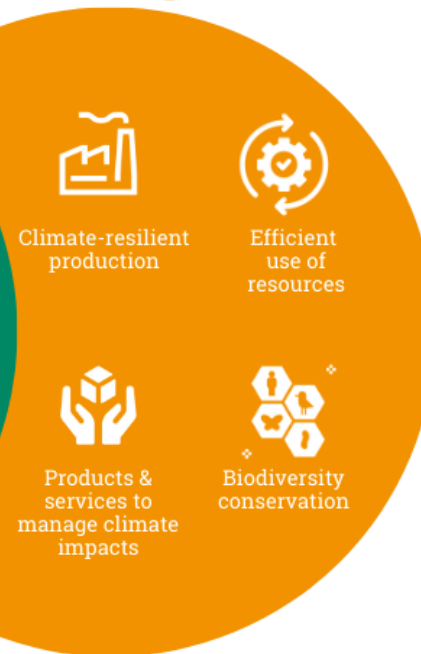
Small and medium-sized enterprises in climate change mitigation focus on:



Climate Change Adaptation

Actions to adjust to the current & future consequences of climate change

Small and medium-sized enterprises in climate change adaptation focus on:



Low-hanging fruits

Some ideas (not exhaustive of course)

- Solar in dirty grids (replacing diesel generators or coal power plants).
- Solar heaters in sunny countries.
- Investing in public transport system (bus).
- Clean cooking solutions.
- Adaption measures and resilience.
- ... measures to be adapted to the context / country specific.

Thank you

Any question?