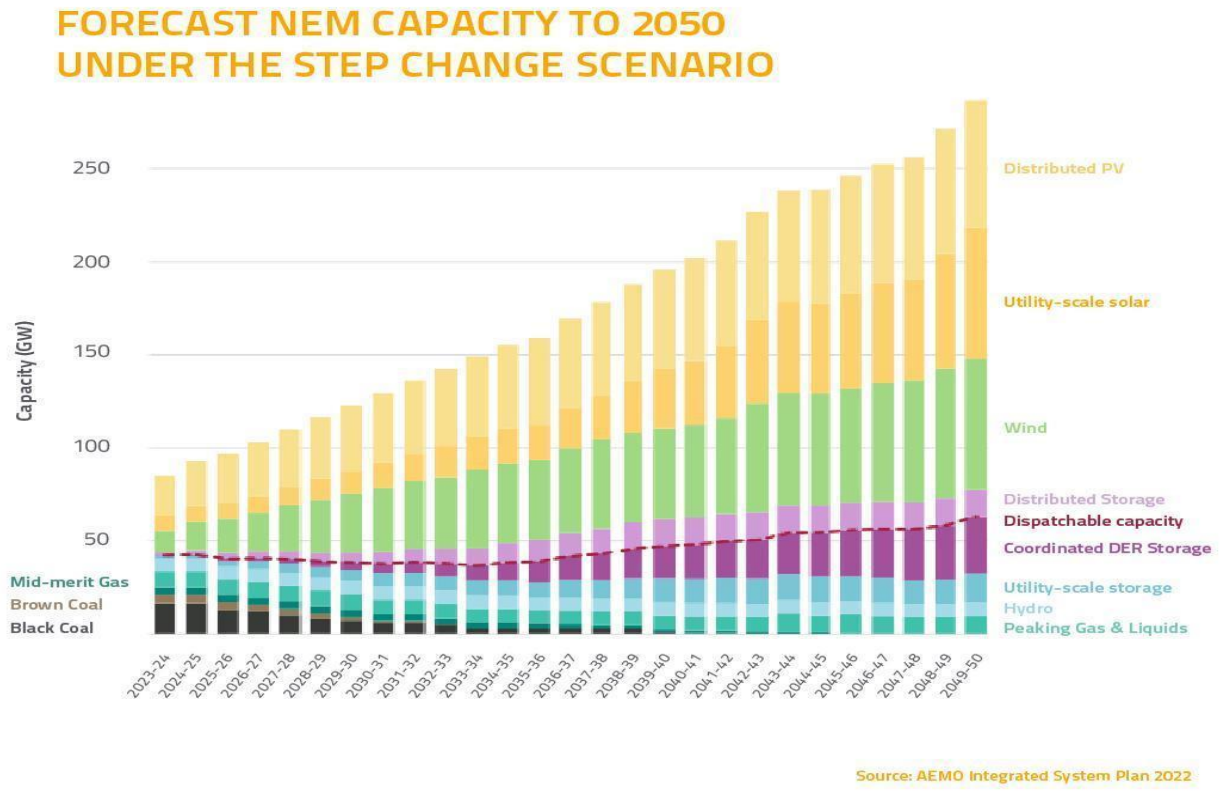
Green Energy and Net Zero

Dr D W Allen (May 2024)

Australia is now one of 16 countries (including NZ. UK and Canada) legally committed to achieve net zero emissions by 2050 or earlier. Thanks to our sunny climate, strong economy and government subsidies, Australia has lead the world in deploying rooftop solar, ten times faster than the global average per capita. In 2022, 36% of Australia's electricity was renewable: solar 15%, wind 13%, hydro 7% and bioenergy 1%.

An inventory of annual emissions estimates from 1990 to 2019 by economic sector shows agriculture, forestry and fishing dropping by 68% (from 292Mt to 93Mt) while electricity, gas, water and waste increased 25% (from 150Mt to 187Mt, after peaking at 222Mt in 2009). Manufacturing emissions fell 13% to 58Mt, construction remained flat at 10Mt, mining increased 117% to 100Mt and transport increased 160% to 34Mt (6% of total emissions). A third of our emissions now come from producing electricity and another third from agriculture and mining, much of the latter being for minerals to manufacture renewables and EVs to reduce global emissions!

Labor set renewables targets of 83% by 2030, 96% by 2040 and 98% by 2050. The Australian Energy Market Operator (AEMO) of Eastern Australia's National Energy Market (NEM) thinks this is doable and proposes an integrated system plan with a step change scenario (shown below) with capacity increasing even as coal is phased out but **dispatchable capacity** (broken line) dropping 15% over the next decade. This is because PV solar supplies only about a quarter of its stated capacity and wind supplies a third at best.



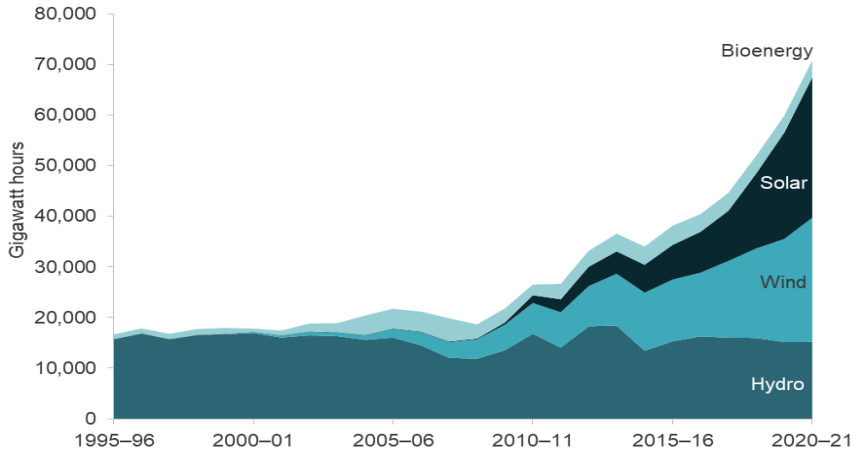
During peak loads around 7am and 6pm, solar power is minimal in summer and nil in winter when the total demand reaches around 34 gigawatts (GW). It is forecast to reach 40GW by 2040 and could go much higher if other states adopt Victoria's policy of phasing out gas for heating and cooking. If Australia replaces its present 15.3 million cars with EVs with an average battery capacity of 72 kWh, and if they are recharged overnight (8hrs) just once a week, another 20GW (160GWh) would be required. Wind might produce only 10% of capacity (~7GW) and 12% of demand in 2050. AEMO plans for only ~17GW from hydro/gas/diesel plus 46GW from batteries (16GW utility-scale and 30GW in homes and businesses) making a total of 63GW, but 63GWh might last only an hour. South Australia's Hornsdale Power Reserve, plus Victoria's future Big Battery plus NSW's Waratah Super Battery will provide up to 2.3GWh, enough for today's NEM peak load for about five minutes!

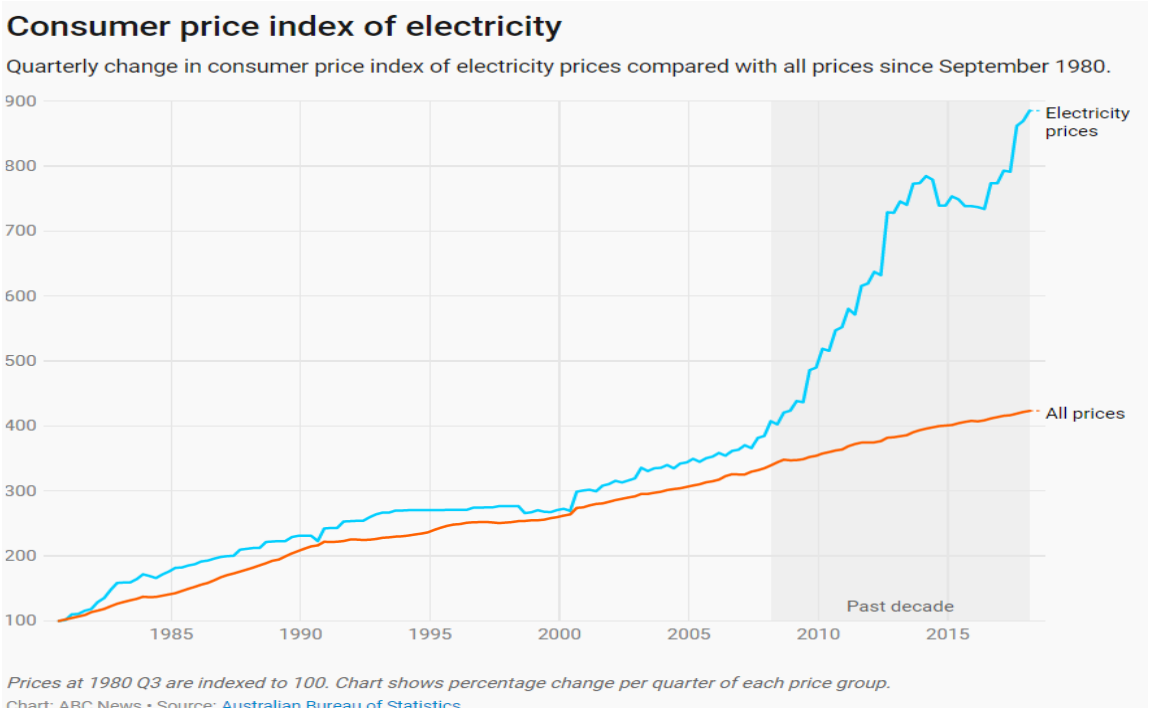
Whereas lithium-ion batteries are efficient but expensive with short lifespans, pumped hydro is less efficient but much longer lasting. Snowy 2.0 may be able to supply 2.2GW for up to a week (170GWh of storage capacity) but will cost over $12 billion to provide 4% of required wind storage. Queensland is planning a 2GW Borumba Pumped Hydro with an estimated cost of $14.2 billion and a massive 5GW Pioneer-Burdekin facility, each with only 24 hours of storage capacity. A widespread multi-day wind and solar drought, not uncommon in winter, would render them almost useless. Green hydrogen storage is the least efficient and as yet untested anywhere.

Weather dependent renewable energy is intermittent and unreliable, requiring very extensive and expensive storage, especially if we want to recharge EVs on windless nights. Instead of controlled supply we will have controlled demand and rolling blackouts. Electricity will become increasingly unreliable and unaffordable.

Integrating intermittent renewables into a grid requires a sophisticated and expensive network and firming with gas-fired plants playing second fiddle, sitting idle waiting for the wind to drop after dark, then charging much more. The wholesale price, set every five minutes on the NEM, can increase by up to 15,000%. As already discussed, the required storage is also very expensive. Unlike rooftop solar near energy users, long transmission lines to remote utility scale wind and solar plants are expensive and can lose up to 22% of the power generated. In April 2024, the IPA critiqued CSIRO's GenCost report based on biased Levelised Cost of Electricity (LCOE), and in May the Centre for Independent studies identified six fundamental flaws underpinning AEMO's energy transition. South Australia has the most renewables and the dearest electricity in the world. As shown in the graphs below, there is a strong correlation between renewables added to the grid and the consumer price of electricity.

Australian electricity generation renewable sources





Source: https://www.abc.net.au/news/2018-07-18/electricity-price-rises-chart-of-the-day/9985300?nw=0

Expensive energy means declining manufacturing and increasing living costs, plus more global emissions! Much of the cost of renewables is hidden in government subsidies, hitherto topping $2.8 billion annually, and hence debt and taxes. Labor's 2023-24 Budget provides $1.6 billion for an Energy Saving Plan, $0.4 billion for a Guarantee of Origin Scheme (focusing on hydrogen), and $2 billion for Hydrogen Headstart. Its Capacity Investment Scheme will *invest* $10 billion on the grid, $20 billion Rewiring the Nation, and $1.9 billion Powering the Regions. Renewables aren't cheap!

The annual export value to Australia of fossil fuels now tops $200 billion, supporting our balance of trade and the Aussie dollar. Federal taxes for 2022 totaled $8.45 billion for just five fossil fuel companies whose fifty thousand highly-paid employees paid even more tax. Many supporting businesses also contribute tax. Royalties received from coal and gas in Queensland alone tallied $12.9 billion in 2022-23, enough to fund 72% of its schools. Phasing them out will only increase our debts and taxes.

How clean and green are renewables?

A solar plant with the same output capacity as a gas-fired power plant requires 9 times as much concrete, 60 times as much steel and 2.5 times as much copper and aluminium as the entire weight of the gas plant! A wind plant of the same capacity as a nuclear power plant requires 5-10 times as much concrete, 10-15 times as much steel and over 100 times as much land in the mining, construction, production, and disposal. Mining the vast resources required for renewables and replacing nature with large monoculture biofuel farms, solar, wind and pumped hydro utilities threatens biodiversity much more than does the climate change they mitigate.

Wind turbines kill countless insects, millions of bats and birds, especially endangered raptors annually. Offshore wind may also threaten dolphins and endangered whales. Most wind turbines and solar panels are now made in China using coal and often forced labour. Mining and refining rare earths for turbines and EVs is polluting Inner Mongolian lakes with toxic and radioactive waste, more than the entire US nuclear industry produces annually. Lithium-ion batteries actually contain more cobalt, much of it dangerously mined by Congolese children. Vast swathes of forest and koala habitat are being cleared for wind and pumped hydro facilities across Queensland. Forestry land in NSW is being cleared and large tracts of good agricultural land rendered unproductive to make way for renewables and thousands of kilometers of high-voltage transmission lines across Australia, making many farms uninsurable. Windfarms slow cooling breezes, resulting in local warming which can negatively impact agriculture.

Replacing coal with wood pellets destroys forests and increases emissions; turning corn into biofuel increases food costs and emissions; growing palm oil for biodiesel increases deforestation, emissions and air pollution. Ironically, fossil fuels are much greener than renewables: more carbon dioxide and its warmer winters are not problematic but greening the planet and benefitting humanity; natural disasters and mortality rates are declining.

Nuclear Energy

Safer: Nuclear energy is hundreds of times safer than wind and thousands of times safer than rooftop solar in the US per unit of power produced. There were fewer than 50 radiation deaths from Chernobyl and none at Fukushima.

Cleaner: Nuclear has the fewest lifecycle emissions, half that of hydropower and a quarter of PV solar. Nuclear waste is very carefully stored and miniscule compared to that from short-lived solar panels and unrecyclable turbine blades.

Greener: Nuclear kills no wildlife, requires no long high-voltage transmission lines (especially if located at decommissioned coal-fired plant sites), and uses much less land than renewables.

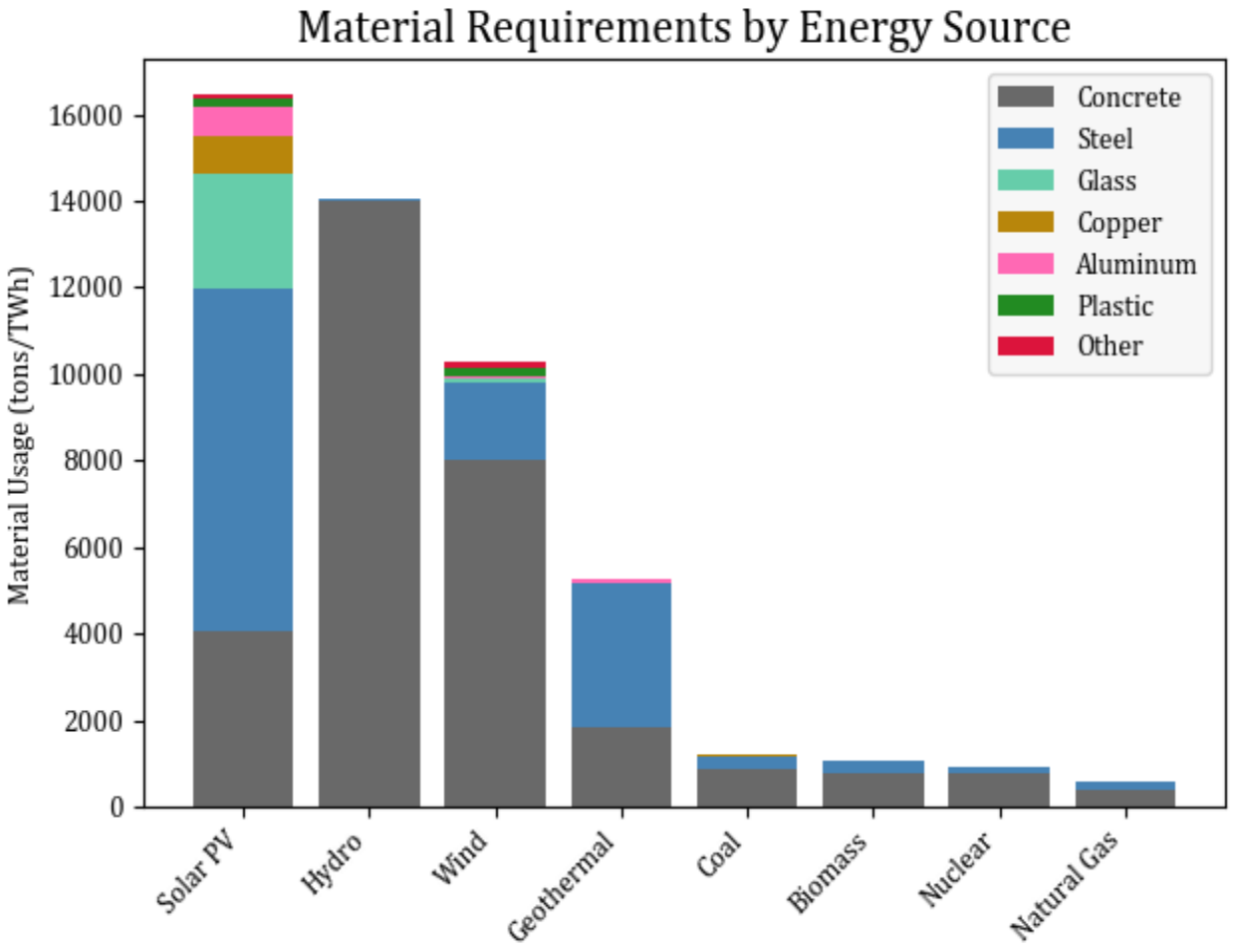
Cheaper: hydropower alone provides a greater energy gain ratio (output divided by input). Electricity in France is 70 percent nuclear and half the price of that in Germany. Small Modular Reactors (SMRs) offer savings in cost and construction time as well as transmission costs, potentially powering the Australian grid for ~$70/MWh.

Longer lasting: Nuclear power stations can last up to 80 years, 3-4 times longer than renewables.

Sooner: In 2021, wind and solar provided only 3% of global energy and 10% of global electricity; using wind alone, over 1,500 turbines (2.5MW each) would need to be added every day to achieve net-zero global emissions by 2050, unachievable without nuclear in the mix.

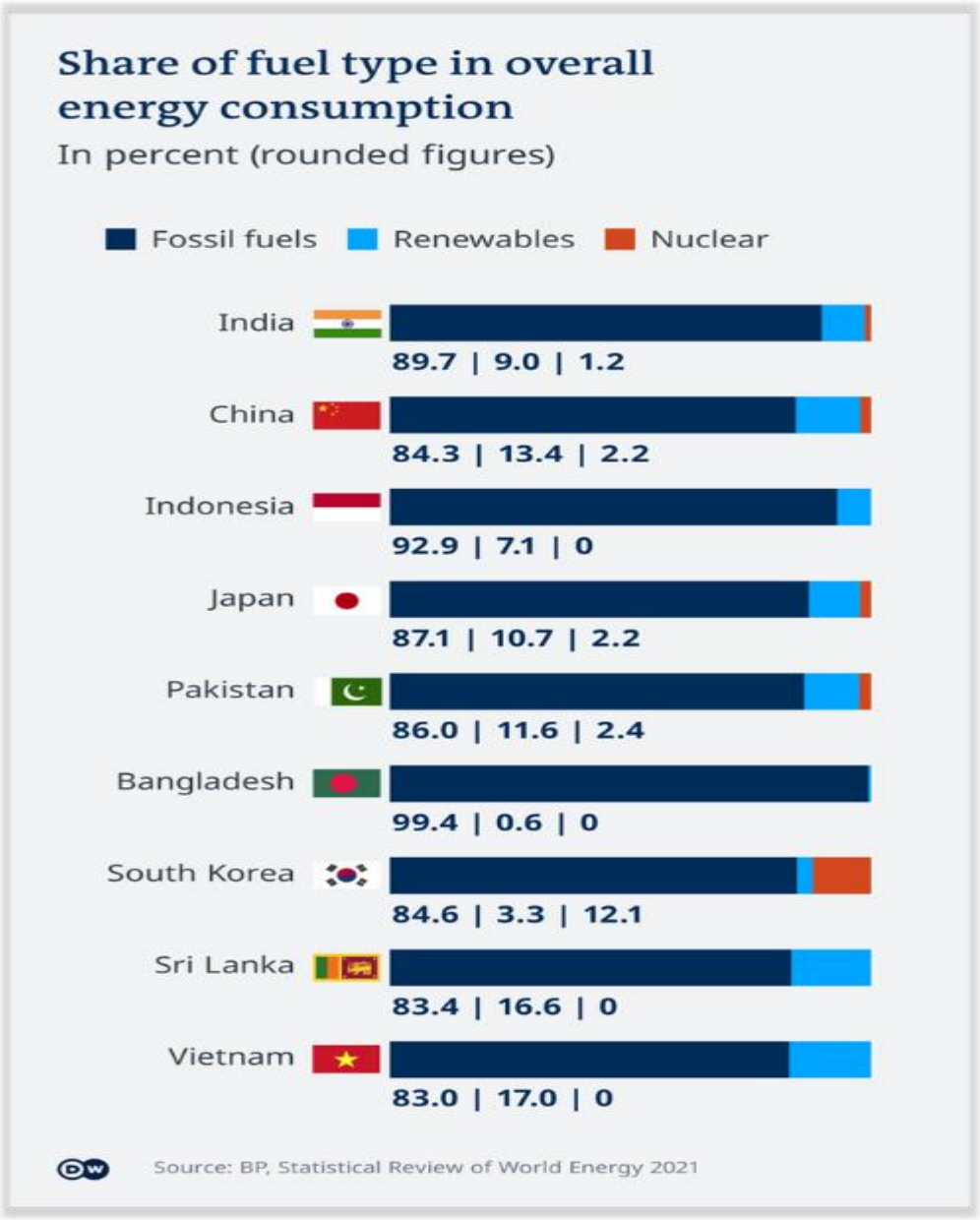
Metric/Source	Coal (No CCS)	Biomass[1]	Gas (No CCS)	Nuclear	Hydro (Med-Large)	Wind[2]	Solar Silicon PV[3]
GHG Emissions (g CO_2e/kWh)[4]	903	900	449	12	24	12	48
EROEI (buffered)	30.00	3.50	28.00	75.00	35.00	3.90	1.60
Land Use (CCUS) (m^2/MWh)	21.0	760.0	1.3	0.3	14.0	99.0	19.0
Critical Mineral Usage (kg/TWh)	7	7	8	12	6	165	124
Bulk Material Usage (CCUS) (t/TWh)	606	606	713	1,192	15,658	5,931	2,441
Mortality (Deaths/TWh)	64.4	14.3	3.4	0.04	0.71	0.10	0.23
Dispatchable/Intermittent (R/I)	D	D	D	D	D	I	I

1. Biomass gross CO2 emissions per Drax annual report; EROEI for corn biomass; Land Use from Freeing Energy; Mineral usage assumed same as coal
2. Wind land usage taken as median of Our World in Data analysis
3. Solar PV land use assumed ground-based silicon
4. GHG Emissions (except biomass) taken as median from UNECE report p83 https://unece.org/sites/default/files/2021-10/LCA-2.pdf



Data source: U.S. Department of Energy (DOE), "Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities," September 2015, p. 390

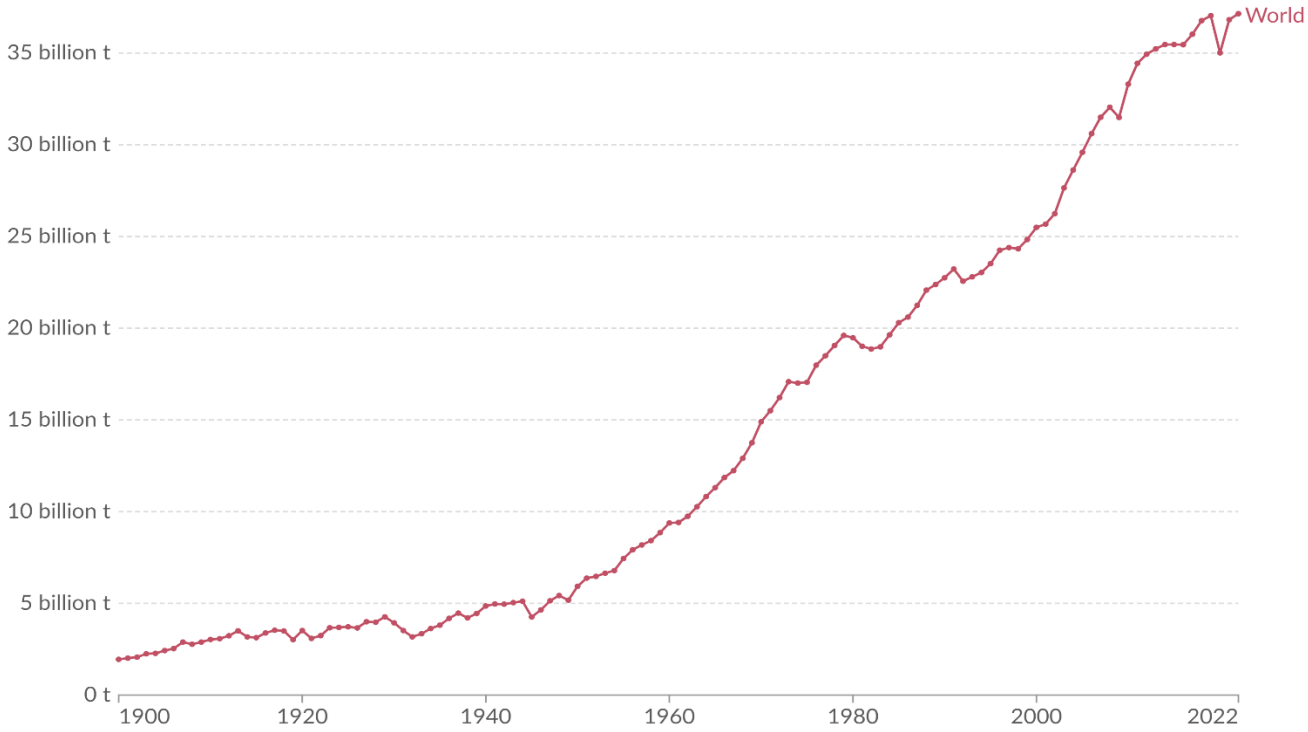
Chart: Chris Martz



Expensive energy also means we run the risk of missing out on the industries of the future such as AI. For instance, Amazon has recently bought a 960MW datacentre campus that is adjacent to and powered by a nuclear power station. Mark Zuckerberg has said the next generation of datacentres will be 1GW or above and Microsoft is considering building a $100bn datacentre campus that could consume 5GW for OpenAI by 2030. Clearly, AI is very energy hungry and suitable datacentres cannot be run on zephyrs and sunbeams, nor with expensive energy.

Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry[1]. Land-use change is not included.



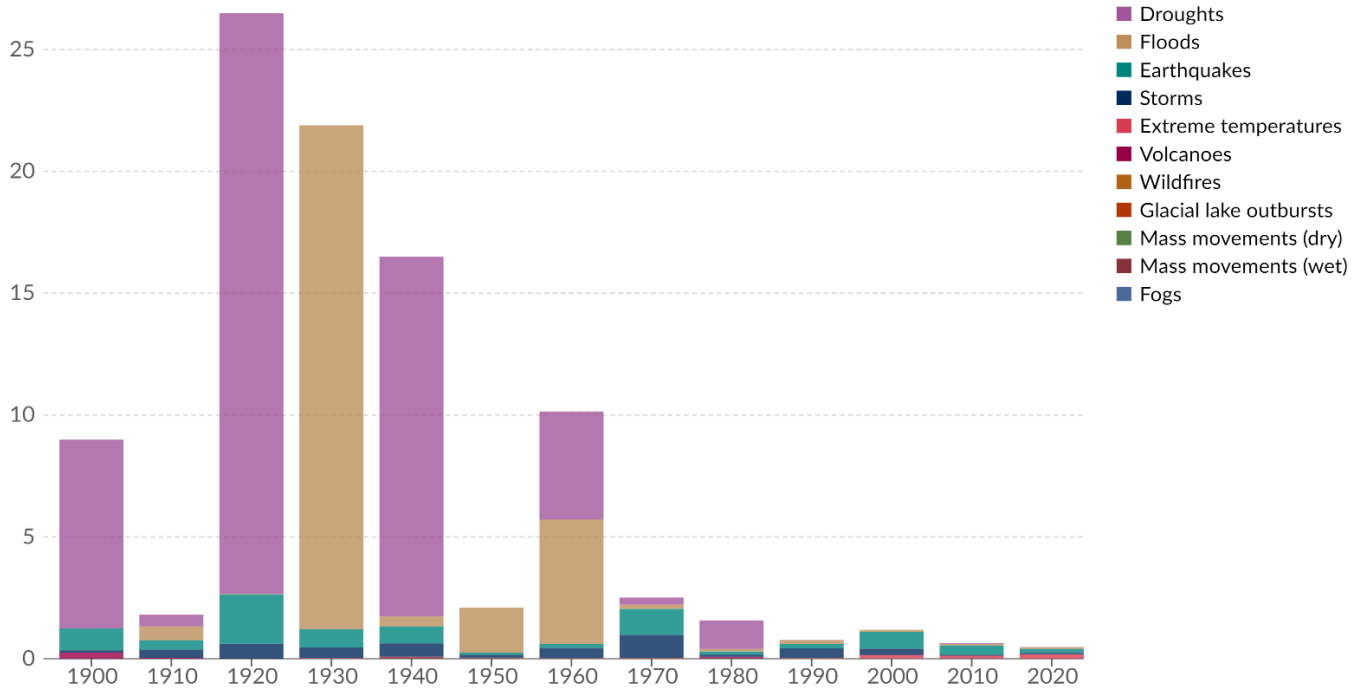
Data source: Global Carbon Budget (2023)

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

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Decadal average: Death rates from natural disasters, World

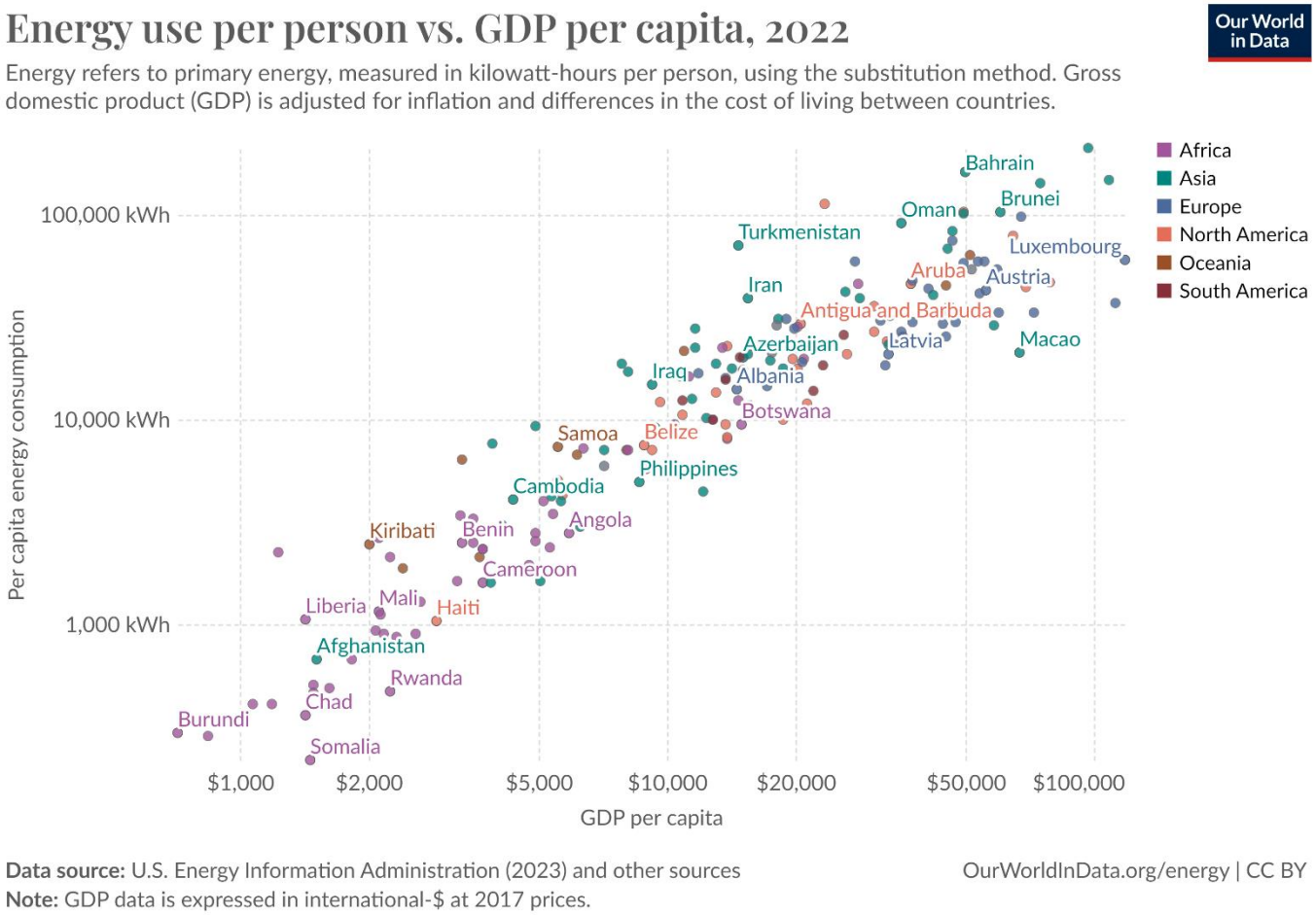
Death rates are measured as the number of deaths per 100,000 people.



Data source: EM-DAT, CRED / UCLouvain (2024); Population based on various sources (2023)

Note: Data includes disasters recorded up to April 2024.

OurWorldInData.org/natural-disasters | CC BY



Google, Microsoft, Meta and Amazon have all promised to be net zero by 2030

Google (92% of search engines) increased its emissions by 13% in 2023 alone.

Microsoft has increased its emissions by 30% since 2020.

Meta increased its emissions by 46% in 2022.

Amazon achieves net zero emissions by purchasing offsets by gilding the lilly.