# WHAT DO GLOBAL DATA VISUALISATIONS TELL US ABOUT THE PERFORMANCE OF LOW-CARBON ELECTRICITY GENERATION?

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**Author:**
Professor Timothy Florin BSc (Hons), MBBS (Hons), MSc, FRACP
Emeritus Professor of Medicine, University of Queensland

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# Preface

Australia's electricity system is entering a period of significant change. Policies aimed at reducing carbon emissions are reshaping how electricity is generated, transmitted and consumed, with major implications for households, industry and the broader economy. Governments, businesses and consumers are being asked to invest heavily in new infrastructure as the country simultaneously electrifies transport, industry and domestic energy use.

Current policy settings largely assume a pathway in which renewable generation, supported by expanded transmission, storage and other firming technologies, becomes the dominant source of electricity supply. While this approach underpins Australia's present transition strategy, the scale of the transformation and the costs involved mean that questions about alternative low-carbon pathways continue to be debated.

This discussion paper by Professor Timothy Florin contributes to that debate by examining publicly available global data on electricity generation, energy consumption and carbon emissions, particularly the datasets compiled by *Our World in Data* (Global Change Data Lab). Rather than modelling hypothetical future systems, the paper examines what real-world evidence from existing energy systems suggests about the relationship between electricity consumption, economic development and emissions, and about the performance of different electricity generation mixes.

Discussion papers published by the Australian Institute for Progress are intended to encourage informed public debate on important policy questions. The views expressed in this paper are those of the author and do not necessarily reflect those of the Institute.

**GRAHAM YOUNG**
EXECUTIVE DIRECTOR
AUSTRALIAN INSTITUTE FOR PROGRESS

## About the author

Professor Timothy Florin BSc (Hons), MB BS (Hons), MSc, FRACP is Emeritus Professor of Medicine at the University of Queensland and a former Senior Staff Specialist at Mater Health Services in Brisbane.

A physician-scientist specialising in gastroenterology, Professor Florin has had a long career in clinical medicine, research and medical education. His research has focused particularly on inflammatory bowel disease and gastrointestinal physiology, and he has authored more than 150 scientific publications. During his career he helped establish the inflammatory bowel disease clinical trials program at Mater Research and has contributed extensively to national and international research collaborations.

He is a Life Fellow of the Royal Society of Medicine. In 2023 he received the Distinguished Researcher Prize from the Gastroenterological Society of Australia in recognition of his contributions to the field.

While his professional background is in medicine rather than energy systems, Professor Florin approaches the questions discussed in this paper from the perspective of a scientist examining publicly available global data on electricity production, energy consumption and carbon emissions.

# Introduction

The Federal government is electrifying  much of the Australian economy in order to reduce carbon emissions, lower household energy costs, and support new industries.

The preferred pathway is an electricity system dominated by renewable generation supported by storage and expanded transmission infrastructure (referred to here **as the renewables-only with storage approach**). While no other G20 country is pursuing such a strategy as its primary electricity system, Australian policy advisers argue that Australia is particularly well suited to this approach because of its geography.

In this article, I will ask readers to interrogate for themselves the Oxford University's affiliated Our World In Data website on electricity, energy, population and $CO_2$. Our World in Data's stated mission is to publish "the research and data to make progress against the world's largest problems". Its research is cited in broadsheets as well as scientific, economic, medical and global health journals.

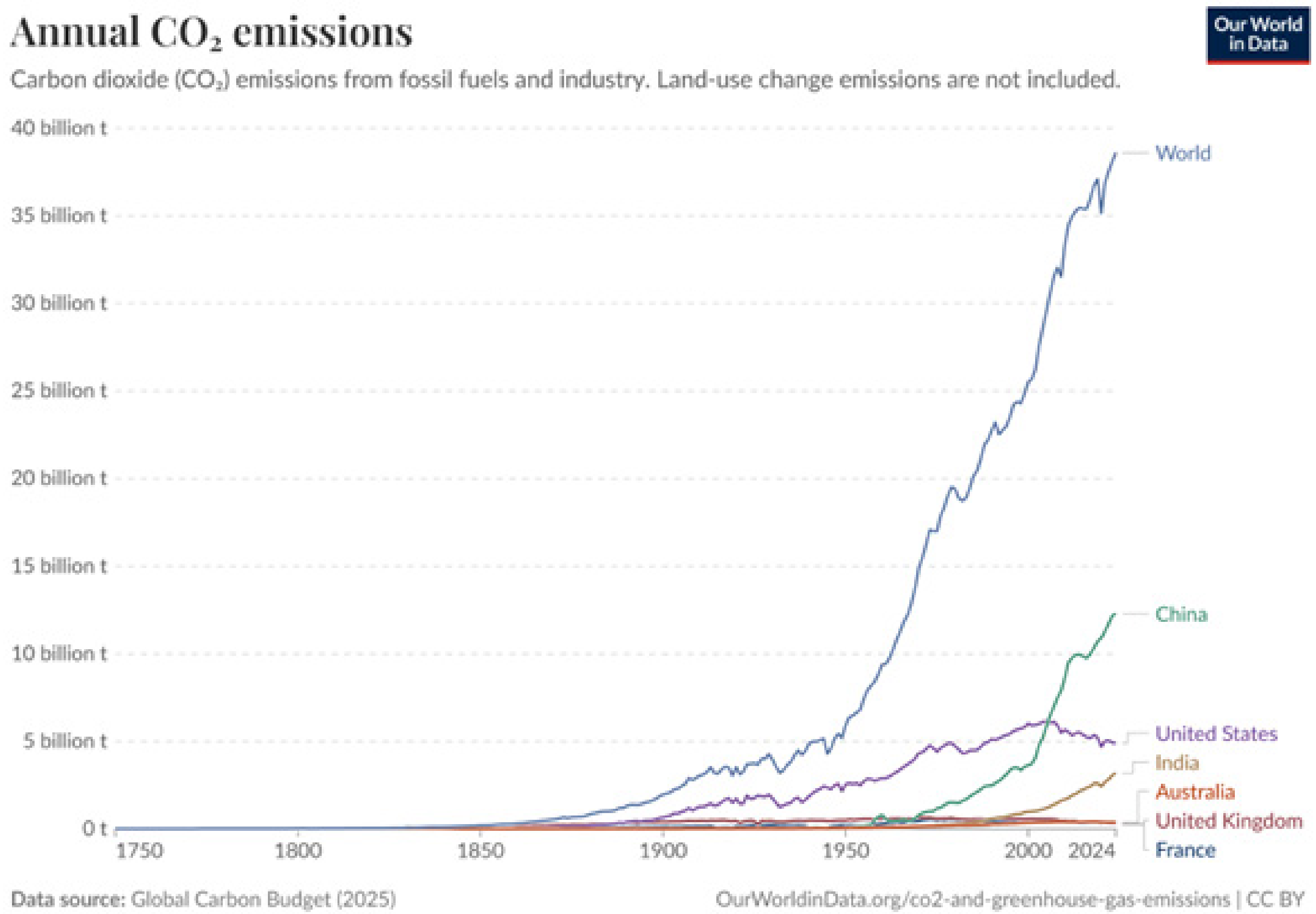


*Figure 1: Annual CO2 emissions. Source: Our World in Data*

# Anthropogenic $CO_2$ emissions continue to rise

The rise is happening despite the many COP meetings since 1995. Figure 1 shows 'counting' of total fossil fuel $CO_2$ emissions for the world, and for some representative countries to 2025.

It is not only total fossil fuel combustion that accounts for rising $CO_2$ emissions. $CO_2$ emissions from fossil fuel-generated electricity are also increasing. This is despite the rapidly incrementing electricity generation from renewable energy sources **(Fig 2)**.

So why do global emissions continue to rise in absolute terms? Several factors help explain this:

- Total world population is still growing. Fertility is falling to below replacement levels, but it will take time in a world where people on average live longer for population replacement (i.e., net births - deaths) to become negative and so for the world human population to fall. Anthropogenic $CO_2$ is more likely to fall when there are fewer people.
- The third world is still transitioning away from poverty. The transition out of subsistence poverty with no electricity, to people having electricity + trains, buses, cars, washing and dishwashing machines and air transport, air conditioning, heating, lighting, modern health care, remains a vast project despite much progress(i). There remain over 675 million people without electricity of any sort in parts of sub-Saharan Africa, SE Asia, and Latin America.
- Much of the power required to manufacture renewables (and backup battery storage) is underwritten by fossil fuels to generate electricity, to purify silicon for PV panels or manufacture steel, etc. Renewables are not producing the electricity to make renewables. The energy to fabricate them and the energy for mining transportation and processing is mainly derived from fossil fuels. Fossil fuels still underpin road building, building of cities for people to live and work in, etc.

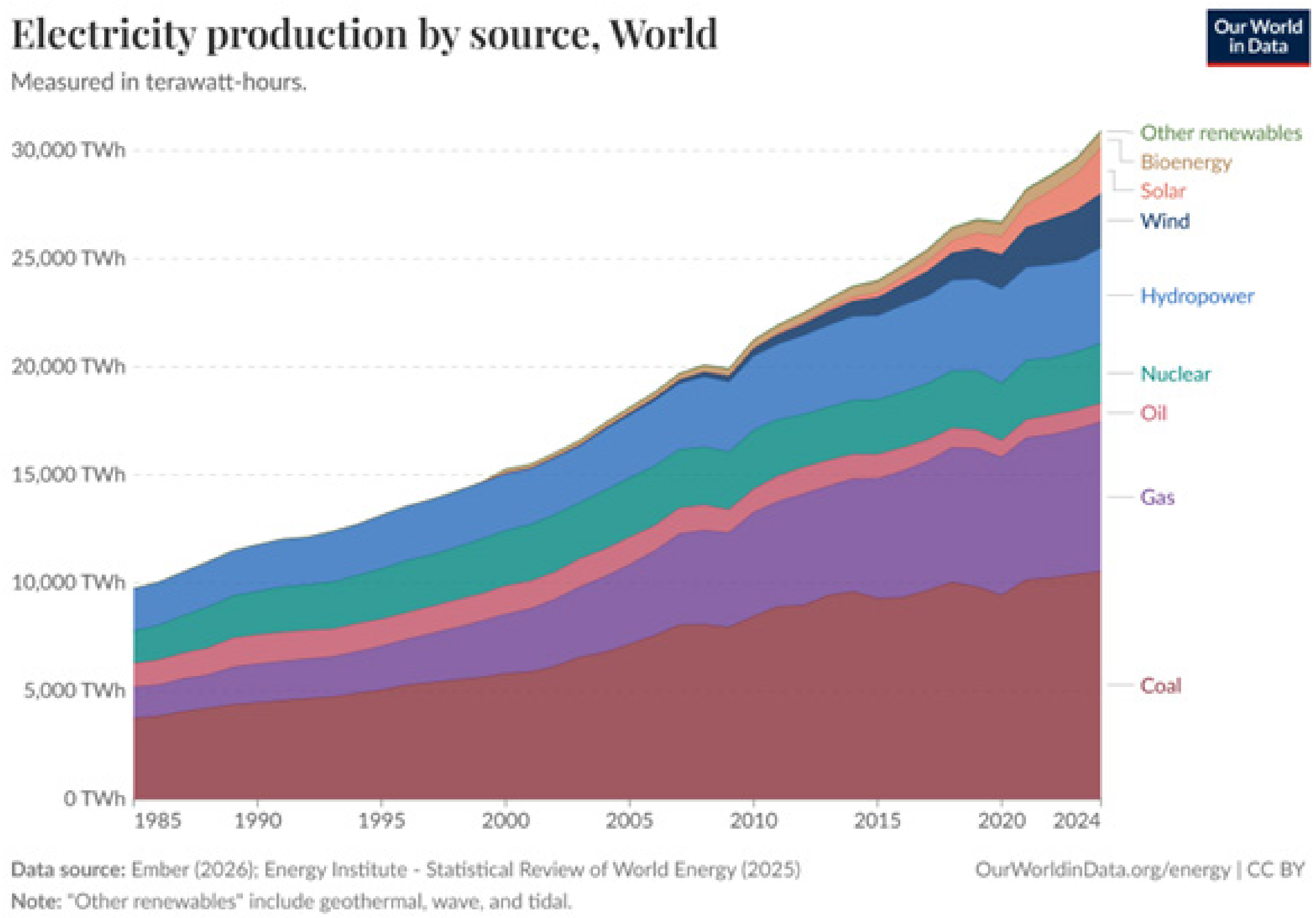


*Figure 2: Electricity production by source, World. Source: Our World in Data*

## The country with most impact on $CO_2$ emissions

Most $CO_2$ emissions emanate from one country, China, where fossil fuels account for more than half of all electricity generated in that country. The burning of fossil fuels is still increasing in China, even though it is often and correctly mentioned that low C source electricity, in particular renewables, are incrementing faster as a percentage of total electricity in China **(Fig 3)**.

While China's progress with renewables is rightly highlighted, it is grossly misleading to omit the fact that China's electricity is mainly generated from burning fossil fuels. It is more misleading still for a government advisor to assert in a sworn deposition to the Federal Government's House Select Committee on Nuclear Energy, that China has "no domestic fossil fuel industry" (12/12/2024)(ii).

The data in figure 3 clearly demonstrate that fossil fuels account for the majority of China's electricity production and this is still increasing. It is no wonder that China is now accounting for over 30% of the world's $CO_2$ emissions.

## Energy inputs into all aspects of the economy, but how much can $CO_2$ emissions be uncoupled from it?

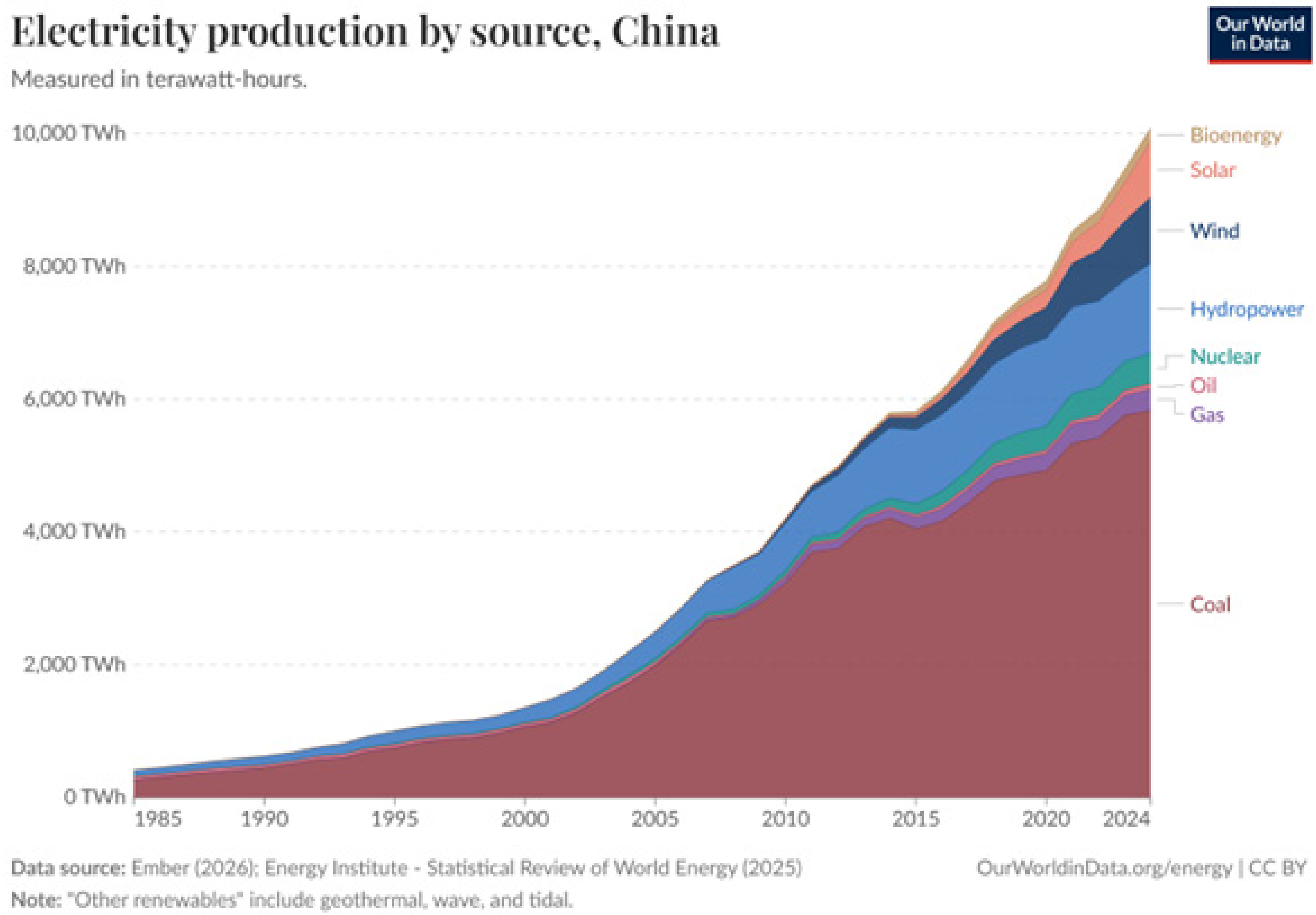


*Figure 3: Electricity production by source, China. Source: Our World In Data*

Electricity consumption is increasing in most countries. This is because the demand is increasing. It seems to be a truism that even the most ecologically conscious people are likely to consume on average more electricity than their parents' generation. Average demand is not getting less. This suggests that it is unlikely that uncoupling can be achieved by decreasing demand, although this is a worthy aim. Electricity is needed for EV transport, industry, air conditioning, heating, manufacture of aluminium etc. The advent of AI, and before that cryptocurrency, has further increased demand.

Our World In Data evidence seems clear on this point: per capita electricity consumption correlates closely with per capita GDP(iii); and per capita $CO_2$ emissions correlate as a power function with GDP **(Fig 4, the axes are logarithmic)**.

In more detail, countries with higher standards of living consume more electricity per capita. I know of no exceptions. For instance, Sweden's per capita consumption of electricity is more than 11 x that of India and nearly 5 x that of Brazil. China, UK, USA and Japan per capita $CO_2$ emissions are about equal to or more than 10 x per capita $CO_2$ emissions of Nigeria, Africa's most populous country.

The correlation of $CO_2$ emissions per capita vs. GDP per capita occurs in large part because a high standard of living is associated with a significantly larger consumption of goods and services. But is this per capita $CO_2$/GDP relationship inevitable? One would hope that $CO_2$ emissions will become lower in countries with a large component of low-C electricity generation. The answer is a guarded yes.

Take Australia as an example, anthropogenic $CO_2$ from electricity generation was increasing from 1950 but has fallen since 2010 from 19 tonnes per capita to 14.5 tonnes per capita in 2024(iv). This relates to Australia's decreased coal generated electricity (176 TWh to 127 TWh) and increased wind and solar electricity generation 5.9 to 82.5 TWh over the same period(v).

However, Australia's $CO_2$ reduction also relates to higher efficiency appliances and vehicles, and especially the reduced fossil fuel consumption that occurs through exporting manufacturing and emissions to China. Furthermore, it also relates to the LULUCF (Land Use, Land-Use Change and Forestry) calculations, as per the IPCC guidance for calculating LULUCF $CO_2$ emission reductions. This is especially significant in Queensland where the reduction was 14.91 $MtCO_2$-e for all Queensland in 2022(vi).

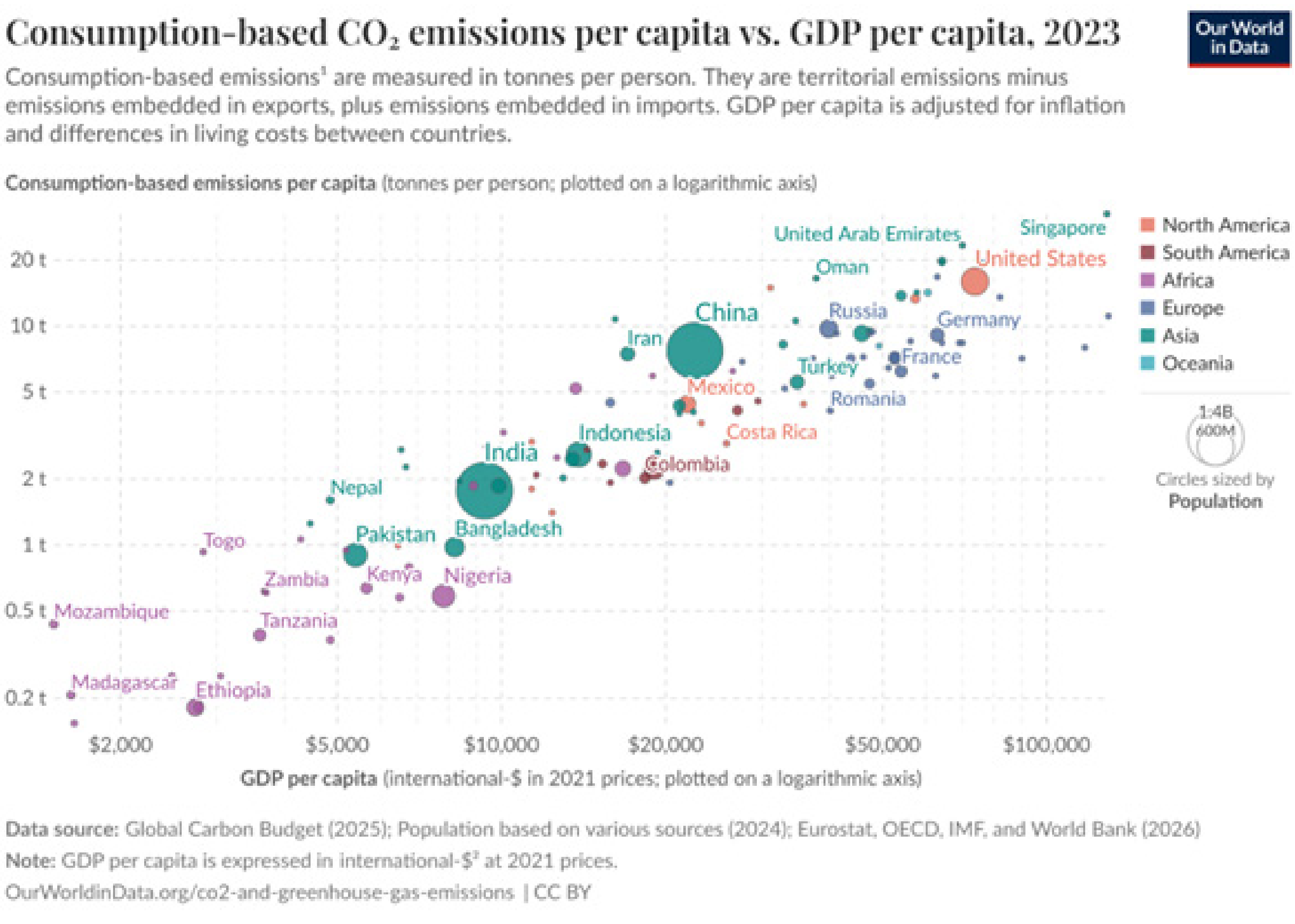


*Figure 4: Consumption-based $CO_2$ emissions per capita vs. GDP per capita, 2023. Source: Our World in Data*

# System cost and reliability

For the consumer, total system costs are a critical issue. The costs are influenced by mode of electricity generation and distribution, population density, local taxes and subsidies, geography and weather, and spending power. In Australia, the cost of electricity to the consumer has increased close to 40% under the current Federal government if one ignores taxpayer subsidies(vii).

So, a related key question is: will the cost of electricity paid for by the residential or industrial consumer fall once that all the low-C electricity infrastructure is in place?

The answer is yes according to our Australian Federal government. Our government asserts that electricity prices will eventually fall when the renewable and associated transmission and storage infrastructure is completed. Thus, the government appears not for turning for this reason, and because there is already much private and public partnership investment in renewable energy and battery storage, and hydro-storage, but this is at what cost?

It is often claimed that renewable energy is cheap or even free. This is true with respect to the wind or solar fuel component, but it ignores the cost of the whole system to provide a reliable and abundant electricity service. To state the obvious, there is obligatory backup infrastructure to maintain the AC electricity grid, balancing the demand for electricity in the AC grid with supply when there is intermittency of the renewables. When not balanced in one location, the wind and solar generated electricity must be augmented from transmitted renewable electricity generated elsewhere or coal if allowed, from readily dispatchable 'firming' gas fossil fuel, or from battery or hydroelectric storage, and if all else fails, then there is diesel fuel stored at sites where national security is deemed to be "critical". All of this is in addition to the costs associated with land use approvals, building, maintainance and the eventual decommissioning of spent turbines or PV panels.

All electricity systems require an overbuild of electricity generation to guarantee the service during extremes of fluctuating demand. However, there is disagreement around the costs of the additional electricity backup infrastructures required for an electricity system that is dominated by intermittent generation. Modelling the costs is dependent on context and many assumptions around demand and weather (especially in the case of renewables).

Case in point - the Australian Energy Market Operator's (AEMO) plan for the Eastern states grid, which was released 26 June 2024, modelled the renewable infrastructure backup to withstand a worst-case intermittency scenario of <14% wind capacity for 8 days. Global Power Energy mapped what actually happened to wind generation through autumn and winter in 2025. There were at least four occasions when the AEMO worst-case scenario proved to be a hopelessly wrong assumption. E.g., from mid-April the wind collapsed to about 6 to 11 per cent of generation capacity, with a run of seven consecutive days in that band.

The renewables-only backup infrastructure would have collapsed without the availability of backup coal or diesel. It was concluded that "even in the operator's best-case scenario, a renewables-based grid survives long wind and solar droughts only by relying on gas and large volumes of diesel stored in tanks beside the generators"(viii).

The truth is that the total cost of a renewables-only with backup infrastructure electricity system is unknown. Cost assessments vary over a wide range depending on the base assumptions and ongoing premises. For example, the Federal Coalition, when accounting for the dollars spent in the Capacity Investment Scheme, suggested that the total system cost for a renewables-only grid, will be in excess of $A1.2 trillion. Whereas AEMO (16 February 2024) costed the total renewable integrated system plan at $121 billion 'annualised' to 2050 but this costing was for generation and transmission only. It apparently did not include already commissioned or anticipated projects and consumer energy resources (CER) such as residential roof top solar or home batteries, so it was never a total system cost in these respects. There may be other items that were not costed. The Net Zero Australia study (Universities of Melbourne, Sydney and Princeton 2023) costed the net zero total system renewables-only at a staggering $7-9 trillion by 2060(ix).

With costs ballooning more than inflation, an example being the Snowy hydro-storage project (originally $2 billion now $12 billion, plus the cost of transmission, and still increasing), it seems to be very clear that the costings of the so-called transition to any renewable low-C electricity generation have either not been admitted, or have not been recognised, or have been exaggerated or understated depending on the biases and preferences of the policy czars and politicians.

Without clarity around the total cost of the renewables-only option for a reliable electricity service, it is difficult to answer the next question: is there any other low C approach to provide an efficient and reliable electricity system that may be less costly? The next section attempts to address this.

# Energy generation with or without nuclear in the mix

The renewables-only electricity system requires a huge rollout of distribution lines (in addition to existing transmission lines), wind turbines and PV panels, nearly all manufactured in China using mainly fossil fuel generated energy. The sheer numbers, as flagged by the Climate Change Authority in 2022 (x) are daunting and may be impossible to deliver: 40 x 7 MW wind turbines per month and 22,000 large solar panels (500 Watts) every day till 2030. The life expectancies of the wind turbines and PV panels, and the batteries to back up the grid ultra-short term, as measured in minutes and hours, which are made from minerals mined in large part from Australia and then processed elsewhere in energy intensive factories, are less than 25-30 years. I believe that it is safe to state that the decommissioning and rehabilitation of these infrastructures and the ongoing replacement and disposal at the end of their life are not properly costed. Then there are also the costly synchronous condensers to stabilise renewable-only grids, which were once planned to come on-line in order to safely shut down some coal power stations which currently provide this stabilising function.

The LNP proposed an alternative low-C electrical grid at the last Federal election. It comprised 7 nuclear reactors at currently existing coal-power sites to provide ~ 50% nuclear electricity generation with the rest of the mix being renewable + gas firming.  Costing was based on Frontier Economics modelling (2025) that concluded that "AEMO's preferred (renewables-only) energy future is, by far, the most expensive scenario modelled, with the combined generation and transmission costs". The LNP plan that included nuclear power in the mix, was 44% cheaper at $331 billion compared to the Federal Labor Government's AEMO's Step Change scenario, estimated to cost $594 billion by the report's modelling. However, the government's Smart Energy Council (SEC) analysis flagged that this Federal Coalition plan would cost $600 billion.

The SEC is a lobby group for the renewables industry. The current Australian government accepted its costing over the LNP costing. It may have been argued that nuclear power was not feasible in the Australian context because any benefits were outweighed by opportunity costs, additional costs to secure water cooling, the lengthy timelines, and perceived unresolved issues of long-term waste disposal and safety. It is not known if such discussion took place, but it was ultimately the view adopted by the Australian government.

How confident are the policy makers in Australia in making such arguments? Not very it seems because the current government is and remains 100% intent on blocking calls for the lifting of the nuclear energy ban.

Australia is the only G20 economy that has a ban on nuclear power for peaceful electricity generation. Two non-G20 developed countries, which had a ban on nuclear for electrifying their grid, either repealed the ban in May 2025 (Belgium); or are reevaluating its ban (Denmark). Australia provides foreign aid to five less developed countries that are constructing nuclear power plants. These are Bangladesh, India, Pakistan, Egypt, Turkey. What does the Australian government know that these countries don't know? If the government were confident in its arguments around low-carbon electrification, then it would not censor serious consideration of nuclear for energy.

# Life cycle carbon intensity

Australia's net zero electrification plan, which has been spearheaded by the left side of politics, aims to shift energy consumption away from fossil fuels because it is the combustion of fossil fuels that results in $CO_2$ emissions. However, in aiming for net zero emissions and in order to measure the success of this endeavour, it is critical to count not only the $CO_2$ emissions from fossil fuel combustion, but to count also those emissions arising from the manufacture and maintenance of the infrastructure of the whole electricity system. This requires assessment of life cycle carbon intensity.

Figure 5 from Our World In Data compares the carbon intensity of electricity generation in countries with broadly similar standards of living. Carbon intensity is reported as $CO_2$-equivalents emitted per kWh of electricity generated. For Australia, which had 40% renewable electricity generation in 2024, carbon intensity was an average of 554 g per kWh of electricity generated. The carbon intensities of UK and Germany, countries with more renewable penetration than in Australia, and using respectively some or no nuclear electricity generation, were 217 g and 338 g per kWh of electricity generated.

In USA, a country with an increasingly high percentage of gas generated electricity, as well as some nuclear in the mix, carbon intensity was 384 g/ kWh of electricity generated.

However, France and Sweden with high nuclear penetration +/- hydroelectricity, had the lowest carbon intensity of electricity generation with 41 and 35 g/ kWh respectively. This is more than 10-fold lower than Australia's and more than 5-fold lower than the carbon intensities of electricity generation in UK or Germany. (xi) **(Figure 5)**

Therefore, from Our World in Data, it seems to be clear that nuclear is better at reducing $CO_2$ emissions than a majority reliance on renewables or gas. Furthermore, the world's share of low C generated electricity would have been greater than 40% by now if percentage nuclear had not decreased from > 17% in the 1990s to < 9% in 2024(xii).

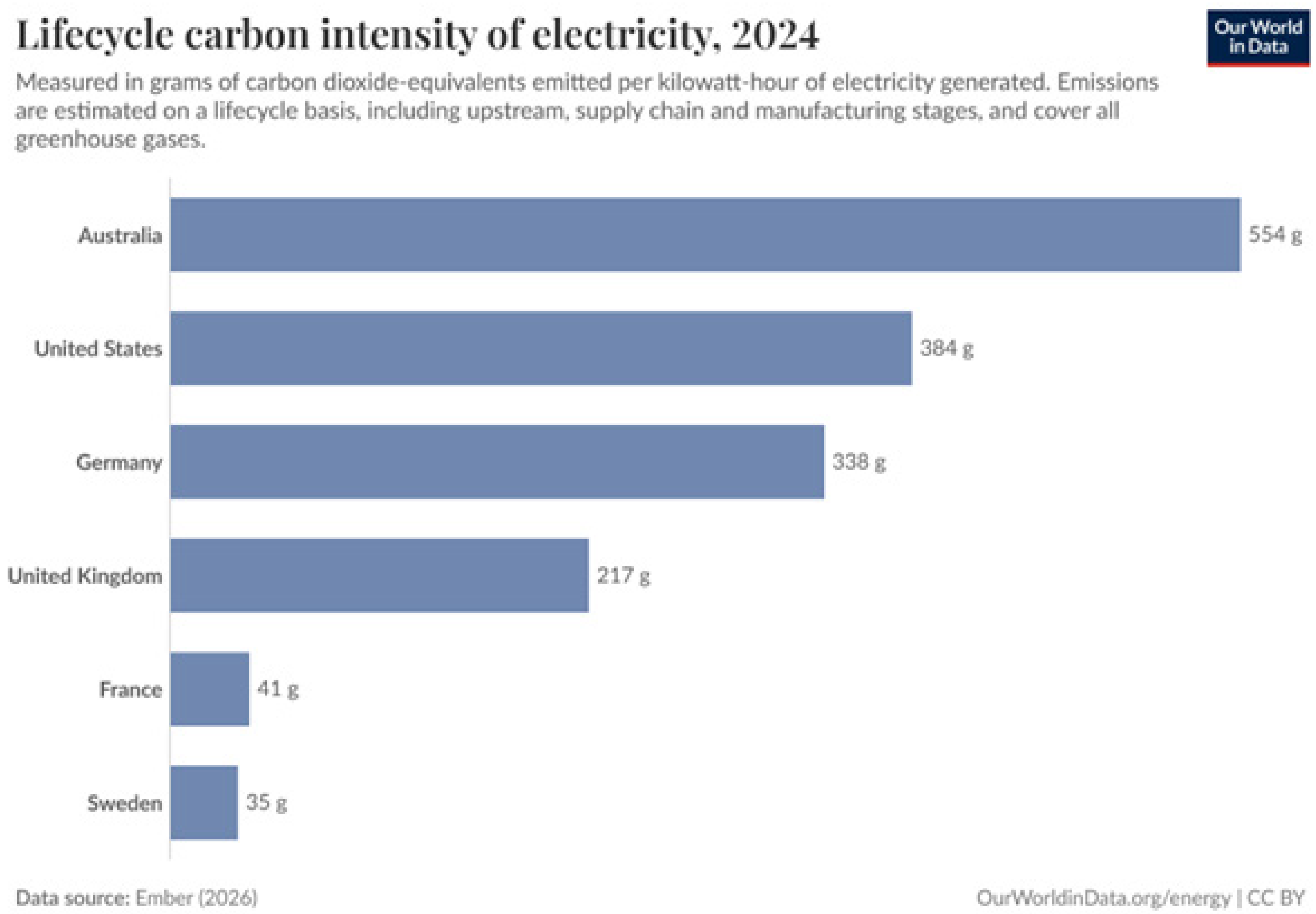


*Figure 5: Life cycle carbon intensity of electricity, 2024. Source: Our World in Data*

# Energy return on investment (EROI)

Energy Return On Investment (EROI) is a methodology to compare costs of the different modes of electricity generation. EROI calculations involve a comprehensive life-cycle analysis, including the energy costs of fuel associated with mining, extracting, processing, transporting, and the energy cost of building, maintaining and decommissioning the infrastructures. Nuclear is easily the most favorable, being 10x more economical over its life cycle than renewable sources and more than 2.5x more economical than fossil fuels over their life cycles. This EROI analysis assumes more than 90%+ time-utilisation for nuclear power plants **(Fig 6)**, but also readily available water for cooling. It is worth noting here that COP28's concluding recommendations were that the world should aim for a 3-fold increase in nuclear-generated electricity. There is bipartisan support for this in the USA, but not in Australia.

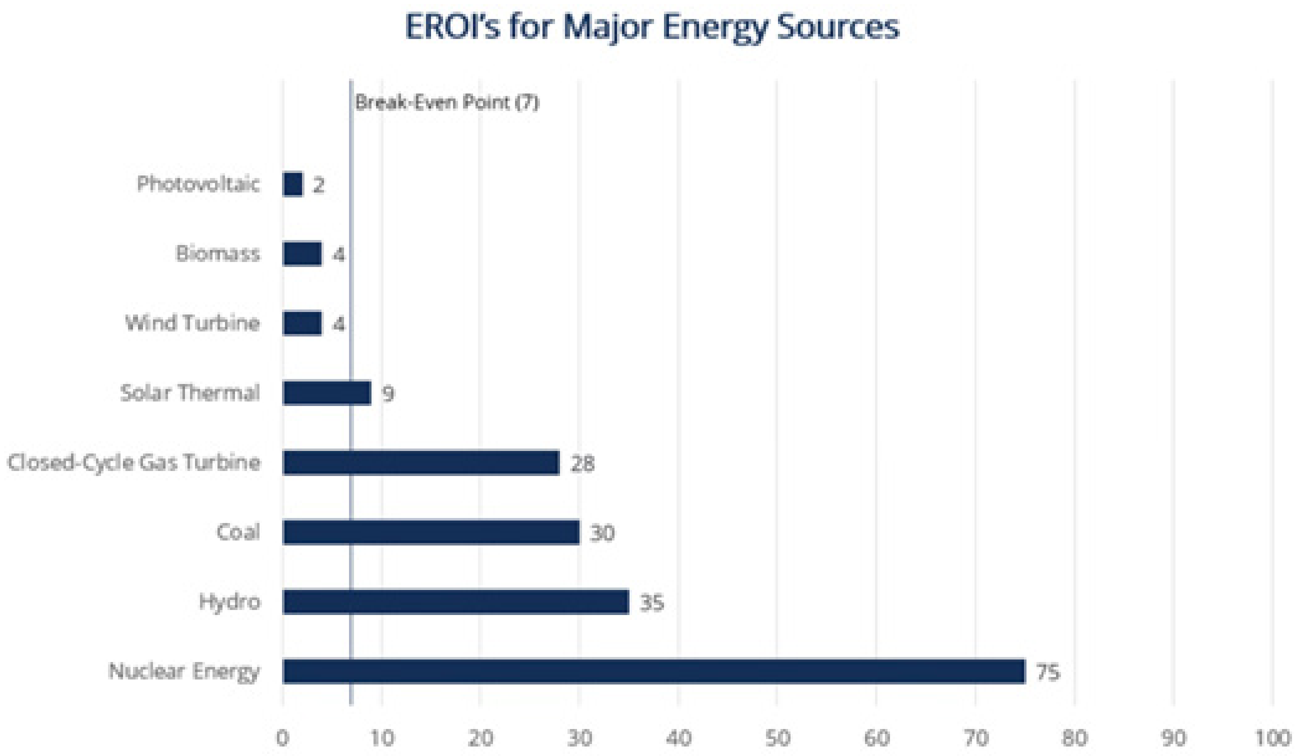


*Figure 6: EROI Source: Corporate Finance Institute (https://corporatefinanceinstitute.com/resources/accounting/energy-return-on-investment-eroi/)*

# Safety of nuclear v other electricity generation technologies

Nuclear is safe. This is the lived reality, as opposed to the perception of many Australians. World In Data Figure 7 compares mortality data for the different modalities of electricity generation.  The data to generate this figure are comprehensive. (They include major catastrophes such as Chernobyl and Fukushima). The lived reality is that nuclear energy generation is much safer than coal. It is safer than natural gas and hydro. It is safer than wind. In addition, it generates on average the lowest $CO_2$ emissions per GWh of electricity by any mode of generation.

The next sections relate to the Australian Eastern Grid, and to Germany's electricity production.

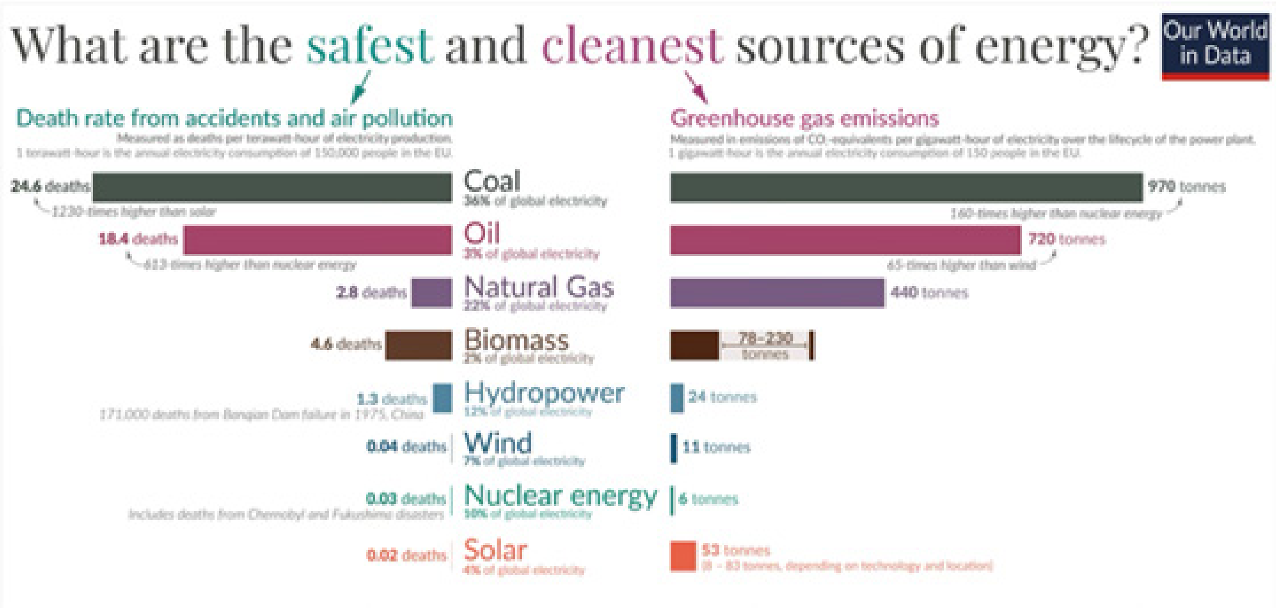


*Figure 7: What are the safest and cleanest sources of energy? Source: Our World in Data*

# The Eastern Australian grid

**Figure 8** shows the projected renewable infrastructure build for the total renewable integrated system plan (ISP) to 2050. This AEMO integrated system is a distributed system comprising customer generated electricity and storage as well as utility generated electricity from solar, and (at the time of this plan) off-shore wind. The total power capacity was projected to increase from ~60 GW to 300 GW per annum. Much but not all of this increased capacity would be from roof top solar and other customer energy resources (CER), which include electric vehicles (EVs) and home batteries. **Figure 9** "shows (the location of) indicative new generation and storage in 2040, and transmission projects that include new transmission lines, increased capacity by 500 MW (sic) or more, and are required in all scenarios by 2050".

Ben Beattie(xiii), an electrical engineer who comperes the The Baseload Podcast, contends that the 'transition' to the renewables-only system and its associated infrastructure appears to be more like the 'addition' of a costly renewable and storage infrastructure, rather than a 'transition' to it. This is because the ISP necessitates a substantial contribution from fossil fuel with an overbuild of renewable transmission and storage infrastructure, which aims to be large enough to compensate for intermittency. Gas (and a slivver of biomass) is still substituting for some coal. In other words, the reality is that this will not be a renewables-only ISP. Rather, AEMO now envisages this to be an addition of 'renewables' to a total electricity generating system, which must still rely on some fossil fuel, if it ever comes to fruition.

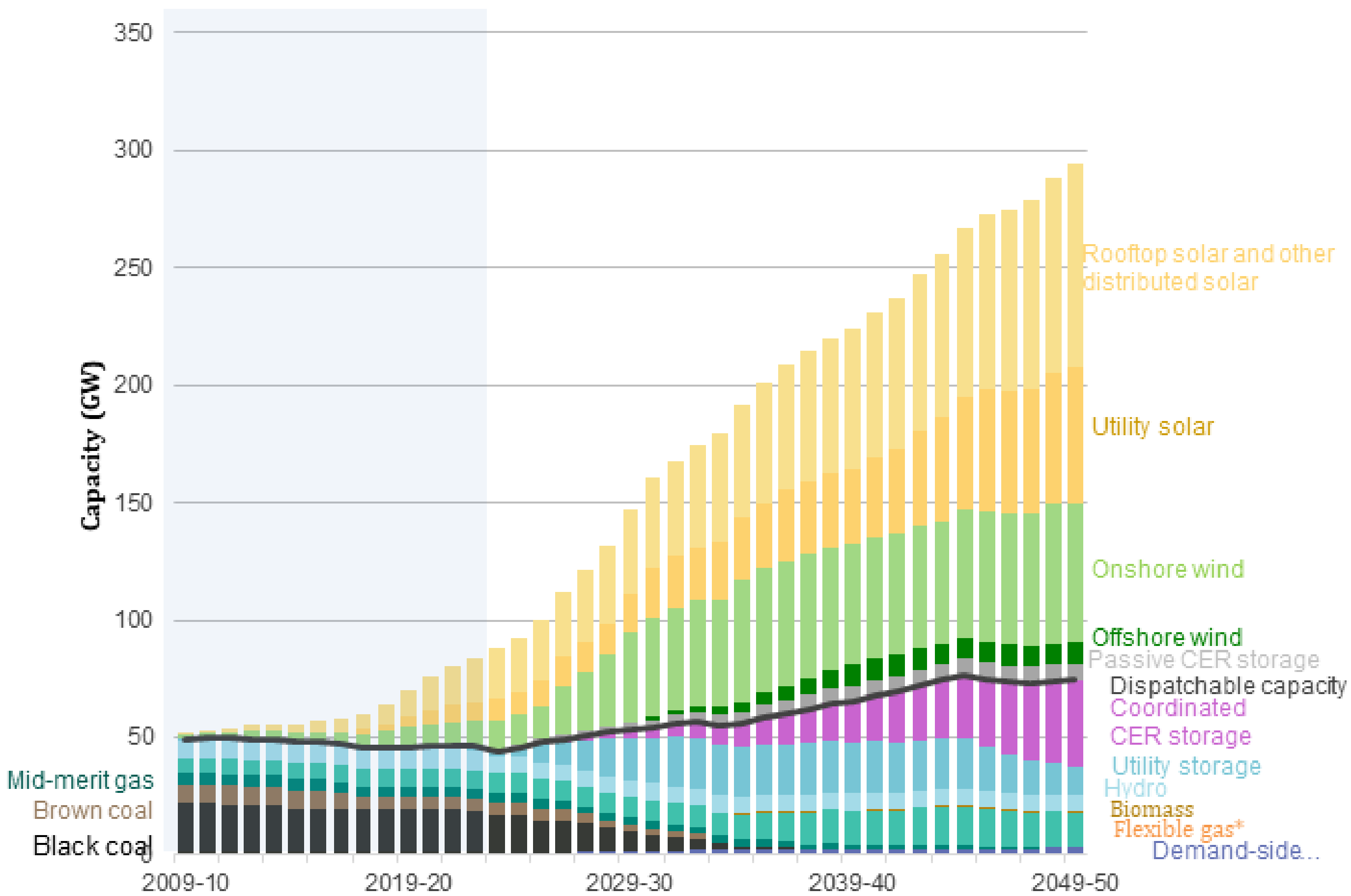


*Figure 8: 2024 Integrated System Plan: Report Charts version 1.0 (figure 2)*

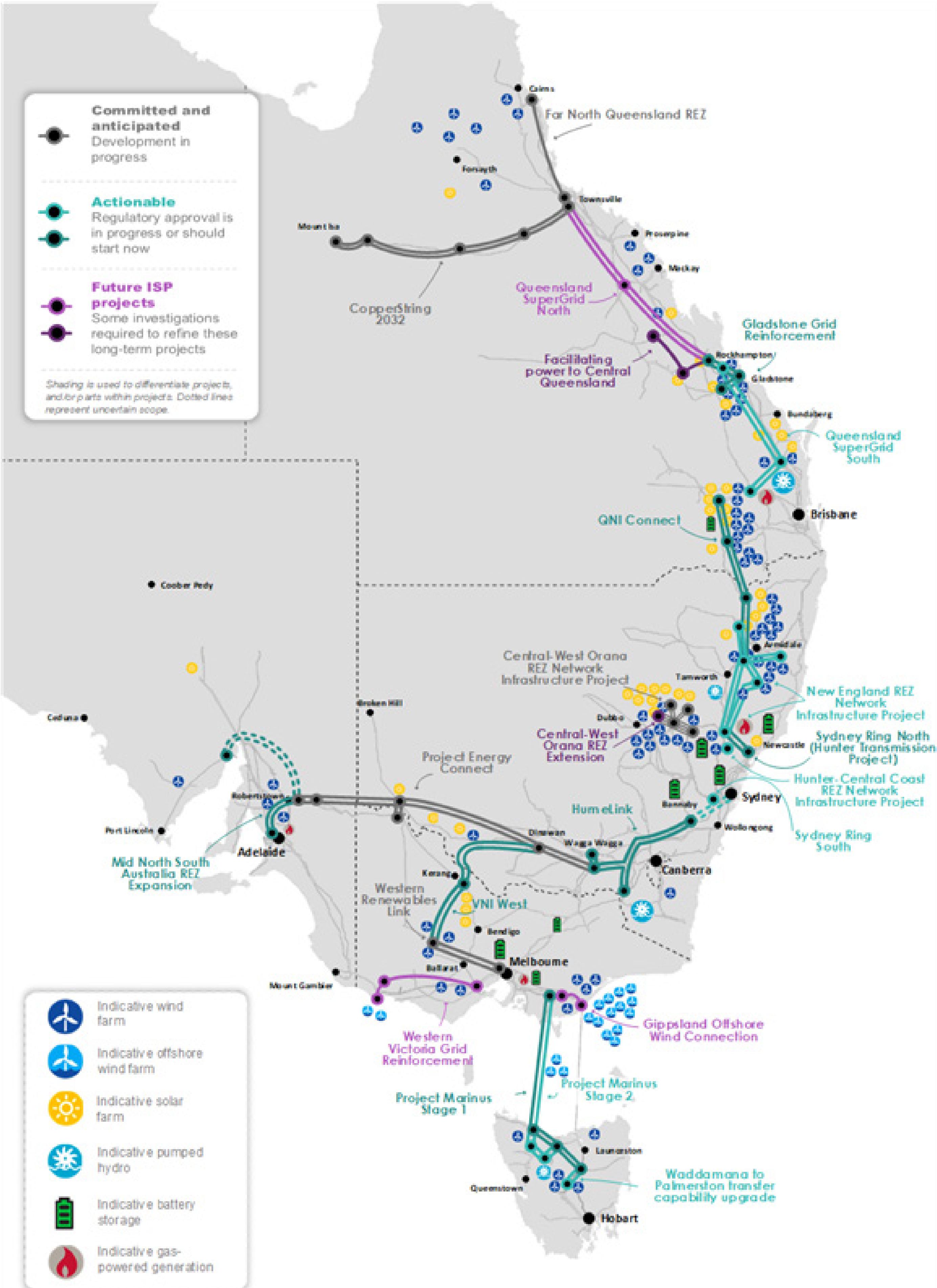


*Figure 9: 2024 Integrated System Plan: Report Charts version 1.0 (figure 3)    in Data*

# The German experience

Germany is further down the renewable electricity generation pathway than Australia with 59% of its electricity generation coming from renewables in 2024. In 2000, its renewable component of electricity generation was ~20%. **Fig 10** shows real world data from 2002 to 2025 as shared by Dr Lars Schernikau(xiv). The left-hand figure shows the electricity generation capacity; this was approximately one and a half times peak electricity demand in 2002, but this increased to more than 3.3-fold peak demand by 2025. While the fossil fuel component decreased significantly as a percentage of capacity from 67% to 26%, it has remained nearly constant in absolute values around 70 GW p.a over that time. The renewable component increased an impressive 7-fold, while home-generated nuclear was phased out by 2022.

The price of electricity in Germany is significantly higher than that in Australia, and around 2.5x the average consumer price in the USA. Much of the price of German electricity is due to government taxes to pay for the electricity generating infrastructure. Dr Schernikau believes that the reason that prices are high and increasing, relates both to the necessary infrastructure overbuild that is required for an intermittent, in large part renewable with battery storage system, and also to the ongoing requirement for firming by fossil fuels. The top right figure shows the breakdown of power sources for the electricity generated from 2002 to 2025. While over 58% was from renewables, 39% (194 TWh) was generated from fossil fuels in 2025. In addition, not shown, there was 15.8 TWh of electricity imported from France (nuclear) and an approximately similar amount from Denmark (renewable).

It is salutary to note that most energy consumption by industry and individual citizens has yet to be electrified.  That assertion has been writ large by the closure of the Strait of Hormuz. This AIP discussion paper is focused on electricity generation, but the bottom right figure shows a breakdown of sources for primary energy consumption in Germany, i.e. electricity plus the rest being energy for agriculture, industry, transport, etc. Primary energy consumption was around 5-fold more at 3000 TWh compared to electricity consumption, which totalled less than  600 TWh in 2025. Renewables (wind, solar) provided only 8% of primary energy consumption, but fossil fuels 77%.)

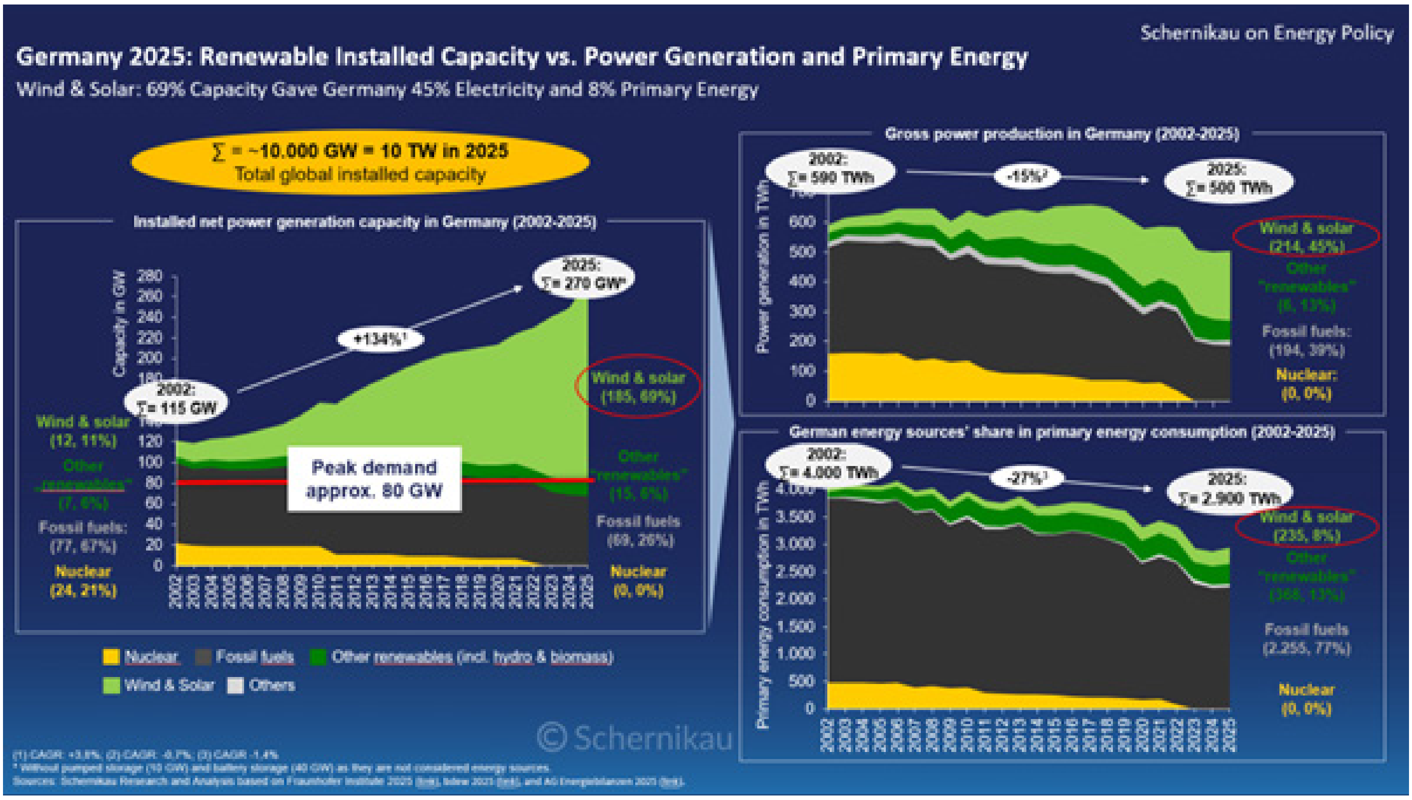


*Figure 10: Germany 2025: renewable installed capacity v electricity power generation, and primary energy. Source: Lars Schernikau http://unpopular-truth.com/wp-content/uploads/2026/02/Germany-2025-Renewable-Installed-Capacity.png*

# The German experience *CONTINUED...*

In summary, Lars Schernikau(xv), like Ben Beattie, believes that the transition away from fossil fuels in the absence of nuclear for baseload, is more like an addition replacing one 'dirty' system with four or more additional systems **(Fig 11)**.


*Figure 11: Replace one "Dirty" System with Four or Five "Clean" Systems Source: Lars Schernikau*

# Environmental considerations and conclusion

Environmental considerations are as important to me as the economic considerations, but I will cover these only briefly.

A renewable system may improve off-grid services but is a less obvious low-C choice for baseload-utility for urban conglomerates and industry. This is because of its extremely low energy density. One is talking here about the environmental footprint of the different modes of electricity generation. Wind and solar can generate 1-20 W/m$^2$; coal 8-10 kWh/kg; fission U-235 (nuclear) a whopping 24,000,000 kWh/kg(xvi). Solar has a place on roofs but there is an environmental, biodiversity and aesthetic cost to carpeting our land with acres of short lifespan solar panels and kilometres of access roads for transmission lines and wind turbines. A research paper from the Institute of Public Affairs(xvii) estimated that the footprint of Australia's renewables-only low-C electricity option will require a minimum of 7% of Australia's terrain. Australia is a big country, but its environment and biodiversity are fragile.

The placement of wind turbines or solar harvesting farms near existing transmission towers will reduce distribution costs. This is happening, for instance, in Queensland along the Great Dividing Range. There is no getting away from the fact that this results in some spoliation of the countryside. In some instances, there is damage to pristine forest, in order to realise the Eastern Australia grid (integrated system plan), which includes access roads and clearing for batteries as well as turbines and PV panels , is. It is estimated that the footprint of the completed renewables-only system will be greater than the whole of Tasmania by several factors according to Steven Nowakowski of Rainforest Reserves Australia (2025(xviii)).

In conclusion, there are environmental, economic and reliability trade-offs with all types of electricity generation.

- Biofuels, gas, coal, oil all emit $CO_2$. They have nowhere near the energy density of nuclear.
- Renewable energy harvesting by industrial PV panel and wind turbine farms require a lot of space and on viewing visual footage from Steven Nowakowski, I am arguing is causing some irreparable damage to Australia's fragile environment.
- Mining is 'dirty' whether it be for coal or gas or uranium and their downstream processing or for mining large amounts of 'rare earth' and other minerals like nickel for batteries or turbines or for the making of concrete bases for industrial turbines, or hydroelectric dams. The mining, processing, manufacture and placement all impact the environment.
- Batteries deliver electricity for only short periods and have a non-negligible risk of catching fire.
- Nuclear has long term waste problems that require mitigation. Coal has a large waste problem.
- All electricity generating modes eventually require decommissioning and replacement, some much sooner than others. PV panels, turbines and batteries, which have comparatively short lifespans, all have disposal problems.

The global evidence suggests three broad observations. Electricity consumption remains closely linked to economic prosperity; global $CO_2$ emissions continue to rise despite rapid renewable deployment; and countries with large nuclear electricity sectors tend to have some of the lowest carbon-intensity electricity systems in the developed world.

These observations do not settle every policy question, but they raise a reasonable question about whether Australia should continue to exclude nuclear power entirely from consideration. Australia has never properly considered low-C nuclear for its integrated system plan.

I am asking  those readers, who currently embrace the largely renewables-only electrification option, to interrogate for themselves the publicly available global data from Oxford University's Our World In Data on electricity, energy, population and $CO_2$.

# Endnotes

[i] GDP per capita,1820 to 2022: https://ourworldindata.org/what-is-economic-growth

[ii] Dr Saul Griffith https://www.youtube.com/watch?v=XoqpTaXig1w. at 17.5 minutes into the submission

[iii] https://ourworldindata.org/electricity-mix

[iv] $CO_2$ emissions per capita in https://ourworldindata.org/CO₂ -and-greenhouse-gas-emissions

[v] Electricity production by source in https://ourworldindata.org/electricity-mix

[vi] https://www.greenhouseaccounts.climatechange.gov.au/

[vii] https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/consumer-price-index-australia/nov-2025

[viii] Chris Uhlmann, Powerlines December 1, 2025 https://chrisuhlmann.substack.com/p/fancy-a-model-wait-till-she-moves

[ix] https://www.netzeroaustralia.net.au/publications/

[x] Climate Change Authority Annual Progress Report 2023 https://www.climatechangeauthority.gov.au/2023-annual-progress-report

[xi] https://ourworldindata.org/grapher/carbon-intensity-electricity?tab=line

[xii] https://ourworldindata.org/electricity-mix

[xiii] https://substack.com/@benbeattie

[xiv] https://schernikau.substack.com/about

[xv] Lars Schernikau, Smith, Falcon Journal of Management and Sustainability; Vol. 12, No. 1; 2022; https://www.freedom-research.org/p/energy-expert-dr-lars-schernikau

[xvi] Ben Layton 2008 International Journal of Green Energy, 5: 438–455

[xvii] Analysis of Land Use by Variable Renewable Energy Production by 2050, Drs Kevin You & Morgan Begg, IPA December 2023

[xviii] Stephen Nowakowski www.rainforestreserves.org.au (2025)