Logistics and costs for Australia to achieve net-zero carbon dioxide emissions by 2050

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Foreword

Across the world, politicians are going out of their way to promise costly climate policies. For example, US President Joe Biden has pledged to spend $US500bn ($648bn) each year on climate — about 13 per cent of the entire federal revenue. The EU will spend 25 per cent of its budget on climate.

In this report, I'll present what net-zero carbon dioxide emissions by 2050 means for Australia in terms of cost and the rate of deployment of carbon-free energy and the coincident decommissioning of fossil fuel infrastructure.

I have carried out extensive research on what this target will mean for Australia. This research can be verified by reference to the endnotes.

To achieve the target, Australia will need to install a massive amount of wind turbines, rooftop solar systems and solar farms.

For stability of electricity supply, a system of CO2-free baseload power must also be installed, either by nuclear power generation or by a system of utility-scale battery systems.

This report provides costings for each baseload power option.

For the nuclear power generation option, I calculate the total cost of net-zero for Australia by 2050 as 1.4 trillion dollars.

Battery systems are considerably more expensive in providing an equivalent amount of energy.

In the event the nuclear option is not palatable for the government in power and based on the United States Energy Information Administration figures, I calculate the cost of achieving net-zero with a battery system as 4.47 trillion dollars.

As a guide to the magnitude and accuracy of these numbers, I refer the reader to Bank of America's October 2021 report, wherein the bank's researchers claimed the global cost to reach net-zero by 2050 is a staggering US$150 trillion (A$208 trillion)[1].
Australia's economy is 1.7% of the global economy, and therefore, its share of the cost is estimated at A$3.53 trillion. This is more than the nuclear option but less than the battery option. A combination of the two options would be very close to this theoretical cost.

To conduct the analysis, I used data from the federal government report **'Australian Energy Update, Commonwealth of Australia 2020 – Guide to the Australian Energy Statistics 2020'**[2], as well as other sources quoted in the endnotes.

Contents

Executive summary

This study will show that to achieve net-zero carbon dioxide emissions by 2050, Australia will need to:

1. Decommission an amount of fossil fuel-burning generators, vehicles and equipment that collectively consume 1,085,000 gigawatt-hours of fossil fuel annually and replace with zero-emission equipment.
2. Install 125,000 wind turbines over an area of 60,000 square kilometres, an area as large as the area of 3 million MCG stadiums. Construction and installation of the turbines will consume 38 million tonnes of steel and 150 million tonnes of concrete.
3. Install 6 million rooftop solar systems.
4. Build 23,000 solar farms.
5. For the 516,000 gigawatt-hours of fossil fuel-burning equipment that cannot be replaced, provide carbon offsets by planting 36 billion trees for a total cost of $54 billion.
6. Build six new baseload power stations utilising small nuclear reactors, or install an industrial scale battery system to provide baseload power.
7. Spend an estimated total of $842 billion on renewables infrastructure
8. Take an estimated $540 billion hit to the economy.

This infrastructure requirement may be tweaked with more of some items and less of others, but it will still need to add up to the total number of gigawatt hours to replace or offset.

The total gigawatt-hours are based on Australia's current energy usage, derived from the Australian government report **'Australian Energy Update, Commonwealth of Australia 2020 – Guide to the Australian Energy Statistics 2020'**.

If construction started on 1st January 2023, a total of 386 wind turbines would need to be installed every month, or 13 every day, until 2050, at a total cost of $500 billion.

In the same time frame, 19,000 solar rooftop systems would need to be installed every month together with 72 solar farms at a total cost of $343 billion.

The total infrastructure cost would run out at $842 billion, not including the cost of baseload power or offsets.

For all the massive costs and societal disruptions, the impact on global temperatures would be, in the words of Australia's chief scientist, "virtually nothing".

1. Definitions

To those not familiar with the subject I will give a brief explanation of the terms and units used in this analysis.

A watt is a unit of power and is used to quantify the rate of energy transfer.

Units: 1 kilowatt (KW) is a thousand watts

1 megawatt (MW) is 1,000 kilowatts = 1 million watts

1 gigawatt (GW) is 1,000 megawatts = 1 billion watts

Electrical generating plants are often designated as having a capacity of so many Megawatts or even Gigawatts, but this is not very helpful as it doesn't specify how much electricity it can actually generate over a specified time period.

A more useful unit is the megawatt-hour (MWh) or gigawatt-hour (GWh), which is the actual amount of electricity generated over one hour. For example, an electricity generator supplying one megawatt of energy for one hour will generate one megawatt-hour (MWh) of electricity. For generators operating 24 hours per day, such as coal or nuclear plants, a one-megawatt plant can generate 8,760 megawatt-hours (MWh) in one year, where 8,760 is the number of hours in one year. For a solar farm where the solar panels can only gather energy five hours per day, the multiplier becomes 8760 x 5/24.

A further complication is that the Australian Energy Update Report specified above quotes most energy consumed or generated in another unit, petajoules (PJ). For this analysis, I have converted petajoules to gigawatt-hours, where one petajoule is equal to 277.778 gigawatt-hours.

I added an extra column to the tables derived from the above report showing energy also in gigawatt-hours, which makes it easier to follow examples later.

1. Australia's energy consumption per annum

The relevant figures for energy consumption are shown in Table 1:

Table 1 - Australian Energy Consumption by Energy Type - 2019

	PJ	GWH	Share (per cent)
Oil	2,402.1	667,250.5	38.8
Coal	1,801.6	500,444.8	29.1
Gas	1,592.7	442,417.0	25.7
Total Fossil	**5,796.4**	**1,601,112.3**	**93.6**
Renewables	399.6	110,000.0	6.4
Total	**6,196.0**	**1,711,112.3**	**100**

PJ is energy in petajoules
GWH is energy in gigawatt hours
1 petajoule = 277.778 gigawatt hours
Source: Australian Energy Update, Commonwealth of Australia 2020

The figures include not only electricity generation but fuels consumed by industry, aircraft, passenger vehicles, trucks, mining equipment and heavy machinery. With over 2 million rooftop solar systems, a number of solar farms and wind turbines, renewables provide only 6.4 per cent of Australia's energy needs.

The problem of looking to renewables to supply all of Australia's energy needs by 2050 is the difficulty of scaling up. Some 20 per cent of all residences, mainly the more affluent, already have rooftop solar. This relatively high figure was achieved mainly because of large taxpayer-funded subsidies. Under this scheme, the less wealthy homeowners are often subsidising the more wealthy homeowners who can afford to install solar.

2. Replacing fossil fuels with renewables

For Australia to reach its net-zero target with renewables, it will have to decommission 1,601,112 GWh of fossil fuel generators and devices (Table 1) and replace them with a combination of solar and wind turbines. Where they can't be decommissioned, carbon offsets will have to be deployed.

In addition to installing renewables, provisions must be made for baseload and backup energy. The only two options are nuclear power generation or utility-scale battery systems.

Not all fossil fuel devices can be decommissioned. A problem arises with converting large trucks and industrial machinery to electric.

For example, the Caterpillar 797F dump truck is powered by a 4,000 horsepower turbocharged diesel engine. At full power, it will require 2.98 megawatts of energy. Assume the truck runs at 50 per cent of maximum power for an eight-hour shift. It would consume around 12 megawatt-hours of electricity. It would need 120 of Tesla's latest automotive batteries to power it. The batteries would weigh 64 tonnes

This is just an example of the impossibility of converting large machinery to electric. Not to mention converting a Boeing 787.

The following table lists energy consumed by sectors that can only be partially converted.

Table 2 -Australian Energy Type by Sector

	PJ	GWH
Transport	1,748.4	485,667.0
Manufacturing	1,050.2	291,722.4
Mining	812.4	225,666.8
Agriculture	103.1	28,638.9
TOTAL	**3,714.1**	**1,031,695.1**

PJ is energy in petajoules
GWH is energy in gigawatt hours
1 petajoule = 277.778 gigawatt hours
Source: Australian Energy Update, Commonwealth of Australia 2020 Page 11

Let's assume that 50 per cent of the vehicles and equipment in these sectors can be converted to electric. That amounts to 515,847 GWH to be subtracted from the total fossil fuel amount of 1,601,112 GWH (Table 1), leaving 1,085,265 GWH to be replaced by renewables. The other 515,847 GWH will need to be dealt with by carbon offsets, which we will come to.

The following table lists the sources of renewable energy in Australia for the 2019 year. The only renewables with expansion capability are wind and solar PV. The other sources are mostly static.

Wind and solar make up just 32,633 gigawatt-hours of the total.

Table 3 - Australian Renewable Energy Consumption by Fuel Type For 2019 year

	PJ	GWH	Share (per cent)
Biomass	179.1	49,750.0	44.8
Biogas	16.3	4,527.8	4.1
Biofuels	7.4	2,055.6	1.9
Other	4.6	1,277.8	1.2
Hydro	57.5	15,972.2	14.4
Wind	63.8	17,772.2	16.0
Solar PV	53.5	14,861.1	13.4
Solar hot water	17.5	4,861.0	4.4
TOTAL	**399.7**	**111,027.9**	**100.0**

PJ is energy in petajoules
GWH is energy in gigawatt hours
1 petajoule = 277.778 gigawatt hours
Source: Australian Energy Update, Commonwealth of Australia 2020

3. The task

And therein lies the problem. How do we scale up some 33,000 GWH of wind and solar to 1.085 million GWH, a factor of 33?

Iced-up solar panels Germany February 2021

A large amount of baseload power will still be needed when the wind stops blowing, and the sun stops shining.

There are two options to provide the necessary "clean" baseload power: Nuclear power generating plants or industrial-scale battery storage systems. Both options will be explored in this paper.

I calculate (Section 9) the minimum baseload power requirements as 14,000 GWH.

That leaves a balance of 1,040,000 hours (rounded to the nearest thousand) to be shared between wind and solar. Table 4 shows the split between wind, solar and nuclear.

Table 4 - Fossil fuel replacements and offsets

	Gigawatt hours per annum	GWh/unit	Total units
Total fossil fuel emissions	1,601,112		
less carbon offsets	516,000		
Net replacement	1,085,112		
Baseload - nuclear or battery	14,000		
Balance - wind and solar	1,071,112		
70% wind	749,778	6	124,963
10% rooftop solar	107,111	0.017	6,300,659
20% solar farms	214,222	9.12	23,489

If the split is 70 per cent wind and 30 per cent solar it equates to 750,000 GWh for wind, 214,000 GWh for solar farms and 107,000 GWh for rooftop solar, which will require 6.3 million installations (there is a total of 9 million dwellings in Australia and around 2 million rooftops already have solar.) All figures are rounded.

One wind turbine can generate on average 6 gigawatt-hours of electricity per annum. In a windfarm, the generally accepted minimum area required for each turbine is 0.5 square kilometres. This is to take into account topography and to ensure minimum air turbulence between turbines.

Wind turbines chop up a large number of birds and bats each year. Figures are hard to come by, but the US Fish and Wildlife Service estimate America's 67,000 wind turbines kill up to up to 500,000 birds and 888,000 bats each year.[3] Based on the US figures, the required 124,000 turbines could kill around one million birds, including the iconic wedge-tailed eagle, and 1.6 million bats annually.

The cost of an average wind turbine of 3 Mw capacity is about $4 million. The cost of installing 124,000 wind turbines in Australia will run out at around $500billion. In addition, maintenance, estimated at $45,000 per unit will cost an additional $5.35 billion per annum.[4]

Materials required

Material requirements of a modern wind turbine have been reviewed by the United States Geological Survey. On average, 1 MW of wind capacity requires 103 tonnes of stainless steel, 402 tonnes of concrete, 6.8 tonnes of fibreglass, 3 tonnes of copper and 20 tonnes of cast iron. The elegant blades are made of fibreglass, the skyscraper-sized tower of steel, and the base of concrete.[5]

4. Carbon footprints

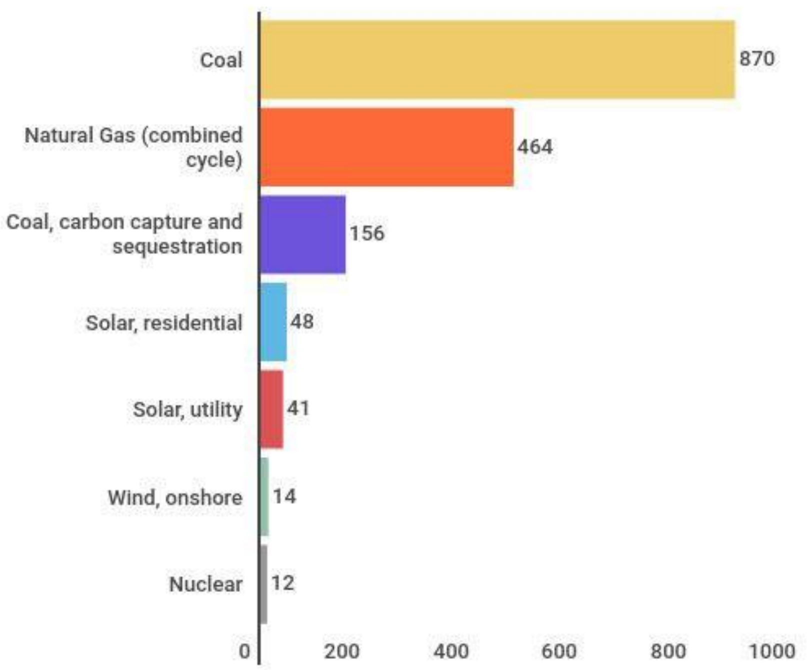
All types of electricity generators have a carbon footprint, which is the amount of CO2 generated over its lifecycle, from mining its constituent minerals, to the construction, maintenance and decommissioning of the generator.

Figures vary from researcher to researcher, but I have taken the figures of the 2017 report from the University of Texas as being the most authoritative[6].

The University of Texas carbon footprint figures for various forms of electricity generation are shown in the chart below.

One gram of CO2 per KWh equates to one tonne of CO2 per GWh.

Table 5 Estimated Carbon Footprints



grams of CO2 per kilowatt of electricity produced

Source: Joshua D. Rhodes, University of Texas at Austin, Energy Institute, 2017

5. Solar farms

Many solar farms are being built around Australia, but they still account for a small percentage of renewables generation. I used a December 2019 report by MCG Quantity Surveyors[7] to arrive at the cost of building a 5-megawatt solar farm. The average cost from the two case studies is $11.9 million. Assuming an area of 20 acres is required for a solar farm of this size gives a total space requirement of 1,900 square kilometres.

6. Cost comparisons

One way of comparing the costs of different energy producers is known as the levelised cost of energy (LCOE) which includes the lifetime costs of building, operating, maintaining and fuelling a power plant. The LCOE is calculated as the ratio between all the discounted costs over the lifetime of an electricity generating plant divided by a discounted sum of the actual energy amounts delivered.

Table 6

Levelized cost of electricity
Based on 5% WACC

Generator type	Median cost 5% WACC USD/MWh
Coal	61
Gas - Combined Cycle	71
Biomass - Dedicated	130
Geothermal	130
Hydropower	22
Nuclear	65
Concentrated Solar Power	150
Solar PV - rooftop	150
Solar PV - utility	110
Wind onshore	59
Wind offshore	120

Source: IPCC wg3 ar5 Table A.111.1 Page 1333

7. Carbon offset calculations:

Finally, let's deal with the matter of carbon offsets. Rounding out the calculation above, we had an estimated 500,000 GWH that cannot be replaced with renewables. We must instead use carbon offsets by the planting of trees. In order to prevent fraud, the trees must be planted in Australia, where they can be monitored.

One kilowatt-hour of fossil fuel burning generates 0.707 kilograms of CO2[8]

According to the US Department of Agriculture, one mature tree can absorb 21 Kg of CO2 per annum.[9] However, for the carbon offset calculations below, I have chosen Pinus Radiata because it is one of the fastest-growing trees. The information on sequestration of Pinus Radiata is sketchy, but it appears to be about 10 Kg per annum.

The table below calculates the total number of trees to be planted at 36 billion.

Table 7 - Carbon Offset Calculation

Units	Quantity	CO2 emitted (Kg)
Fossil fuel emissions/KWH	1	0.707
Emissions per gigawatt hour	1	707,000
		CO2 absorbed (Kg)
Tree	1	10
Trees/Gigawatt hour	70,700	
Total Gigawatt hours P/A	516,000	
Total trees required	36,481,200,000	
Carbon sequestered P/A (tonnes)	364,812,000	
Total cost @ $1.50/tree	$54,721,800,000	
Total are (Hectares)	36,481,200	

Number of trees to be planted to offset burning of fossil for equipment that can't be converted to electric

The 515.847 GWh to be offset annually is calculated on page 6.

The trees will take 20-30 years to reach maturity before they can sequester this amount of CO2

Area required is based on 1,000 trees per hectare

The trees will take 20-30 years to reach maturity before they can absorb their full 10 kilograms of CO2 so there will be a constant backlog. A dog chasing its tail comes to mind.

It is difficult to get an estimate of tree planting costs, but let's assume the cost of each plant, together with labour, roads, firebreaks, maintenance, and management amounts to $1.50 per tree. That amounts to $53 billion in total.

It does not take into account the acquisition of land.

8. Baseload power

Option One: Nuclear power plants

Currently, there are 440 nuclear reactors in thirty countries in operation around the world. As of April 2020, 55 reactors were under construction, including 4 in the US and 12 in China.

Nuclear-produced energy is clean, green, reliable baseload electricity. Australian politicians will have to get their heads around the fact that nuclear power is the cheapest baseload option essential to meeting their net-zero targets. The only alternative is the far more expensive utility-scale battery system.

In its 2019 submission to the federal government **Inquiry into the Prerequisites for Nuclear Energy in Australia,** GE-Hitachi estimated the overnight capital cost of its BWRX-300 modular reactor at one billion dollars, where the overnight cost is the cost of the units without finance costs. Taking the worst case, the total finance costs could be as high as 30 per cent over the time taken to build and install such a plant.

This would bring the total cost per plant to $1.3 billion.

Operating 24/7, each 300 megawatt nuclear reactor can produce 300 x 8760 megawatt hours per year.

= 2,628,000 megawatt hours per year
= 2,628-gigawatt hours per year

Where 8,760 is the number of hours in one year.

To ensure continuity of energy supply, with a margin of safety, it would be desirable to instal one small modular reactor in each mainland state.

The reactors would produce:

6 nuclear plants x 2,628
= 15,768,000 MWh
= 15,768 GWh

The total cost of the six nuclear power plants is estimated to be $7.8 billion

Based on a study by the University of California, Berkeley, building such a plant requires approximately 8,000 tonnes of steel and 55,000 tonnes of concrete[10]

The practicalities for Australia are that after overcoming massive environmental hurdles, placing orders, training technicians and incurring long construction times, the first nuclear power plant would not be commissioned before 2030. That time frame is optimistic considering the time allocated to build Australia's next-generation submarine fleet. That leaves just 240 months to build six nuclear plants, or one plant every three years.

Australia has by far the largest identified uranium resources in the world[11]

Option 2. Battery storage systems

If nuclear power generation proves to be unpalatable for the government in power, the only alternative at this stage of technology development is large-scale battery storage systems.

However, liquid hydrogen may be viable at some time in the future.

Battery storage systems will serve two purposes: smooth out daily fluctuations in generating capacity and electricity demand and to provide electricity during full or partial shutdown of the grid.

During October 2021, wind power generation across Europe collapsed due to lack of wind, an event that persisted for weeks. Britain's 3,000 wind turbines stood still for many days.

I have estimated that to overcome such events in Australia, battery storage systems will need the capacity to supply 30 per cent of total energy needs for a minimum period of five days. Considering the events in Britain and Europe, I consider this to be the very minimum requirement.

Table 8 examines the costs of battery storage systems.

The cost of industrial-scale battery systems has been established by a US government agency, the US Energy Information Administration.[12] as ranging between US347(A$482)/KWh to $US423(A$587)/KWh depending upon the size of the installation.

I have chosen the lesser figure of A$482/KWh for these calculations.

The cost estimate includes civil works, foundations, buildings, electrical equipment and related equipment, substation, switchyard, transformers, transmission lines, cabling, controls, and instrumentation.

Some studies suggest costs of batteries may drop by around 60 per cent by 2050. However, as the lithium ion batteries have a lifespan of some 3,000 cycles (around ten years), the batteries must be replaced after ten years. Any batteries installed over the next five years will be replaced twice by 2050.

I have prepared a spreadsheet calculating the total cost of a battery installation program, for a number of different scenarios, taking into account the cost of battery replacement, assuming an equal number of batteries will be installed each year until 2050.

The spreadsheet calculations assume battery installation costs will reduce by two per cent each year.

I have assumed the minimum backup requirement as providing thirty per cent of the required gigawatt-hours for a period of five days. The spreadsheet reveals the total cost of the battery installation program by 2050 under this scenario will be A$3 trillion.

Table 8 - Battery Storage Calculations		
Australia's total annual energy needs GWh		1,700,000
Less carbon offset GWh		516,000
Net energy requirements after offsets GWh		1,184,000
No of GWh Per day		3,244
No of GWh in 5 days		16,219
Assume 30% battery power required Gwh		4,866
Battery storage cost per KWh	A$	482
Battery storage cost per Gigawatt-hour	A$	482,000,000
Cost for 5 day backup at 30% - refer spreadsheet		**A$ 3.0 trillion**

The spreadsheet can be viewed at: https://actforaustralia.org/how-to-calculate-battery-costs-for-net-zero-australia/

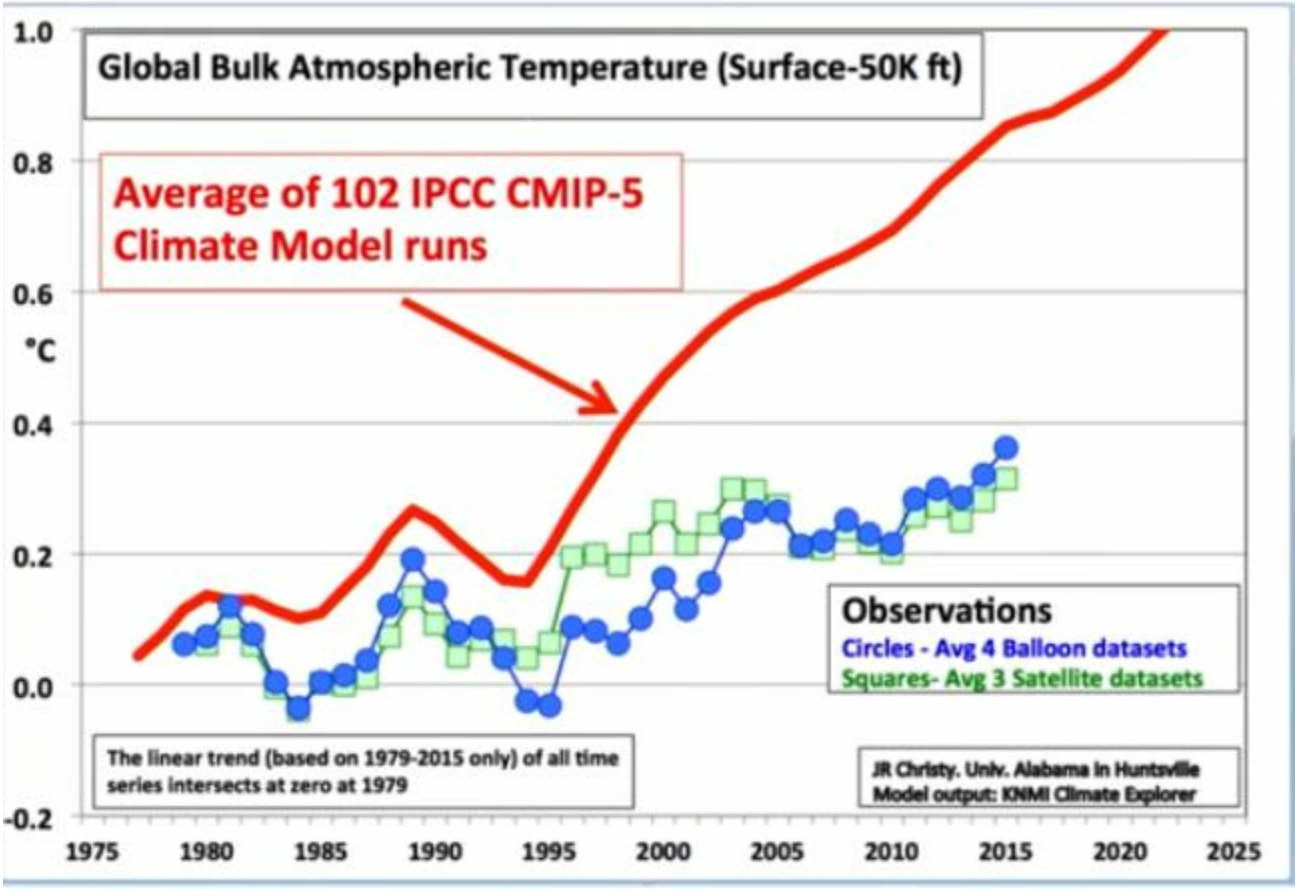
This figure does not take into account the cost of transmission lines connecting the batteries to the grid, or interest on the capital required.

The battery calculation is just an exercise to demonstrate the horrendous costs of installing battery systems. In reality, the relevant authorities would overbuild wind and solar to reduce the battery requirements. Nevertheless, when the sun doesn't shine or the wind doesn't blow, battery power will be required. For example, every day, the battery system and wind farms, if generating, will have to supply around 490 gigawatt-hours of energy when solar farms and solar rooftop systems shut down at night.

9. The global warming hypothesis

All of this economic pain and industrial disruption over an unverified hypothesis about the impact of carbon dioxide on global temperatures. Looking at the climate change subject rationally, it is quite bizarre that a colourless, odourless trace gas comprising just 0.04 per cent of the earth's atmosphere and essential to all life on the planet can be routinely described by governments and the media as a "pollutant." All life is carbon-based, and the primary source of this carbon is the CO2 in the global atmosphere.

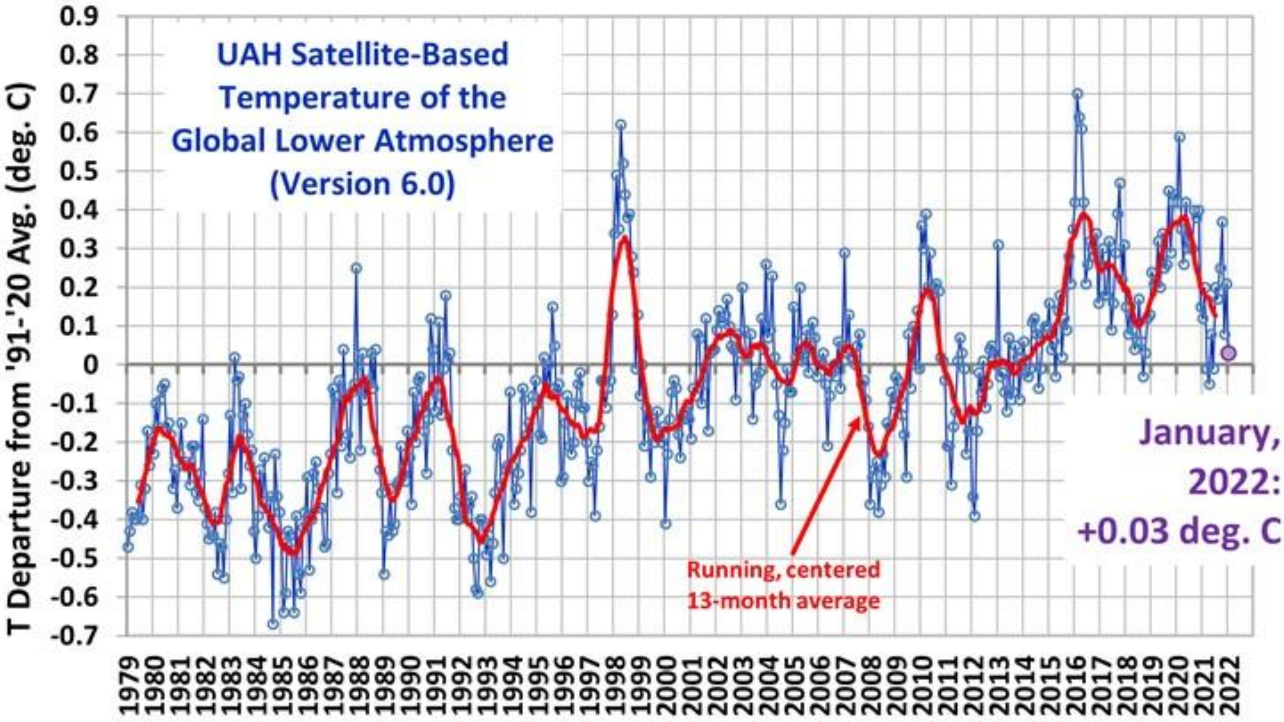
There is no scientific evidence the planet is in any danger from runaway global warming. A "consensus" between a select group of "scientists" is not science. Science does not depend on consensus. It depends on testable hypotheses. We have a hypothesis that fossil fuels may be responsible for the minimal increase in temperature over the last century. But such a hypothesis can only be tested over a very long period of time. All we have so far are predictive models. These have already been shown to be grossly inaccurate.



The top line of the chart above is what gets climate catastrophists such as Al Gore, Sir Richard Attenborough, Prince Charles and Greta Thunberg in a lather. To these and many other activists, the top line "proves" the planet is heading for a sizzling Armageddon. Sadly the line is divorced from reality. It is just a representation of computer modelling, which over time, has been proven to be hopelssly inaccurate. The bottom datasets represent actual temperature measurements.

Dr Roy Spencer is one of the world's leading climatologists. He is the Principal Research Scientist at the University of Alabama in Huntsville, USA. His team carry out what is regarded as the most accurate measurements of the earth's temperature from satellite readings of the earth's entire lower atmosphere, using NASA's Aqua satellite.

The latest chart from Dr Spencer's team reveals that for the forty three years from 1979 to January 2022 the earth's temperature rose by a miniscule 0.03 degrees Celsius.



As there has been no discernible increase in earth's temperature for the past forty three years, the term "global warming" has quietly been abandoned in favour of an all-encompassing "climate change". Now every anomaly, whether it be drought, floods, bushfires, hurricanes and even earthquakes, can be attributed to the nebulous "climate change".

There is no evidence that hurricanes and cyclones are increasing in frequency and intensity. In fact, the reverse is the case.[13]

Studies by reputable institutions, including the CSIRO, have concluded the average sea level rise between 1992 and 2016 is a minuscule 3.31 millimetres annually,[14] nothing like the six metres claimed by Al Gore.

The one indisputable fact about CO2 is that it is essential for all life on earth. Without it, there would be no life on earth for two very good reasons.

Firstly, CO2 is plant food. All plant life depends upon CO2. No CO2 means no plant life and hence no life on earth.

Secondly, the so-called greenhouse gases, of which carbon dioxide is just one, combine to make the planet habitable by raising the average temperature of the earth by some 20 degrees Celsius.

Without this greenhouse effect, the planet would largely be an uninhabitable ice sheet.

Carbon dioxide should be revered, not demonised.

Statement from Australia's Chief Scientist, Alan Finkel:

"On 1 June 2017 I attended a Senate Estimates hearing where Senator Ian Macdonald asked if the world was to reduce its carbon emissions by 1.3 per cent, which is approximately Australia's rate of emissions, what impact would that make on the changing climate of the world. My response was that the impact would be virtually nothing".[15]

Embarrassed, Finkel quickly put out a media statement trying to cover his tracks, but he did not deny his statement.

10. Summary

In section 4, I asked the question, how do we scale up from the current 33,000 gigawatt-hours of wind and solar to 1.085 million GWh, a factor of 33?

Together with the proposed nuclear plants, or battery system and the carbon offsets (table 7), this is what is required for Australia to achieve its target of net-zero carbon dioxide emissions by 2050.

Table 9 reveals Australia must install 386 wind turbines per month, or 12 every day, as well as 19,446 rooftop solar systems and 72 solar farms every month until 2050, a logistically impossible task.

Table 9 - Rate of deployment

	Wind turbines	Solar rooftop	Solar farms
Total units required	124,963	6,300,659	23,489
Deployment annually	4,628	233,358	870
Deployment/month	386	19,446	72
Total area required (sq. km.)	60,000	n/a	1,810

It is assumed wind and solar installation will commence 1/1/2023

It is assumed each wind turbine wil require 0.5 square kilometres of space

It is assumed each solar farm will occupy 20 acres. 1 Sq. kilometre =247.1 acres

Material requirements of a modern wind turbine have been reviewed by the United States Geological Survey. On average, 1 MW of wind capacity requires 103 tonnes of stainless steel, 402 tonnes of concrete, 6.8 tonnes of fibreglass, 3 tonnes of copper and 20 tonnes of cast iron. The elegant blades are made of fibreglass, the skyscraper-sized tower of steel, and the base of concrete.[16]

As a guide for material requirements for a nuclear plant, three academics from the University of Berkeley, California, produced a report showing the GT-MHR 286 MW nuclear plant requires 21,816 cubic metres of concrete (1 cubic metre weighs 2.4 tonnes) and 7,707 tonnes of total metal per plant.[17]

Table 10 - Total materials required in the manufacture of wind turbines and nuclear plants		
	Wind turbines	**Nuclear plant**
Total units	124,963	6
Average megawatt capacity	3	300
Total megawatts	374,889	7,500
Stainless Steel (tonnes)	38,613,567	46,242
Concrete (tonnes)	150,705,378	314,150
Fibreglass (tonnes)	2,549,245	
Copper (tonnes)	1,124,667	
Cast iron (tonnes)	7,497,780	

Estimated cost of net-zero infrastructure

Table 11

Estimated infrastructure costs of net zero emissions by 2050

Option 1 - nuclear power generation

	Wind	Solar rooftop	Solar farms	Nuclear	Total
GWh per annum	749,778	107,111	214,222	14,000	1,085,111
Per unit GWh P/A	6	0.017	9.120	2,628	
Total units	124,963	6,300,647	23,489	6	
Cost/unit	4,000,000	10,000	11,900,000	1,300,000,000	
Cost/ GWh	666,667	588,235	1,304,825	494,673	
Cost - renewables $ billion	**500**	**63**	**280**		**842**
Cost = nuclear $ billion				**8**	**8**
Cost - carbon offsets $ billion					**53**
Total costs $ billion					**903**

One rooftop solar unit is defined as 20 x 300 watt solar panels plus one battery. The cost is before subsidies.

Costs do not include transmission lines, which can be considerable when connecting remote locations to power grids.

The cost/GWh provides an interesting comparison between the different types of electricity generators.

The carbon offsets figure is derived from Table 7.

Table 12
Estimated infrastructure costs of net zero emissions by 2050
Option 2 - battery system

	Wind	Solar rooftop	Solar farms	Battery system	Total
GWh per annum	749,778	107,111	214,222	4,866	1,075,977
Per unit GWh P/A	6	0.017	9.120		
Total units	124,963	6,300,647	23,489		
Cost/unit	4,000,000	10,000	11,900,000		
Cost/ GWh	666,667	588,235	1,304,825	482,000,000	
Cost - renewables $ billion	**500**	**63**	**280**		**842**
Cost = batteries $ billion				**3,037**	**3,037**
Cost - carbon offsets $ billion					**53**
Total costs $ billion					**3,932**

One rooftop solar unit is defined as 20 x 300 watt solar panels plus one battery. The cost is before subsidies.

Costs do not include transmission lines, which can be considerable when connecting remote locations to power grids.

The cost/GWh provides an interesting comparison between the different types of electricity generators.

Costs to the economy

In addition to the infrastructure costs, net-zero will inflict a considerable cost on the economy. Dr Brian Fisher is Managing Director of BAEconomics Pty Ltd. Dr Fisher has been involved in climate policy research since 1992 and has participated as a lead or convening lead author in three IPCC climate assessments.

In 2019, his firm, BAEconomics, carried out an analysis of the Labor Party proposal which it was taking to the 2019 federal election, to reduce emissions by 45 per cent by 2030, together with a target of 50 per cent renewables.

The report produced four different scenarios, depending on the level of abatement up to 45 per cent and the amount of international trade in abatement permits.

In the worst-case scenario, the report concluded that Labor's plan would result in:

- The NPV cumulative loss to the GNP by 2030 of $542 billion
- The wholesale price of electricity to rise 85% from $69/MWH to $128/MWH
- Real wages to fall by 8 per cent
- The loss of 167,000 jobs by 2030[18]

NPV (net present value) is the calculation of future cash flows at current values.

Although the above is the worst-case scenario, it still only represents 45 per cent CO2 emission reductions. Net-zero will almost certainly take a much larger toll on the economy and jobs, but as I can find no modelling of such a scenario, I will take GNP's $542 billion loss into account in my overall summary.

Table 13- Estimated total costs of net-zero emissions by 2050		
Option 1 - Nuclear power		
		$ Billion
Wind		**500**
Solar rooftop		**63**
Solar farms		**280**
Nuclear		**8**
Carbon offsets		**55**
Loss of GNP		**542**
TOTAL	**$ BILLION**	**1,448**

Table 14- Estimated total costs of net-zero emissions by 2050		
Option 2 - Batteries		
		$ Billion
Wind		**500**
Solar rooftop		**63**
Solar farms		**280**
Batteries		**3,037**
Carbon offsets		**55**
Loss of GNP		**542**
TOTAL	**$ BILLION**	**4,477**

The total cost to achieve net-zero by 2050 with nuclear power generation is an estimated 1.448 trillion dollars.

The total cost to achieve net-zero by 2050 utilising large-scale battery systems is an estimated 4.477 trillion dollars.

By comparison, the federal government's annual total revenue pre-Covid was $493 billion.

One country that has not bought into the climate change lunacy is China. Chinese President Xi Jinping must be sitting back smugly watching the Western nation lemmings racing to the economic cliff.

Communist China, in 2020, built over three times as much new coal power capacity as all other countries in the world combined -- the equivalent of more than one large coal plant per week. In addition, over 73 gigawatts (GW) of new coal power projects were initiated in China, five times as much as in all other countries, while construction permits for new coal projects also accelerated.[19]

Also, in 2020, China's CO_2 emissions rose by 1.5%, while those of most other countries fell. Although in 2020, the world retreated from coal, these retirements were eclipsed by China's new coal plants.[20]

Even before China built those new plants, it was already the world's biggest emitter of fossil fuel carbon dioxide (CO_2): In 2019, China was responsible for almost 30% of CO_2 emissions -- roughly twice the amount emitted by the US, then the second-largest emitter.[21] China, the planet's primary coal consumer, already has the largest concentration of coal plants globally.[22] In 2020, it produced 3.84 billion tons of coal, its highest output since 2015. In addition, China, in 2020, imported 304 million tons of coal, up 4 million tons from 2019.[23]

11. Conclusion

And there you have it.

Massive industrial and economic disruption. Unreliable energy. Higher energy prices reducing Australia's international competitiveness.

Deployment targets that will be logistically impossible to achieve in the time frame.

A huge total cost of 1.4 trillion dollars for the renewables and nuclear power option.

The gargantuan 4.447 trillion dollar cost for the renewables with the battery backup system, is nine times the federal government's total annual revenue.

And in the words of Australia's Chief Scientist, virtually no impact on the world's climate.

It begs the question, why would any political party want to condemn Australia to such an ill-conceived scheme that would decimate our economy.

Meanwhile, China happily continues building dozens of new coal-fired power stations, using its cheap electricity to manufacture goods cheaper than competitors in the Western world. It utilises the hundreds of billions of dollars profit from this unfair trading practice to buy up assets around the world as well as building up an already menacing military presence.

Xi Jinping must be laughing all the way to the bank.

12. Endnotes

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