

From: Kevin Loughrey
Sent: Friday, 7 May 2021 11:36 AM
To: EES ECCS Electricity Infrastructure Roadmap Mailbox
Subject: Interim Submission on the NSW Electricity Infrastructure Roadmap (<https://energy.nsw.gov.au/government-and-regulation/electricity-infrastructure-roadmap>)
Attachments: A_RoughScopingOfAn8GigawattSystem.pdf



Non Volatile Technologies

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Helping others to have a future assures our own.

Dear Sir/Madam

When I registered to attend the NSW Electricity Infrastructure Roadmap Webinar, I received a confirmatory email saying:

"Thank you. Your submission has been received."

I suggest you have a bug in your webpage. I did not provide a submission nor was there any opportunity that I could see for doing so.

But speaking of submissions, I would like to take this opportunity to submit the following:

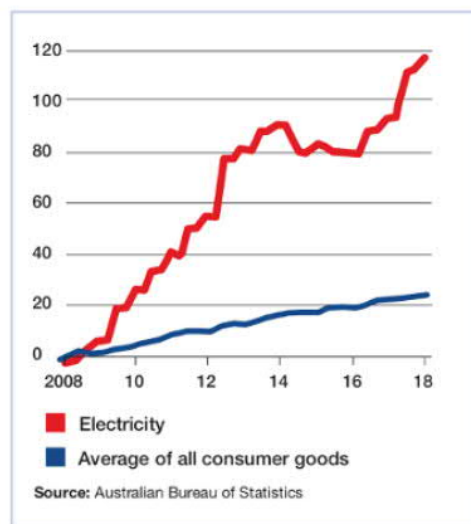
Having perused the material, it is huge and I am concerned it is beyond my ability, within the limited time and resources available, to properly comprehend and to debunk in detail its numerous fallacies. In my opinion there are many.

This being the case, I feel it best to provide you with a summary of key points which will direct you to more detailed information I have prepared:

1. All historical data indicates there is no climate crisis sufficient to warrant Australia reducing its emissions of CO2. Related to this is the reality that there is considerable contention as to whether the climate has actually warmed substantially in the last 100+ years and whether any such warming, if it is actual, is the result of CO2 in the atmosphere. For a detailed understanding of my position on this matter please read thoroughly the webpage I have created at <http://www.nvtech.com.au/Climate/AGW.html> and download the PowerPoint presentation I have prepared at <http://nvtech.com.au/Climate/TempCO2ClimateCrisisGraphs.pptx> complete with the script for the presenter which can be found at <http://nvtech.com.au/Climate/TempCO2ClimateCrisisGraphs.pdf>
2. From "1", the key motivation to transition from coal-fired base-load power generation to "clean" energy is based on a flawed thesis which will cost the taxpayers of this country dearly, profit the Communist Party of China and destroy any chance of Australian Manufacturing/Industry being competitive because of high power prices which China will not have to endure.
3. Renewables are not "clean" and, in fact, their manufacture and eventual disposal is causing largescale environmental harm. Related to this is that the equipment has a limited lifespan; generally in the region of 20 years.
4. Renewables have not, up to this point, delivered reliable energy and their introduction into the grid has caused power prices to rise by almost 6 times the CPI per the graphic below. Will this initiative reduce the cost of energy below the CPI curve, ie, the blue line (in the graph below) starting from 2007? I think not. To illustrate this point I have developed a brief study paper that roughly scopes the likely cost of a recently foreshadowed initiative to create a pumped hydro scheme, driven by windmills and solar panels, to produce power in the order of 8GW.
5. There is no prospect there will be future advances in technology that will enable "renewable" energy to provide power as cheaply as coal or nuclear when these means of power production are not burdened with the disruption/diseconomies of production that "renewables" inflict.
6. The suggestion that present power generation facilities are nearing the end of their life and therefore have to be retired is sophistry. For over 20 years I was involved in the maintenance of a wide variety of large mining plant and diverse equipment ranging from night vision equipment through to main battle tanks and watercraft. I have received some of the best maintenance engineering training available in the world, here and in the United Kingdom and have lectured on this subject to international audiences. I assure you that it is highly cost effective to perform methodical refurbishment and upgrade of existing facilities. Modern power generation, transformation, switching and transmission equipment is more compact and more capable than earlier generations extant in Australia's base-load generation facilities. Being so, it is not technically difficult to upgrade existing facilities within the existing buildings and the real estate upon which they stand. Demolition of these facilities amounts to unbelievable vandalism.

Fig 1. PRICE SHOCK

Cumulative percentage increase in nominal prices



There is a cost of **\$14 billion per year** incurred by consumers and taxpayers, or a total cost of **\$140 billion over 10 years**.

Already 10 coal fired baseload power stations have closed in Australia.

With \$140 billion, the Australian Taxpayer could have built **70 coal fired power stations!**

I am keen to see the cost modelling that will cause energy prices to go back to conforming with, or going under, the blue line in the above graphic as your presentations would imply. I suggest to you that, if this scheme is to proceed at all (and I would strongly oppose that!), you should firstly build a pilot model of what is proposed so that you can be assured it will meet the predicted cost and reliability targets before embarking on the ambitious scheme you have announced.

Please accept this as my interim submission.

Kevin Loughrey LtCol(Ret'd), BE Mech (hons), psc, jssc

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AN OBJECT EXAMPLE OF THE FEASIBILITY OF “RENEWABLE” ENERGY SOLVING THE ENERGY NEEDS OF NEW SOUTH WALES(NSW)

Background

This paper does not seek to analyse NSW's present and future energy needs. I may investigate that later. Today, we were told that NSW intends to create a pumped hydro system that will generate 8 Gigawatts on a continuous basis. The inference to be drawn from this as a consequence of the previous conversation is that the majority of the power for this pumped hydro system will come from solar panels on the roofs of businesses and domestic dwellings. It may also come from wind farms and mass solar panel installations closely located to the pumped hydro-electric system.

Purpose

The purpose of this paper is to use this example as a means of highlighting the practicality and economy, or otherwise, of such a scheme, ie, a Pumped Hydro electricity system that is capable of delivering 8 Gigawatts on a continuous basis.

Some Basic Physics to Assist the Reader

A watt is a Joule of energy per second. A Joule of energy is expended with a force of 1 kg moves through a distance of 1 metre. When a kilogram mass of water (which is 1 litre) falls through a distance of 1 metre in one second, it is capable of generating 9.80665 watts of power.

Scoping the System

So a system that is creating 8 Gigawatts of power requires that $8/9.80665 \times 10^9$ litres of water flow every second = 0.8158×10^9 litres of water per second through a distance of 1 metre. (Note: This assumes 100% efficiency in the process. I will deal with the matter of system efficiency later in this discussion.) If this system ran for 24 hours it will $0.8158 \times 10^9 \times 60 \times 60 \times 24$ litres of water = $70,485.12 \times 10^9$ litres = 70,485.12 Gigalitres/the elevation of the dam. The average height of the Great Dividing Range is around 600 metres so we will assume that all of the repositories in which the water is stored will be held at that elevation. The number of Gigalitres that would be required to flow through the system to produce 8 Gigawatts for 24 hours is thus, $70,485.12 \text{ Gigalitres}/600 = 117.4752 \text{ Gigalitres}$.

To put this into perspective, Warragamba Dam, when full, holds around 2,031 Gigalitres.

Pumped hydro works by pumping the water up to an elevation and then letting it run through turbines, usually Francis Turbines, to generate electricity. The efficiency of a Francis turbine and generators is typically around 90%.

The pumps that move the water up to the elevation usually work at an efficiency around 80%. There is around a 10% loss through friction in the pipes and turbulence, so that overall efficiency of the system is $0.9 \times 0.8 \times 0.9 = 0.64$.

In addition to this there are losses in voltage transformation and through transmission of the electricity over power lines but these losses are similar to that which one would encounter with a conventional coal-fired base load facility.

This being the case, the amount of water now needed to provide 8 Gigawatts of power for 24 hours continuously is thus $117.4752/0.64 = 183.555 \text{ Gigalitres}$. This is approximately 1/11th of Warragamba Dam's total capacity.

The Cost of Largescale Rooftop Solar

Let's now look at the cost of the roof-top solar systems that will provide the 8 Gigawatts of power on a continuous basis to the system.

The variability of weather, ie, sunshine and wind is such that it would be necessary to have the ability to provide power on a continuous basis for more than 24 hours. For example, if the solar and wind system did not perform to specification, say 50%, for, say, 30 days, it might be necessary to hold 15 days of supply to satisfy the electricity demand. This is greater than the capacity of Warragamba dam.

For the purposes of this example, we shall assume that all systems are 5 kW capability and cost \$8,000 to acquire and install.

These systems typically produce 15kWh per day of power during the winter and 30kWh per day of power during the summer.

Unfortunately, bright sunny days are not common except in the driest of areas where there are no houses and therefore no roof-top solar. To set up solar PV systems in the dry, sunlit areas of Australia then requires considerable investment in infrastructure in the form of ultra-high-voltage DC power lines with attendant transformation, inversion and transmission losses. So we will, for the purposes of this paper deal only with urban roof top solar systems. From <https://www.currentresults.com/Weather/Australia/Cities/sunshine-annual-average.php> we get the following table.

Average hours of bright sunshine a year		
City	Day	Annual
Adelaide, South Australia	8	2774
Brisbane, Queensland	8	2884
Cairns, Queensland	8	2738
Canberra, Australian Capital Territory	8	2811
Darwin, Northern Territory	9	3103
Hobart, Tasmania	6	2263
Mackay, Queensland	8	2993
Perth, Western Australia	9	3212
Rockhampton, Queensland	7	2592
Sydney, New South Wales	7	2592
Townsville, Queensland	9	3139

There are approximately 8,766 hours in an average year of 365.25 days. Of this, 1/2 is nominally “daylight”, ie, 4,383 hours. It can be seen from the above table that, because of clouds, one could conservatively reduce the power being typically generated from roof top solar on a cloudless day by around 40%, ie, $(15+30)/2 \times 0.6 \text{ kWh/day} = 13.5 \text{ kWh/day}$ average production.

Given the $8/0.64$ (the efficiency) = 12.5 Gigawatt is needed all year round, to produce $24 \times 12.5 \text{ GWh} = 300 \text{ GWh}$ of power requires $300 \times 10^9 / 13.5 \times 10^3 = 22.22 \times 10^6$ roof-top solar systems. These will cost a total of $\$8,000 \times 22.22 \times 10^6 = \text{\$177.760 billion}$.

This equates to around 88 coal fired power stations, each with a capacity of between 1 & 2 Gigawatts or 44 Nuclear largescale power stations.

The Likely Cost of a kWhr Generated by this Means

These roof-top solar systems have an average life of 25 years. In 25 years, each system will generate $365.25 \text{ days in a year} \times 13.5 \text{ kWh/day} \times 25 \text{ years} = 123,271.875 \text{ kWh}$ of electricity. (This does not take into account PV cell degradation which naturally occurs due to aging.) A system costs approximately 800,000 cents. This comes to $800,000 \text{ cents} / 123,271.875 \text{ kWh} = \text{approx } 6.5 \text{ cents/kWh}$. This does not take into account the bank interest that is lost from this sunk investment. The actual marginal cost is thus (@ 2% interest) in the order of \$12,867.50 over a 25 year period which brings the cost of electricity generated by this means to **10.44 cents/kWh**.

This is only the cost per kWhr of electricity generated during the day by PV solar panels. When the sun does not shine and the wind does not blow (in the case of windmills), hydro is necessary and so the cost of a pumped hydro-elect system has to be added to this project.

The Likely Cost of the Pumped Hydro System

The cost of the pumping system, which includes the establishment of significant dams, the pipes, turbines, maintenance, etc is considerable. That cost can be assessed from the experience of the hydro-electricity schemes that do not use pumped hydro. To gain some understanding of this, see: <https://www.irena.org/costs/Power-Generation-Costs/Hydropower>

For large hydropower projects the weighted average Levelized Cost of Energy (LCOE) of new projects added over the past decade in China and Brazil was USD 0.040/kWh, around USD 0.084/kWh in North America and USD 0.120/kWh in Europe. For small hydropower projects (1-10 MW) the weighted average LCOE for new projects ranged between USD 0.040/kWh in China, 0.060/kWh in India and Brazil and USD 0.130/kWh in Europe.

This figure is probably too optimistic in terms of its cost. The cost for the proposed New England project will require massive dams (as touched upon previously in this paper) at both top and bottom plus pumps as well as turbines at the bottom. It has been suggested that the intention is to have massive wind and solar farms fairly close by, thus reducing input transmission losses to the pumps (and the need for long periods of constant hydro), but Armadale is a long way from Sydney and transmission losses could exceed 20%. The total infrastructure and environmental costs would be without precedent in this country.

For this example, we will choose the modest figure of US0.084/kWh (taking the US example which would have similar labour costs.) This comes to 10.6 cents Australian per kWh at present exchange rates..

So the total cost of the proposed pumped hydro solar & wind system, if it is practical at all, is likely to be in excess of **21 cents/kWh**. Now we should compare this with the cost of power generation using nuclear, coal and gas-fired facilities.

Comparison with Nuclear, Coal and Gas Generation Systems

It is very difficult to obtain factual pricing for nuclear, coal and gas however, the order of economy is nuclear, coal and then gas. I have included costs determined by the US Department of Energy as at 2019.

U.S. average levelized costs (2012 \$/MWh) for plants entering service in 2019

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable		Total system LCOE	Total LCOE including	
				(including fuel)	Transmission investment		Subsidy ¹	Subsidy
Dispatchable Technologies								
Conventional Coal	85	60	4.2	30.3	1.2	95.6		
Integrated Coal-Gasification Combined Cycle (IGCC)	85	76.1	6.9	31.7	1.2	115.9		
IGCC with CCS	85	97.8	9.8	38.6	1.2	147.4		
Conventional Combined Cycle	87	14.3	1.7	49.1	1.2	66.3		
Advanced Combined Cycle	87	15.7	2	45.5	1.2	64.4		
Advanced CC with CCS	87	30.3	4.2	55.6	1.2	91.3		
Conventional Combustion Turbine	30	40.2	2.8	82	3.4	128.4		
Advanced Combustion Turbine	30	27.3	2.7	70.3	3.4	103.8		
Advanced Nuclear	90	71.4	11.8	11.8	1.1	96.1	-10	86.1
Geothermal	92	34.2	12.2	0	1.4	47.9	-3.4	44.5
Biomass	83	47.4	14.5	39.5	1.2	102.6		
Non-Dispatchable Technologies								
Wind	35	64.1	13	0	3.2	80.3		
Wind-Offshore	37	175.4	22.8	0	5.8	204.1		
Solar PV ²	25	114.5	11.4	0	4.1	130	-11.5	118.6
Solar Thermal	20	195	42.1	0	6	243.1	-19.5	223.6
Hydro ³	53	72	4.1	6.4	2	84.5		

According to this, the cost of a kWh of power generated from a coal fired power station is 9.5 US cents. Advanced nuclear is 9.6 US cents. These are for new installations. The US fossil fuel installations face special taxes because of their “carbon” pollution so, without these, the costs would be significantly less. The costs attributed to nuclear are also controversial and likely to be inflated here.

It is noteworthy that Australian coal-fired power generation was, before the introduction of intermittent power sources into the network, amongst the cheapest in the world. The US figures therefore are likely to be on the high side compared to what would be experienced in Australia.

Summation

The idea of having pumped hydro driven largely by roof-top solar systems that must be scrapped after 25 years, using components that are largely built in China, appears to carry a high level of risk and will not deliver the cheapest energy to Australian industry and society. Indeed, it is significantly more expensive than coal and worse still if nuclear were to be introduced. Nuclear is also an interesting study because if Australia were to develop a nuclear processing and reprocessing industry, it has the potential to earn the country many billions of dollars per year reprocessing the reactor rods of other countries. This would also aid in preventing nuclear weapons proliferation by tightly controlling the access to fissile material. Any country that did not return its rods for reprocessing would not receive any more enriched uranium.

Given the core justification for pursuing this method of power generation is to reduce emissions, this whole project appears to be imprudent and a great waste of taxpayers' money.