ARTISTS RENDERING OF ROLL-ROYCE'S SMALL MODULAR NUCLEAR REACTOR[1]

INSIGHTS

12 September 2022

Preparing Now for Nuclear Energy Makes Sense

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In June this year, the CEO of the Australian Energy Market Operator (AEMO), Daniel Westerman, said that by 2050 it was estimated the National Electricity Market (NEM) would require:

- A doubling of the quantum of electricity the NEM presently delivers, from 180 terawatt-hours today to about 330 terawatt-hours by 2050 to replace much of the gas and petrol consumed in transport, industry, offices and homes;
- A nine-fold increase in utility-scale variable renewable energy capacity… from 15 GW currently to nearly 140 GW…tripling VRE capacity by 2030 and doubling again each decade after that;
- A lot of firming technology, to iron out the lumps and bumps of intermittent and variable renewable generation so that the supply is there when homes and businesses need it.[2]

Importantly, he warned:

> *It is insufficient to have the energy there if it's not there at the right time.*
>
> *Our Integrated System Plan forecasts the need for 60 GW of firming capacity by 2050, triple what we have today.*
>
> *That firming capacity, including dispatchable storage, is absolutely critical and, to be frank, one of my worries is we're not really seeing that investment in firming capacity in sufficient scale at the moment.*[3]

Westerman is right to point out the enormous and challenging task of Australia relying almost completely on renewable energy to power the grid, as the remaining coal fired power stations are retired over the next 20 years.

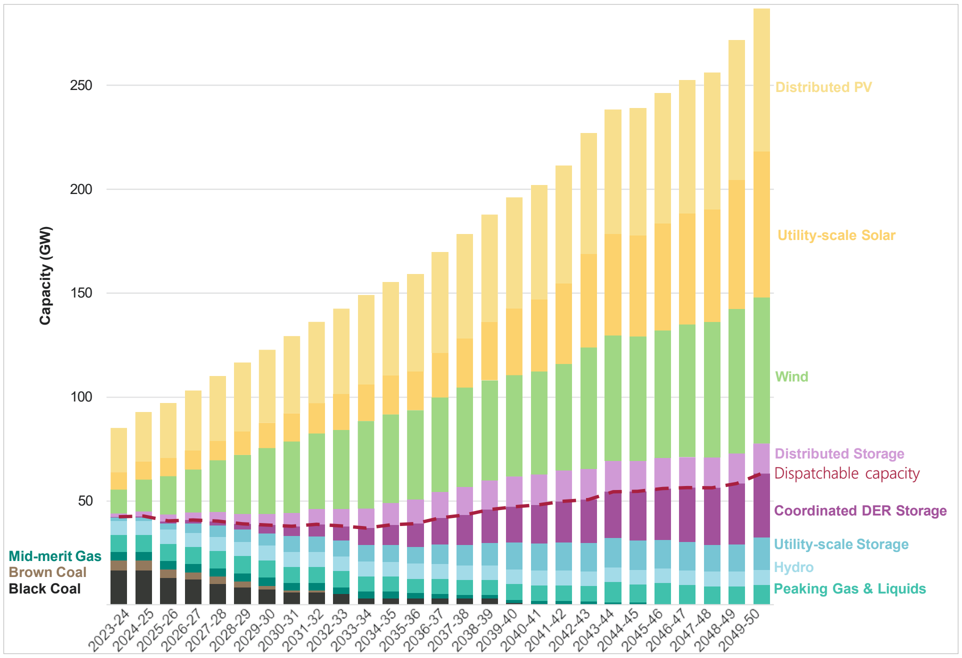
The following chart[4] shows coal being progressively withdrawn to 2042 with fossil fuel gas continuing to play a role to 2050 and beyond, while also providing dispatchable power.

Like gas, hydro-electricity generation continues to make a small contribution, also as a source of dispatchable power.

Wind and solar increase significantly, with half of solar being generated from utility scale solar farms by 2050 with the other half coming from 'Distributed PV', which is largely rooftop solar.

Storage for these renewable energy sources is modest, with reliance on demand management built into the system in times of peak demand, for example, paying businesses and households to switch off or reduce electricity to machines and appliances.

This can be an efficiency measure when turning off or limiting the use of non-economic assets like pool pumps and air conditioning units but a negative when large factories are asked to shut down to keep the lights on elsewhere.



Renewable energy has a lot of support from all governments, including broad public support.

The big question is whether Australia can successfully implement such an ambitious plan, indeed, whether it is achievable at all.

There are not too many large-scale projects that do not run over time and budget. Think the NBN. Snowy 2.0, the 2GW pumped hydro storage project, is now behind schedule and will cost more than originally thought.

It therefore seems prudent to consider all energy technologies that have zero or near zero carbon emissions in Australia's future energy mix.

This should include nuclear energy, to mitigate the risk of failing to transition away from fossil fuels without negatively affecting the economy.

Nuclear Power Stations

Most advanced economies have had large nuclear power stations operating for many decades, some for more than 50 years.

These countries include England, France, Germany, Russia, China, Japan, Canada and the United States.

Large reactors often cost tens of billions of dollars depending on the size of the reactor and it is not unusual for them to take a decade or more to construct, given the rigorous approval process.

For example, a proposed 3.2 GW (3,200 MW) two-reactor nuclear power station in England (Sizewell C) is expected to cost around 20 billion pounds (AUD$35B) with a 9-year build time. It will power the equivalent of about six million homes, with a 60-year life.[5]

Closer to home, South Korea, one of Australia's allies in the Asia Pacific region, is also looking to increase its nuclear energy capacity.

Yoon Suk-yeol, who took over as South Korea's president in May, wants to build two new plants and extend the working life of 18 existing ones to generate 30% - 35% of its power by 2030, up from 27% in 2021.[6]

Australia, on the other hand, has never had nuclear power stations generating electricity, relying mostly on coal fired power stations which are being retired.

There are no plans by government or the private sector to build new coal fired power stations due to their carbon emissions, which would contribute to the acceleration of climate change.

Also, there is little public discussion on Australia going down the large nuclear power station path, even if the ban on nuclear in Australia were to be lifted soon.

This does not mean large reactors should be dismissed as an option. Australia would not have an electricity generating Small Modular Reactor (SMR) before 2035 and possibly closer to 2040, when factoring in the 3-to-4-year build time.

But construction on a large reactor would need to have commenced before the end of this decade, driven and financed by government given the build cost is much higher and governments have access to cheaper finance.

As such, I will focus on SMRs due to the build costs being cheaper with flexibility to construct a single small reactor in a particular location or a 'bank' formation.

Small Modular Reactors (SMRs)

SMRs typically have a power capacity of up to 300 MW electricity (MWe) per unit. They are physically a fraction of the size of a conventional nuclear power reactor with systems and components factory-assembled and transported as a unit to a location for installation.[7]

SMRs can also be located next to each other to potentially generate 1GW (1000MWe) or more of electricity.

SMR technology is fast getting to the point of production. The value of SMRs is recognised by the US Government's Office of Nuclear Energy which has provided substantial support to the development of light water-cooled SMRs, which are under licensing review by the Nuclear Regulatory Commission (NRC) and will likely be deployed in the late 2020s to early 2030s.[8]

The US Nuclear Office is also interested in the development of SMRs that use non-traditional coolants such as liquid metals, salts, and gases for the potential safety, operational, and economic benefits they offer.

Some firms, like Rolls-Royce SMR in the UK, are designing reactors up to 470MWe. It has recently shortlisted six sites in England for a major new factory to begin production.[9]

Their SMRs will have a design life of 60 years with a number of cooling options (direct, closed loop cooling towers and air cooling) which can be determined based on the site requirements. The plan is to deploy its first SMR by 2029.[10]

SMRs (n^{th} of a kind) are estimated to take 3 to 4 years to construct. They can potentially be located at the sites of retired fossil fuel powers plants, taking advantage of existing transmission infrastructure, cooling water and skilled workforces.[11]

Why preparing now for SMRs makes sense

I think there are a number of reasons why the time is right to start preparing now for the possibility of nuclear generated electricity being part of Australia's future energy mix. These are three important ones.

1. Social licence

Most older Australians have grown up with the idea that anything to do with nuclear is 'bad'. This is despite many benefiting each year from nuclear medicine. A nuclear facility has been operational for more than half a century at Lucas Heights, a southern suburb of Sydney.

The facility is fuelled by low-enriched uranium and capable of generating 20MW of thermal power but does not produce electricity.[12]

Despite this, there is some evidence Australians are warming to the idea of nuclear energy.

In 2019, a narrow 51% majority of Roy Morgan survey respondents agreed that Australia should develop nuclear power to reduce Australia's carbon dioxide emissions, with 15% undecided and 34% against.[13] This support was up 16% since July 2011.

More recently, in 2021, 57% approved of the Federal Government buying nuclear-powered submarines from the United States.[14]

Three years ago, the House of Representatives Standing Committee on the Environment and Energy's inquiry into the prerequisites for nuclear energy in Australia acknowledged the importance of the will of the people being honoured.

The Committee recommended maintaining the moratorium on nuclear energy in relation to Generation I, Generation II and Generation III nuclear technology but lifting the moratorium on nuclear energy in relation to Generation III+ and Generation IV nuclear technology including small modular reactors, subject to technology assessment and community consent as a condition of approval.[15]

Still, with Labor, the Greens and some Independents currently against nuclear energy, there is much work to do to get the federal ban on nuclear energy lifted and then for the government of the day to undertake the necessary regulatory actions.

Nuclear energy therefore has some way to go to get its 'social licence', or public acceptance, but there appears to be good support on which to build.

This takes time but is a necessary step. It should not be left until SMR technology is first available to Australia, once the technology is operational in the US and the UK. Social licence is especially important in regard to the siting of SMRs and the safety concerns of communities, as well as storage of nuclear waste.

2. Cost of nuclear energy

One of the things that seems to get lost on many is that, in the Australian context, we would likely be considering nuclear power for up to 20% only of total generation in the next 30 or 40 years.

That is, 80% of generation coming from solar, wind, pumped hydro and other sources, once coal is phased out.

The focus by 'renewables only' proponents, and most media, is on the 'high' end estimated cost for nuclear in the CSIRO's 'GenCost' annual reports. This is problematic.

The stated Levelised Cost of Electricity (LCOE) in these reports does provide a useful way of comparing the cost of the different electricity generation technologies such as solar, wind, coal and nuclear. It is based on the total unit costs a generator must recover to meet all its costs, including a return on investment.[18]

However, placing too much importance on LCOE is misguided, given detailed individual project analyses provide more realistic representations of operational costs and performance.[19]

The following table shows the LCOE data for SMR nuclear and wind and solar (W&S) from the latest 2021-22 GenCost report alongside data from SMR companies NuScale in the US and Rolls-Royce SMR in the UK.

NuScale claims a LCOE range of US$40/MWh to US$65/MWh (AUD$58 - AUD$94) for their SMR design, expected to be providing modules to the market by 2027.[20]

Rolls-Royce SMR claims their SMRs will have a LCOE range of £33 to £60/MWh (AUD$56 - AUD$103).[21]

		SMR	W&S
CSIRO	Low	$136	$58
	Mid	$231	$68
	High	$326	$79
NuScale	Low	$58	
	Mid	$76	
	High	$94	
Rolls-Royce	Low	$56	
	Mid	$80	
	High	$103	

It is noted that in a recent Senate Environment and Communications Committee inquiry on 19 August 2022, the LCOE in an Australian setting for NuScale was claimed to be $60 MW/h to $102/MWh for 12 modules of total 924MWe at approximately 90% capacity factor.

If SMR electricity generation is only one-fifth of the total generation in a mixed-technology network, then it is wrong to focus only on the cost of generating electricity from SMRs.

Take a simplified National Energy Market where 80% of generation comes from wind and solar, and 20% comes from nuclear SMRs. On a conservative calculation, with the cheapest CSIRO wind and solar ($58/MWh) and the most expensive quoted non-CSIRO SMR figure of ($103/MWh), the cost of generation would be $67/MWh, that is, $9/MWh more than 100% wind and solar.

On a fairer comparison, using the midpoint of the CSIRO wind and solar ($68/MWh) and the average of the NuScale and Rolls-Royce midpoints ($78/MWh), this would be $70/MWh, only $2/MWh more than 100% wind and solar.

While some will argue this still results in a slightly higher cost, it is not at all certain that wind and solar will remain cheaper than nuclear, as I make clear in the next point.

Further, the risk mitigation benefits of nuclear energy are not factored in as would be the case in a cost-benefit analysis.

3. National energy security

The third reason for considering nuclear energy in Australia is the mitigation of the risk within the supply chain associated with solar and wind renewable energy.

Focusing on solar energy, China is the most cost-competitive location to manufacture all components of the PV supply chain.

The world almost completely relies on it for the supply of key building blocks for solar panel production and China's share of global polysilicon, ingot and wafer production will soon near 95%.[16]

This is largely due to costs in China being 10% lower than in India, 20% lower than in the United States, and 35% lower than in Europe.[17]

This level of concentration in the solar PV global supply chain is a considerable vulnerability for all countries, especially those that experience geopolitical tensions with China.

Export tariffs or similar can easily be imposed which would increase the cost of solar panels in Australia leading to increased electricity prices and a negative effect on the economy.

In recent times, China has imposed sanctions and tariffs on Australian barley, beef and lamb, wine, cotton, timber and coal.[22]

Manufacturing most or all solar panels in Australia with non-Chinese components would also result in these being more expensive, largely due to our higher labour costs.

While this is not an issue today, it may become one in future decades, especially if Australia-China relations further deteriorate. If a nuclear energy industry was already established, it would give Australia more leverage in such circumstances.

Summary

Renewable energy undoubtedly will generate the majority of Australia's electricity by 2050 due to our advantage over many other countries of superior access to solar and wind resources.

Our large land size means we have the capacity to construct solar and wind farms in renewable energy zones without compromising a lot of prime agricultural or residential land.

However, solar and wind, and to some extent hydro, also carry risks as I have identified.

The public debate is largely on the lower cost of renewables vis-à-vis nuclear energy however this appears to be only a marginal cost saving based on figures provided by two of the world's leading SMR companies.

In any case, it can be argued that value is more important than cost with nuclear being both a 24/7 dispatchable power source and a risk mitigator in terms of national energy security.

Finally, there are other risks I have not covered which also warrant further consideration. These are two:

- Heavy reliance on 'distributed solar PV' (largely home solar panels on roofs) when the proportion of detached dwellings (houses) of all dwellings in Australia is decreasing due to the shift to apartment living (attached dwellings) where rooftop solar on buildings is either non-existent or very limited.

  Also, the risk of detached dwelling owners not replacing solar panels and battery systems over time when they fail or reach end of life.

- The risk of changes in weather patterns due to climate change resulting in, for example, fewer windy or sunny days and extended periods when droughts become more extreme affecting dam levels which can result in decreased hydroelectricity generation.

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