DELAYED REACTION: WHY QUEENSLAND WILL NEVER NEED NUCLEAR ENERGY

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QUEENSLAND CONSERVATION COUNCIL

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This report analyses what would happen in the energy market in 2040 if a 1,000 MW nuclear power station was installed into the Australian Energy Market Operator's most likely forecast scenario, the Step Change scenario.

The key finding is that running just one nuclear power station in Queensland in 2024 would displace more than 3,700 GWh of cheap renewable energy because nuclear plants are inflexible and need to consistently export energy. This means the equivalent of an average of 45,000 Queensland household solar systems would need to be shut off every day.

What nuclear power station is possible by 2040?

This report focuses on large-scale nuclear power stations. Despite much discussion about small modular reactors (SMR), these have not been successfully built anywhere in the world. The problems with realising SMR technology has led the Federal Opposition to pivot to large scale nuclear power stations as the cornerstone of their nuclear policy.

Size

Around the world, nuclear power stations have an average size of 830 MW [1]. Rounding up for simplicity, we assume a newly built power station to be 1,000 MW.

Operating characteristics

Nuclear power stations cannot turn off and on quickly. New generation technology can turn down, within half an hour, to minimum load of 50% [2].

Number

The Federal Oppostion's policy is to place nuclear power stations at nine coal fired power station sites around the country, including two in Queensland at Callide and Tarong. The first large-scale reactor in the Federal Opposition policy is to be built by 2037. We consider this very unlikely, based on international timeframes, for a single power station to be built in Queensland by 2040, let alone two. This report analyses just the impact of one 1000 MW nuclear power station in 2040.

Cost

The CSIRO GenCost report [3] estimates large scale nuclear reactors to cost between $140 - $230/MWh in 2040, with solar and wind between $30 - $70/MWh. In the UK, the Government has signed a purchase agreement worth around $230/MWh with the under construction Hinkley Point C nuclear reactor [4]. CSIRO further calculates that building solar and wind backed by storage, to reach 90% renewable energy, would cost up to $120/MWh in 2030.

Construction Time

2040 is the absolute earliest we could feasibly see a nuclear power station built in Queensland. That would require a swift change in regulation, swift planning and assessment and an on-schedule build.

Hinkley Point C in the UK is also a sobering case study for the deployment of nuclear energy - it has been delayed at least six years so far and is now on track to be operational in 2029, 16 years after the power purchase agreement, or contract for difference, was signed by the UK Government in 2013 [5]. Just signing that contract was the culmination of another eight years of policy work and agenda by the UK Government to revive investment in nuclear power in the UK [6].

In Australia, it is far more likely that nuclear power would not be available until 2050 or even later, if at all.

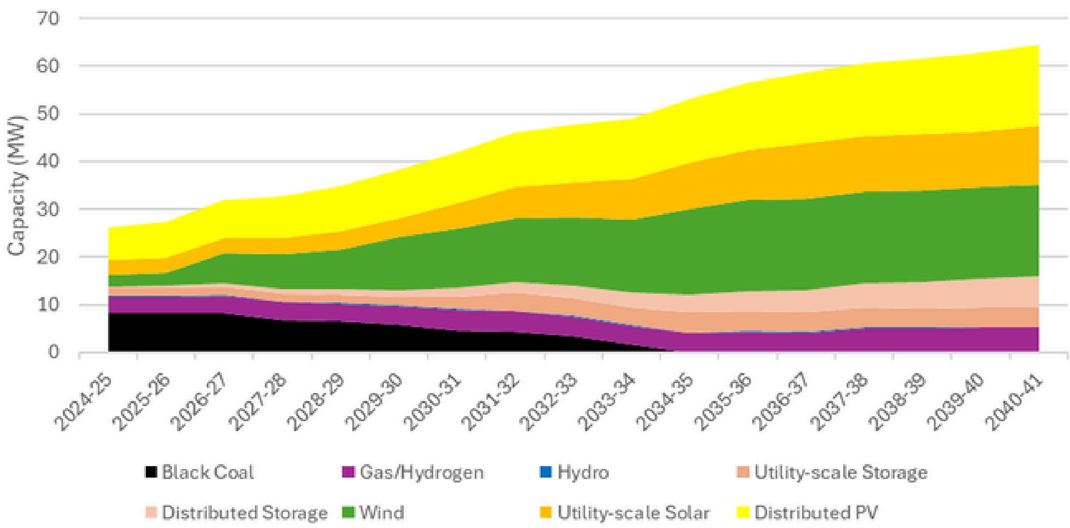
What will our energy system look like by 2040?

Generation

The Australian Energy Market Operator (AEMO) publish a long term plan for the National Electricity Market (NEM) every two years, called the Integrated System Plan (ISP) [7]. The 2024 ISP came out in June 2024. It analyses three scenarios of possible future development: progressive change, step change and green exports. Step Change is assessed by energy market and industry experts to be the most likely future development path.

Under the 2024 ISP Step Change scenario, all of Queensland's coal fired power stations would be retired by 2040. This is necessary to keep our emissions in line with our international targets of below 2 degrees of warming in the Paris Agreement. To replace this capacity, and meet increased electricity demand for vehicles and electrified homes, AEMO forecasts that Queensland will more than double our generation capacity by 2040 (Figure 1).

Figure 1: Generation capacity to 2040 under the Step Change scenario.



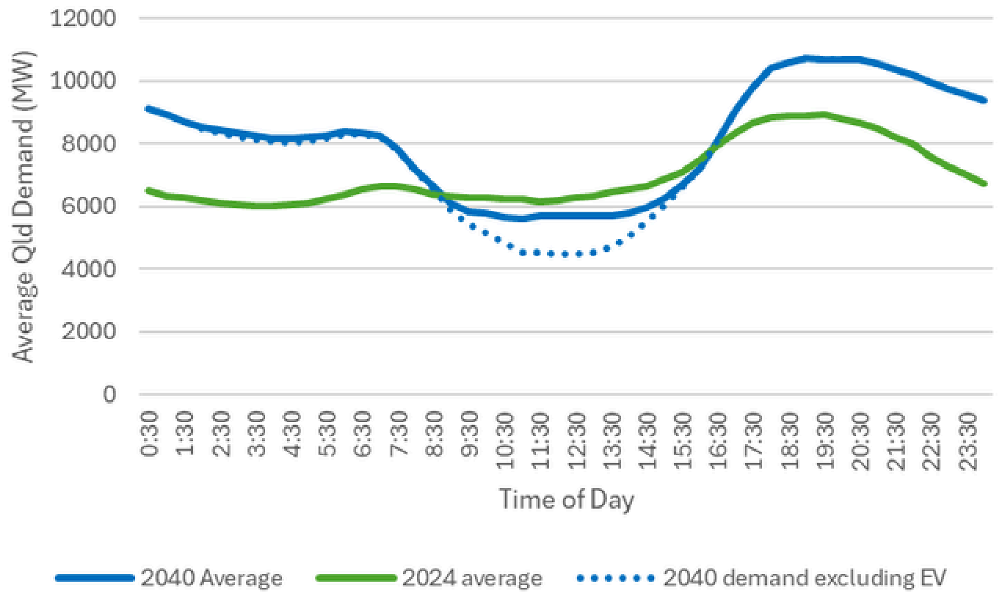
This change is already happening. We are replacing the dirty, expensive and unreliable fossil fuel fired power stations that have provided our energy so far, at speed. The proportion of energy generated from renewable energy in Queensland is on track to almost double in five years, reaching close to 30% in the financial year 2023-24 to date, up from 15% in 2019-20 [8].

Demand

The way we use energy is also changing. Rooftop PV has provided 12.5% of Queensland's energy in 2023-24 so far [9]. This has entirely changed the shape of demand across Queensland. As more consumers install batteries, join Virtual Power Plants, and buy electric vehicles, these changes are accelerating.

The ISP forecasts half hourly demand in Queensland in 2040. This analysis is based on the Step Change scenario, 10% Probability of Exceedance demand traces. These represent demand that has a 1 in 10 chance of being exceeded. Figure 2 shows that demand in the middle of the day will on average be lower in 2040 than it is now, despite higher overnight and peak loads. A significant portion of daytime demand by 2040 will be charging electric vehicles. Without this load, demand would be an additional 20% lower in the middle of the day.

Figure 2: Time of day demand changes to 2040.



The death of baseload

The combination of a renewable energy generation at both a small and large scale, and more flexible demand such as electric vehicles, means that all aspects of a 2040 energy system will have to change. The energy system to date has focused on providing energy from large, inflexible power stations to customers. Households and businesses have been encouraged to change their consumption to match this, for example, with overnight hot water storage. We have developed a range of words and concepts to describe this system, like baseload generators.

However, like floppy disk was a key term in early computing and is now bamboozling to school children, baseload generators aren't a key requirement in a highly renewable energy system. We need storage and technology to move energy throughout the day, and flexible, fast-start back up generation, not inflexible baseload generators.

The underlying growth in demand to 2040 will be met by more than 30 GW of large-scale renewable energy being built in Queensland. In 2040, this large-scale renewable energy, combined with coordinated electric vehicle charging and household batteries, would meet, at the time needed, 52% of Queensland's demand. Figure 3 shows that there will usually be no requirement for non-renewable generation during the day time hours in 2040, and renewables will be meeting on average 80% of demand at other times.

Figure 3: Average residual demand after large scale renewables.

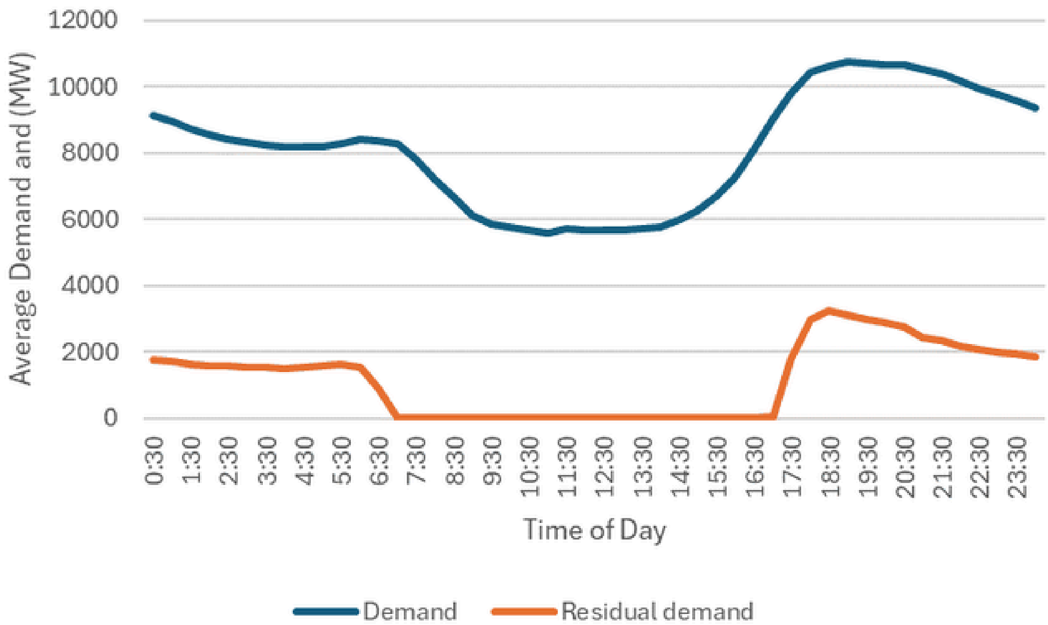


Figure 3 just shows demand, but in 2040, Queensland will have too much energy almost every day. AEMO forecasts electric vehicles and electrification to be focused on increasing daytime usage, but there will still be huge opportunities for further incentivising usage in the middle of the day, for example, through hydrogen or flexible manufacturing demands.

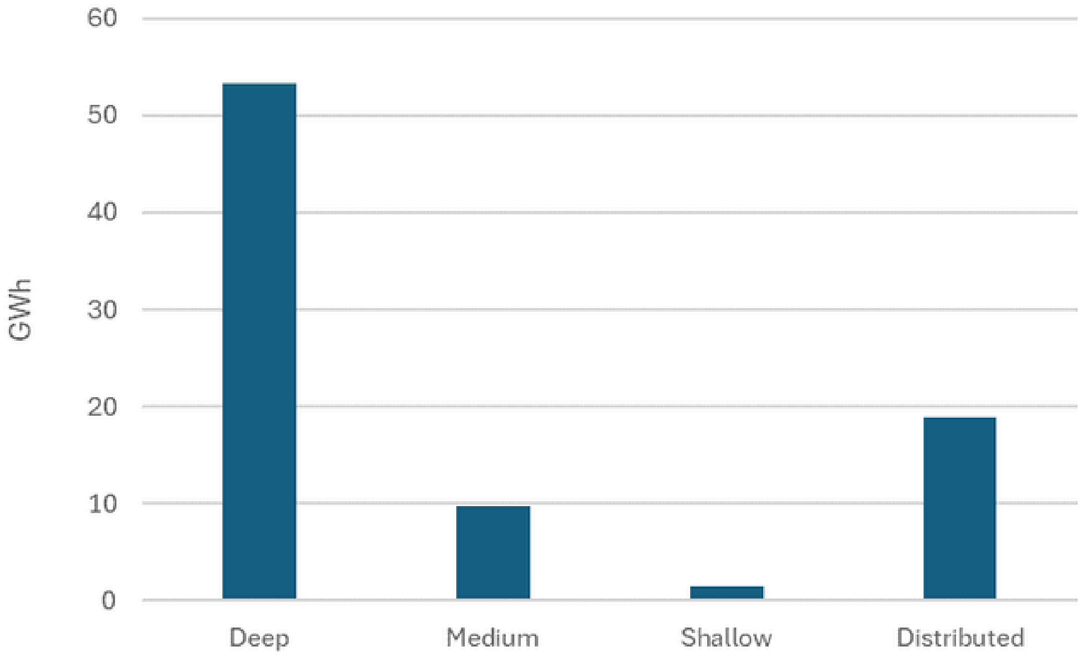
Storage

The high renewable energy system will come with challenges, such as meeting demand at the evening peak or overnight when renewable production has been low. This will need a combination of:

- Hours long storage - for example, batteries, which can store energy during the day and release for the evening peak and into the next morning.
- Fast response dispatchable generation - for example, hydrogen or other zero emissions gas power plants which can be turned on quickly when required.
- Long duration storage to cover periods of several days where solar and wind are below peak production.

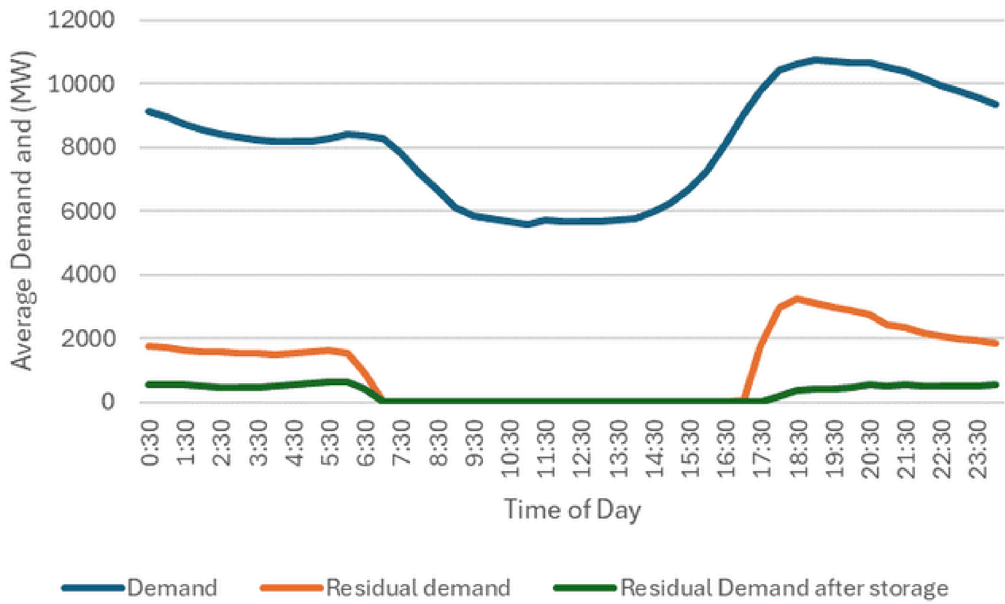
AEMO forecast that Queensland will have 84,000 MWh of storage by 2040, primarily in distributed energy storage, that is household batteries, and deep pumped hydro storage at Borumba.

Figure 4: Storage Energy by 2040.



This amount of storage will meet demand more than 70% of the time and leave a very limited residual demand (Figure 5).

Figure 5: demand after storage.

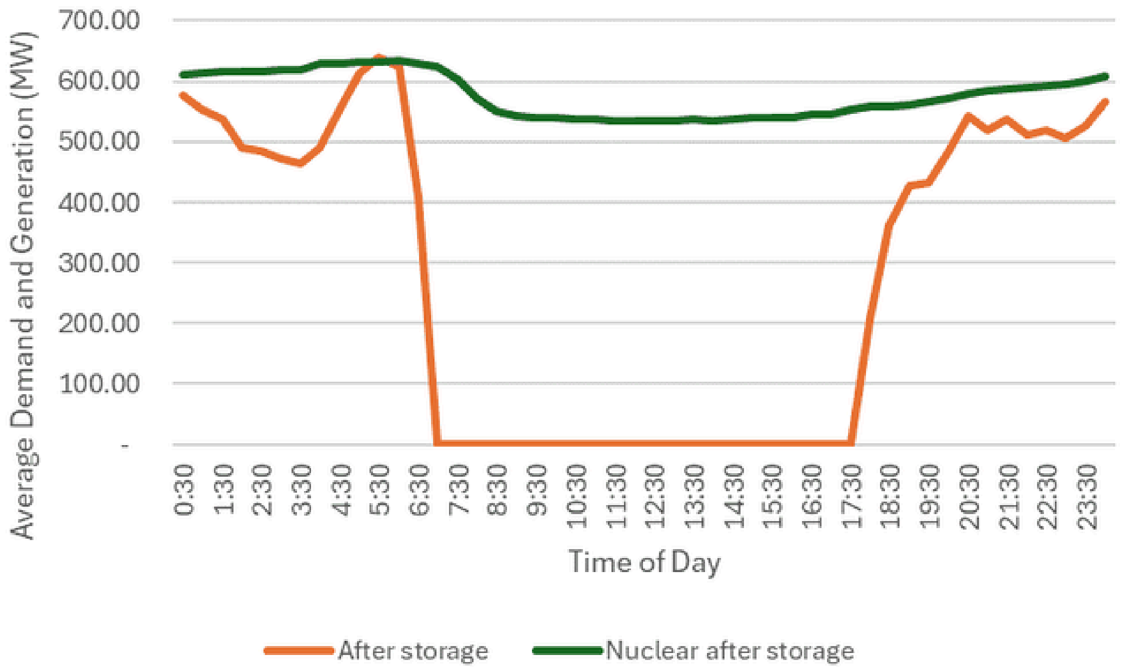


Impact of a nuclear power station in 2040

This analysis shows that in 2040 there will be, on average, less than 1,000 MW of demand to be met in Queensland, and excess generation during the middle of the day.

A nuclear power station, which can only run down to 500 MW then, would usually be supplying more energy than the system needs (Figure 6).

Figure 6: Average nuclear operation vs demand.



Running a nuclear power station would displace more than 3,700 GWh of cheap renewable energy in 2040 to enable it to stay online as it needs. This means the equivalent of an average of 45,000 Queensland household solar systems would need to be shut off every day. We would be shutting off cheap energy, like people's rooftop solar, to allow expensive nuclear power to run.

This report shows that, even if large-scale nuclear energy can be built in 15 years in Australia, we won't need it.

Conclusion

The Australian Energy Market Operator (AEMO) set out a detailed 20 year plan for how to meet our energy needs while retiring all coal fired power stations by 2040 through renewable energy and storage.

Nuclear energy is a technology that fits the energy system we had for decades. It doesn't fit the system we have now, with increasing demand dips in the middle of the day, and it certainly doesn't fit the system we could have in 2040, if we focus on building renewable energy well.

This is not an easy task, but it can be achieved with the right regulatory changes and regional planning to protect nature and benefit communities.

This is clear evidence that proponents of nuclear power want to slow down the build of renewable energy, to force our energy system to stay the same until a like-for-like technological replacement is found.

But keeping our energy system the same condemns us to increased climate chaos. We need to start building the low carbon energy that we can now. We cannot wait until 2040 to decarbonise, and by the time we build renewable energy, it will be too late for nuclear power.

Methodology

This analysis uses the 2024 Integrated System Plan demand traces for Queensland, specifically the reference year 2011, probability of exceedance (PoE)10 traces.

The renewable energy installed capacity is taken from the results of the Step Change scenario and allocated renewable energy traces based on existing plant, or AEMO REZ demand traces where no generation is yet built.

Table 1: Renewable Energy Capacity by 2040 and modelled trace.

Technology	AEMO REZ	Capacity	Renewable Trace (RY11)	Type of trace
Solar	North Qld Clean Energy Hub	358	Kennedy	Actual plant
	Northern Qld	437	Collinsville	Actual plant
	Isaac	1,183	Lilyvale	Actual plant
	Barcaldine	82	Haughton	Actual plant
	Fitzroy	2,346	Rugby Run	Actual plant
	Wide Bay	2,507	Woolooga	Actual plant
	Darling Downs	4,750	Western Downs GPH	Actual plant
Wind	Far North QLD	1,121	Kaban	Actual plant
	North Qld Clean Energy Hub	2,894	Kennedy	Actual plant
	Isaac	2,898	Isaac	AEMO REZ
	Barcaldine	113	Barcaldine	AEMO REZ
	Fitzroy	3,500	Fitzroy	AEMO REZ
	Wide Bay	1,100	Wide Bay	AEMO REZ
	Darling Downs	7,675	Coopers Gap	Actual plant

The half hourly operational demand trace for 2040 is then compared to the expected combined generation of these renewable energy plant to calculate residual demand. The operation of storage is then calculated based on excess or required generation for every half hour, to calculate demand after storage. This is taken as the requirement for a nuclear power station.

The nuclear power station is constrained to 50%, with a ramp rate of 5% per minute. The energy displaced by operating a nuclear power station is then calculated for the year.

References

[1] Carbon Brief (2016). *Mapped: the world's nuclear power plants.*

[2] Sustainable Nuclear Energy Technology Platform (2016). *Load following capabilities of nuclear power plants.*

[3] CSIRO (2024). *GenCost 2023-24 Report.*

[4] Aurora Energy (2024). *What a Delay to Hinkley Point C means for the GB Power Market.*

[5] UK Department of Energy and Climate (2013). *Initial agreement reached on new nuclear power station at Hinkley.*

[6] EnergyPost (2014). *The saga of Hinkley Point C: Europe's key nuclear decision.*

[7] Australian Energy Market Operator (2023). *Draft 2024 ISP Consultation.*

[8] OpenNEM (2024). *Queensland yearly data.*

[9] OpenNEM (2024). *Ibid*.

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