Submission
No 2

INQUIRY INTO ELECTRICITY SUPPLY, DEMAND AND PRICES IN NEW SOUTH WALES

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Submission to NSW Legislative Council Inquiry into Electricity Supply, Demand and Prices in New South Wales

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Summary

The Terms of Reference that my submission addresses are:

(a) the reasons for recent large increases in the price of electricity,

(f) the adequacy of planning to meet future electricity demand, including utilising high efficiency, low emissions coal technology as well as the use of nuclear, gas, solar and wind energies, and energy storage through batteries, pumped hydro and hydrogen, and improved transmission between regions,

Reasons for recent large increases in the price of electricity

The reasons for increases in wholesale electricity prices include:

- Increase in the price of gas to Asian levels (and above) due to fungibility caused by construction of a large east coast export capability
- Market manipulation
- A long period of low investment in new generation capacity. This suppressed price in the past since provision for capital replacement was often not made. Now most fossil fuel power stations are reaching the end of their lives, and substantial capital expenditure for renewable energy replacements is required.

Planning to meet future electricity demand

Wind, Solar photovoltaics (PV), pumped hydro energy storage and improved high voltage interstate connectors are the most credible combination for meeting future electricity demand. This is detailed in the following pages.

Recommendations

- Wholesale prices can be expected to decline once large amounts of wind and PV are included in the NSW grid, since both are cheaper than new fossil fuel plant. A state-based clean energy target should be introduced that dovetails with accelerated closure of existing coal fired power stations.
- Construction of wind and PV can be largely left to private industry. However, provision of storage and stronger interstate high voltage connectors requires strong Government intervention, in a similar way to the role of Government in transport planning.

Details

Solar PV and wind dominate the worldwide electricity industry

Solar photovoltaics (PV) and wind are now the #1 and #2 generation technologies in terms of new capacity installed worldwide each year [https://theconversation.com/solar-is-now-the-most-popular-form-of-new-electricity-generation-worldwide-81678], with coal in third spot (figure 1). PV and wind are likely to accelerate away from other generation technologies because of their lower cost, large economies of scale, low greenhouse gas emissions and the vast availability of solar and wind resources.

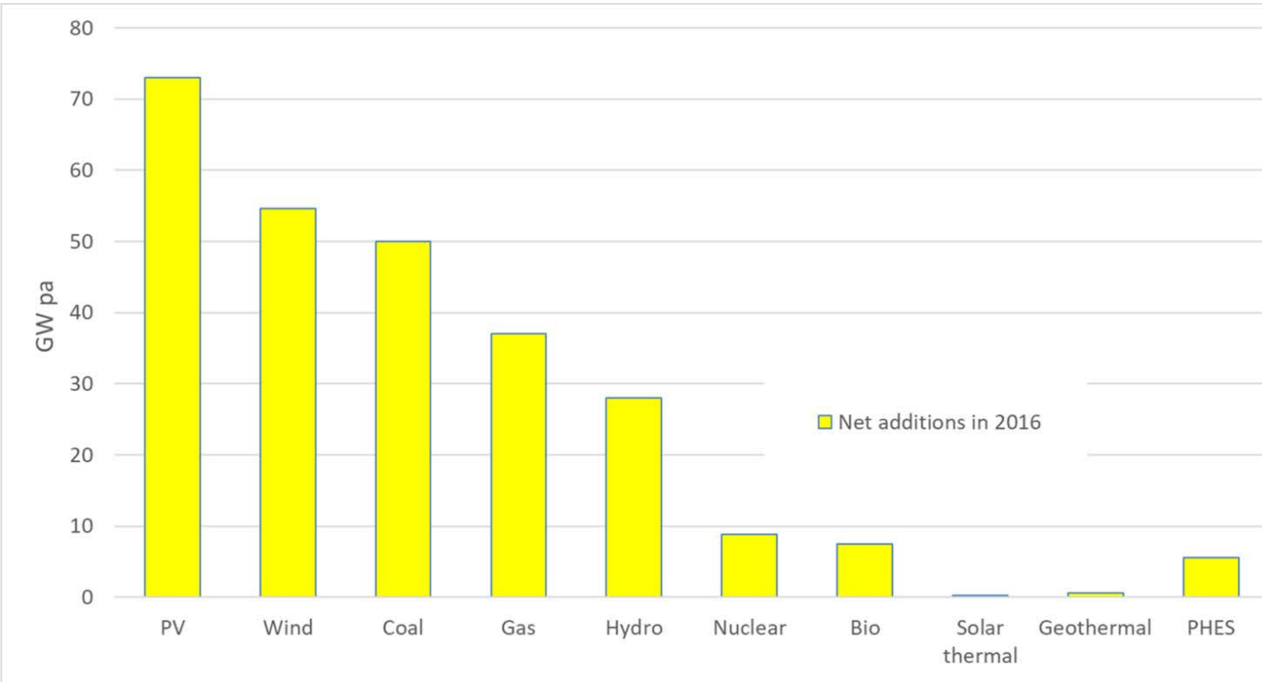

Figure 1 New generation capacity installed worldwide in 2016

Solar PV and wind are the cheapest available electricity generation technologies

Solar PV and wind are both cheaper than new-build coal, gas, nuclear and other renewable energy technologies. This is why they are dominating new generation capacity installed worldwide.

Our ***earlier work*** [http://www.sciencedirect.com/science/article/pii/S0360544217309568] examined the cost of a 100% renewable electricity system for the National Electricity Market (which includes eastern NSW). It shows that a fully balanced 100% renewable electricity system will cost less than fossil fuels or alternatives: ***the all-in cost is about $75/MWh***, which is lower than the current NEM wholesale price. Fully balanced means that the reliability standard of the current fossil fuel system is met.

It is straightforward to balance variable solar PV and wind

Although solar and wind are variable energy resources, the methods to support them in order to achieve a reliable 100% renewable electricity grid are straightforward:

- Storage in the form of pumped hydro and batteries, coupled with demand management; and

- Strong interconnection using high voltage powerlines spanning large areas, for example the million-square-kilometre National Electricity Market. This allows access to a wide range of weather, climate and demand patterns, and greatly reduces the amount of storage needed.

Pumped hydro accounts for 97 per cent of energy storage worldwide because it is the lowest cost large-scale energy storage technology. Pumped hydro systems have a lifetime of 50 years or more. Most existing pumped hydro systems are located in river valleys. However, there is vast potential for off-river pumped hydro.

Off-river pumped hydro requires pairs of reservoirs at different altitudes, typically with an area of 10 to 100 hectares, and located in hilly farmland away from rivers. The reservoirs are joined by a pipe with a pump and turbine. Water is pumped uphill when wind and solar energy is plentiful, and electricity is available on demand by releasing the stored water through a turbine. Off-river pumped hydro typically delivers maximum power for 5 to 25 hours, depending on the size of the reservoirs.

Researchers at ANU have identified about 22,000 potential pumped hydro energy storage sites spread across all states and territories of Australia. Most of them are off-river, and all identified sites are outside national parks and urban areas. The location of the sites is shown in Figure 2.

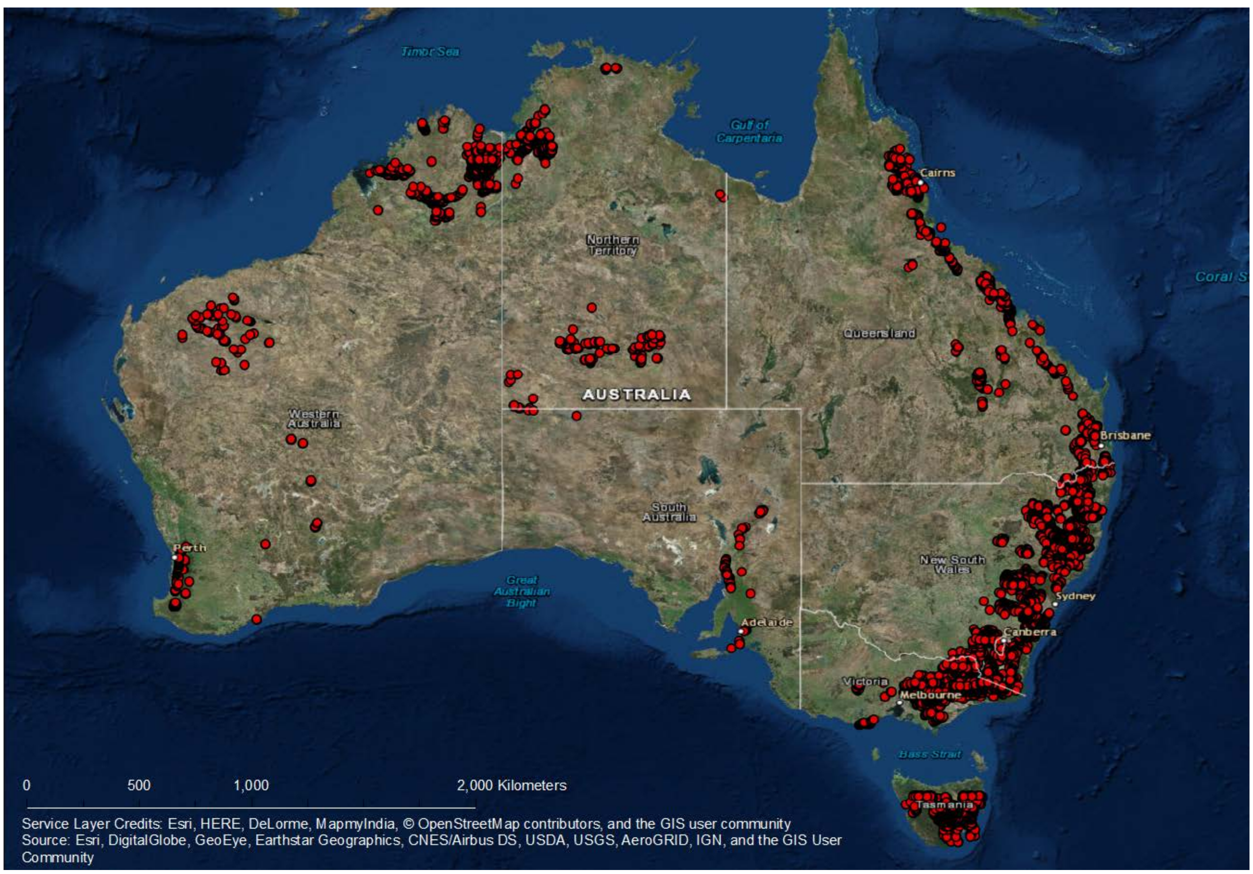

Figure 2 Pumped hydro sites in Australia

Each site has storage potential in the range 1 to 300 Gigawatt-hours (GWh). To put this in perspective, our earlier work demonstrated that Australia needs about 450 GWh of storage energy (and 20 GW of storage power) spread across a few dozen sites to support a 100% renewable electricity system.

Australia has so many good sites that only the best 0.1% of sites will be needed. Developers can afford to be choosy.

The number of sites found in each state is shown in table 1. Head refers to the minimum altitude difference between potential upper and lower reservoirs - larger is generally better.

Table 1	**Approximate number of sites**	**Approximate energy storage capacity (GWh)**	**Minimum head (m)**
NSW/ACT	8600	29,000	300
Victoria	4400	11,000	300
Tasmania	2050	6,000	300
Queensland	1770	7,000	300
South Australia	185	500	300
Western Australia	3800	9,000	200
Northern Territory	1550	5,000	200
TOTAL	**22,000**	**67,000**	

Figure 3 shows a synthetic Google Earth image for potential upper reservoirs in a site-rich region in NSW (Araluen near Canberra). There are many such site-rich regions in NSW. The larger reservoir depicted are of such a scale that only about a dozen of similar size (scattered across the populated regions of Australia) would be required to stabilise a 100% renewable electricity system.

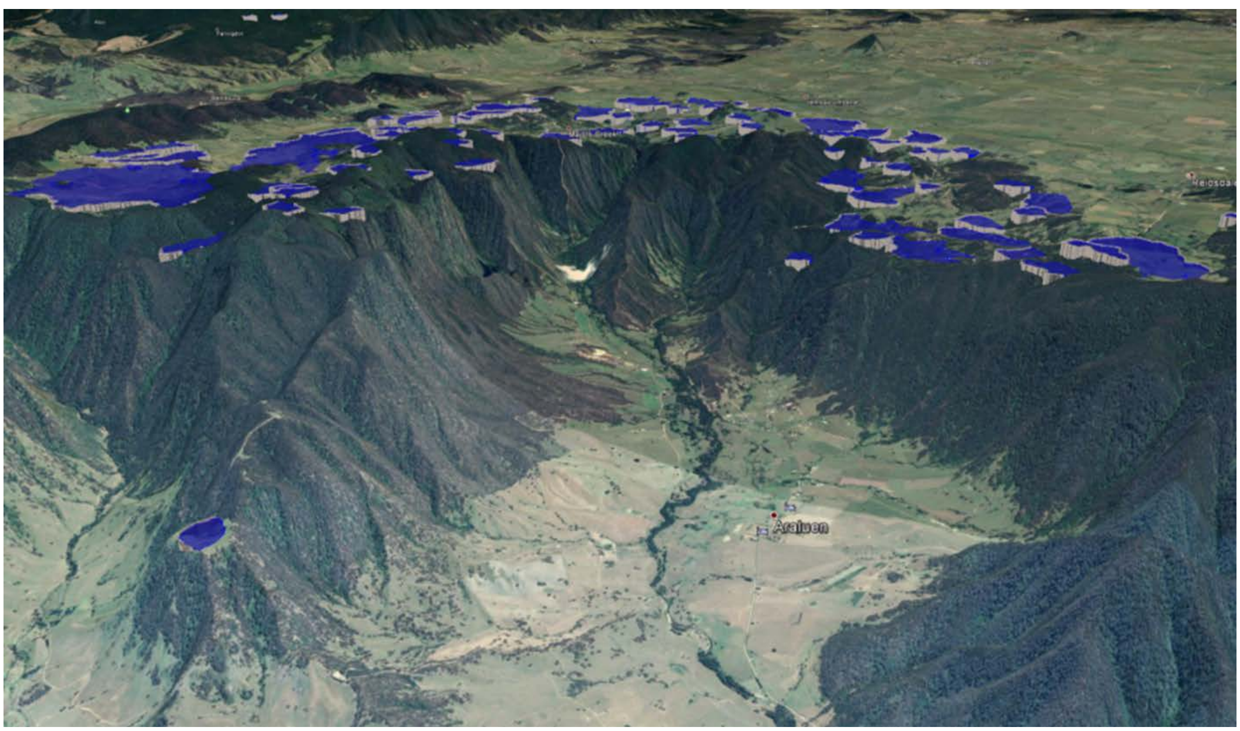

Figure 3 Araluen Valley near Canberra (potential head: 500-600 m). At most one of the sites depicted would be developed.

Annual water requirements of a pumped hydro-supported 100% renewable electricity grid would be less than one third that of the current fossil fuel system because wind and PV do not require cooling water. About 3,600 hectares of pumped hydro reservoir is required to support a 100 per cent renewable electricity grid for Australia, which is five parts per million of Australia's land mass and far smaller than the area of existing water storages.

Pumped hydro, batteries and demand management are all likely to have prominent roles as the grid transitions to 50-100% renewable energy. Currently, about 3 GW per year of wind and PV is being installed. This rate is sufficient (if continued until 2030) to supply half of Australia's electricity consumption. If this rate is doubled then Australia will reach 100% renewable electricity in about 2033. Fast track development of a few excellent pumped hydro sites can be completed in 2022 to balance the grid when the Liddell and other coal fired power stations close. Pumped hydro storage, including Snowy 2.0, can readily be developed fast enough to balance the grid with any quantity of variable wind and PV generation.

The STORES (Short Term Off-River Energy Storage) project is funded by ARENA with the following goals:

- Detailed hour-by-hour balancing and cost modelling of the NEM with 50-100% renewable electricity penetration (mostly PV and wind);
- Find all the pumped hydro energy storage sites in Australia;
- Develop a detailed cost model for pumped hydro to assist rapid deployment in support of PV and wind; a beta model is expected by the end of the year.

Details of the site searching, including maps of the identified sites, are available at http://re100.eng.anu.edu.au/research/phes/. Visualisation of sites is possible by opening kmz files with Google Earth. The website contains instructions on how to do this.

Figure 4 shows the largest identified off-river pumped hydro in each state in terms of energy storage potential (GWh). Also shown for comparison are the Tesla battery and the solar thermal systems to be installed in South Australia, and the proposed Snowy 2.0 system.

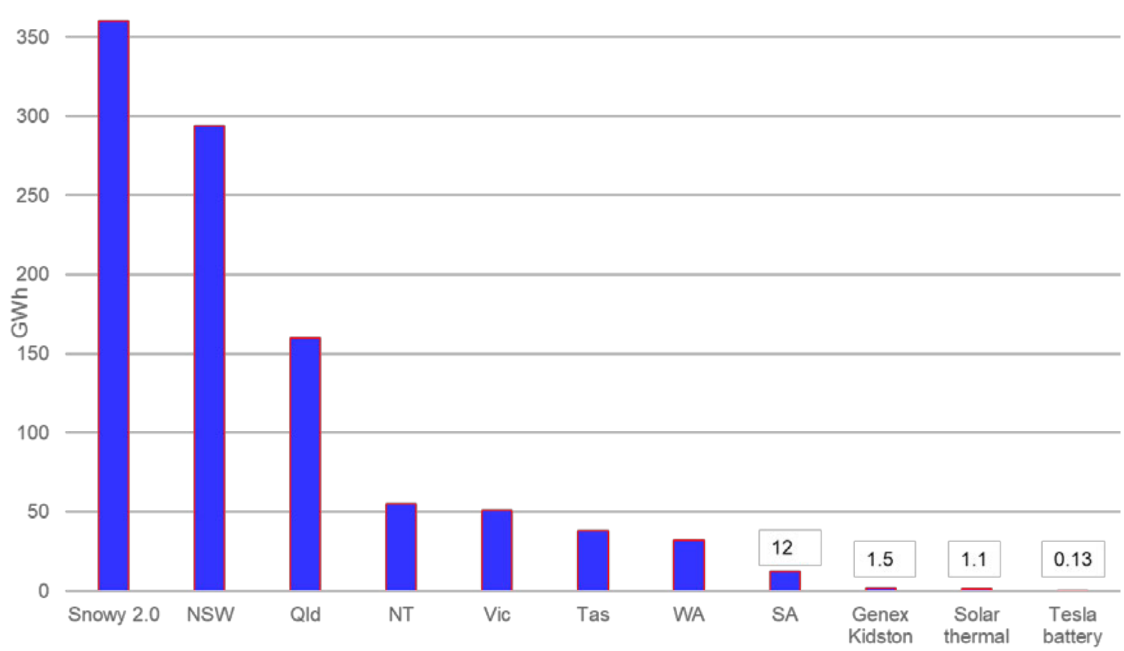

Figure 4 Largest identified off-river pumped hydro sites in each state, together with comparator storage systems