IES INSIDER

ISSUE 25 OCTOBER 2016

Can Energy Storage Provide Dispatchable Renewables?

Bill Nixey (Lead Consultant) and Jennifer Abedin (Energy Analyst), IES Advisory Services

This edition of Insiders investigates whether it would be economically viable for large lithium-ion batteries to store electricity generated from wind and large PV sources. A number of projects using this type of application are currently proposed in the National Electricity Market (NEM). If they are viable, it will mean that renewable energy can improve market efficiency and the overall reliability of the electricity system.

Our use of the term “dispatchable renewables” means a zero emissions generating facility that can participate in the electricity market as a scheduled generator. We have avoided using the term “baseload renewables” given that “baseload” has different definitions among industry stakeholders.

1 Why Dispatchable Renewables?

Electricity is unlike any other commodity as it has limited storage options. The only large scale storage opportunity currently in use in the NEM is hydroelectric power. This makes up 15% of the current registered capacity in the NEM but there are limited opportunities for any future projects[1].

Dispatchable renewables could help avoid situations when there is not enough generation available to meet consumer electricity demand. The market operator (AEMO) is required to ensure that the level of unserved energy should not exceed 0.002% of consumption in any year, in any NEM region. If the market operator doesn’t know when or by how much renewable sources will generate, it means there is a risk there will not be enough electricity produced. AEMO’s *Electricity Statement of Opportunities* report provides an outlook on investment and reviews the ability of the current generation mix to meet future demand. The 2016 report found that the unserved energy limit would be exceeded in the next decade if no new generators were built and some NSW and Victoria coal plant retirements occurred.

But at an aggregate level we can expect a significant oversupply of generated energy, as identified in the previous edition of Insiders. This is a result of national and state based targets to incentivise new investment in renewables, and no coal plant retirements beyond those currently announced. One issue is that too much energy will be generated at certain times - particularly in the middle of the day. Renewable generators are likely to have much of their energy curtailed off at these times. Dispatchable renewables could help improve this outlook by achieving a better match of supply and demand. If viable, it will also reduce over investment in generation and unnecessary costs being passed through to consumers.

2 Our Approach

Our aim is to assess the potential of dispatchable renewables and whether they are likely to be a viable option for electricity supply on a large scale. To do this we carried out a desktop modelling study of the income a battery would earn by storing energy from an existing wind or large PV generator and discharging when prices are

[1] The 2016 Electricity Statement of Opportunities has no proposed new hydro (as scheduled generation)

favourable. A 20 MWh lithium-ion battery was assumed to be installed as a retrofit alongside a large (greater than 45 MW) existing renewable energy generator. We note that the battery wouldn't need to be installed next to a generator to take advantage of regional wholesale prices. Nonetheless, our aim here is to assess projects where this type of application is currently proposed.

14 wind farms and the two NEM connected PV generators were included in the study. The wind farms are located in NSW, Victoria, and South Australia and the PV installations are near Nyngan and Broken Hill in NSW. The Broken Hill site began operation in September 2015 and only the recent 12-month period was modelled for the NSW large PV. We excluded Tasmanian generators as the local wholesale prices were abnormally high in 2016 due to the Basslink interconnector outage. Queensland was not included in the study as it currently has no large renewable generators that are NEM connected.

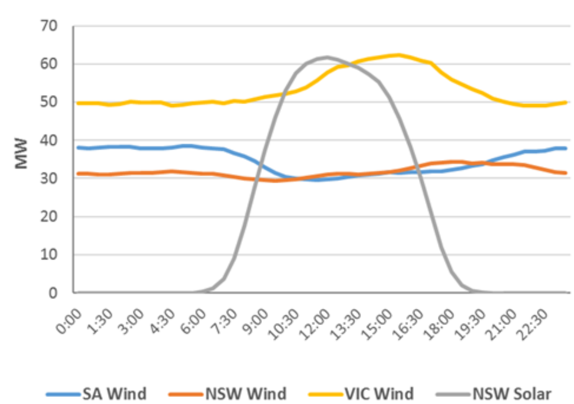
We examined wholesale prices and generation profiles over the last two years[2] and found the optimal charging and discharging regimes. The battery earns an income by storing energy when wholesale prices are cheaper and discharging at times when prices are more expensive. The battery operates a daily cycle and once it starts charging (or discharging) it is assumed to stay in that state until fully charged (or empty[3]). The battery is charged (or discharged) over a four-hour continuous period and there was no difference assumed in the battery operation across weekdays, weekends, and public holidays.

The model used half-hourly NEM generation and price data applicable to each location. Using these assumptions an iterative modelling process found the combination of charge and discharge patterns that would maximise battery income. Of course in practice the decision of when to operate the battery can't be based on actual half-hourly prices as they aren't known in advance. But some warning would be provided through the pre-dispatch forecasts provided by AEMO.

3 Half-Hourly Data

We extracted half-hourly price and generation data for our study from NEO. NEO is a proprietary IES software tool that enables market data to be easily visualised and managed. It presents complex data sets in simple graphical formats and is easy to create, share and run reports using existing or customised templates. This allows its users to quickly see the underlying trends in the selected dataset. NEO data includes the full history of the Australian NEM and gas data (STTM, DWGM, hubs, and bulletin board), Western Australian SWIS, and weather data. The following chart summarises the half-hourly generation data used in this article.

Figure 1: Average half-hourly wind and PV output



More information on NEO energy data is available here: http://products.iesys.com/NEO/NEO

4 Battery Income

The modelling results showed that batteries situated alongside a wind farm could make the most income if they started charging around 1am each day, and then discharged from 3pm in the afternoon. The exact start time of the charge or discharge depends on which wind farm and year of historical data are considered.

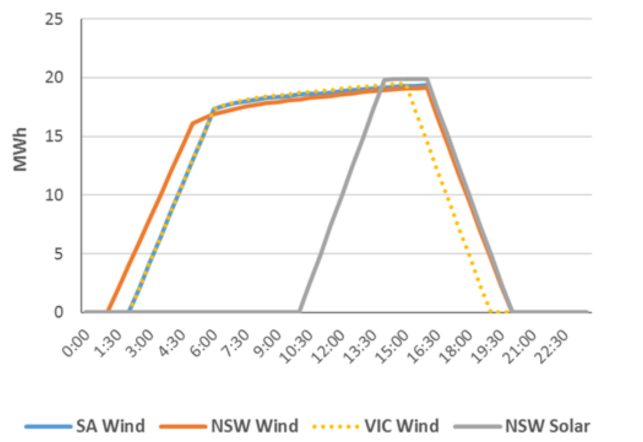
A battery located alongside one of the large PV generators in NSW would make the most income if it started charging

[2] We avoided using wholesale prices from July 2012 to June 2014 as this is when the carbon pricing scheme operated and would overstate results.

[3] Round-trip efficiency is taken as 90% (CSIRO). The depth of discharge was assumed to be 100%.

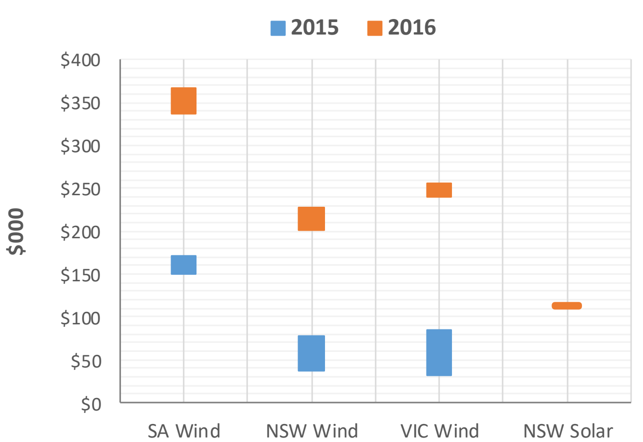
at 10:00am and then discharged from 4:00pm each day. Discharging patterns for both wind and PV were similar and our optimisation determined that this should start from 3pm in the afternoon to take advantage of higher wholesale prices. The following chart shows the battery levels for an average day in 2016 as seen at the selected wind and PV sites.

Figure 2: Average battery levels at wind and large PV sites



The net income from operating each battery in the wholesale market is shown in the figure below.

Figure 3: Annual net wholesale market incomes for a 20 MWh battery providing dispatchable renewable energy



The 2016 results achieved a significantly higher income than in 2015 due to higher wholesale prices. This is due to higher NEM demand and fuel prices combined with some plant outages. Better results were achieved when a battery uses wind farm energy since wind resources (unlike solar) are available overnight when wholesale prices are lower. PV is disadvantaged as it produces in the middle of the day when prices are high, and the pricing opportunity available to the battery is diminished. The battery would be better to charge overnight off the local network and ignore the PV generation.

5 Breakeven Analysis

A final step in our analysis was to determine what the battery capital cost (in dollars per kWh) must fall to for dispatchable renewables to be economically viable. There is a wide range of forecasts available for these costs. We believe that since this represents the biggest unknown in the modelling, the best way to assess the opportunity is to work out what battery costs must fall to for a dispatchable renewables project to break even. Therefore, we don't assume a capital cost; we calculate it as an output of the modelling. The costs of the wind farm and large PV sites used in the analysis are not in this calculation since they are existing plant and can be considered sunk costs.

We produced a project cash flow summary that includes battery wholesale market incomes and assumptions for operating costs, project lifetime, and rate of return. A 15-year project life was used which is a generous estimate considering the published sources[4]. We also used an 8% real rate of return. The operating and maintenance costs are for a large lithium–ion battery and sourced from the CSIRO's *Future Energy Storage Trends* report.

Over the 15-year project life we assumed that the income the battery makes from the wholesale market remains the same. In other words, wholesale prices are held flat in real terms. We believe that this is a conservative assumption and does not result in understating the extent of this opportunity. Wholesale prices will fall as more renewables (more supply) are built to meet national and state based targets and major coal plant retirements are limited to current public announcements.

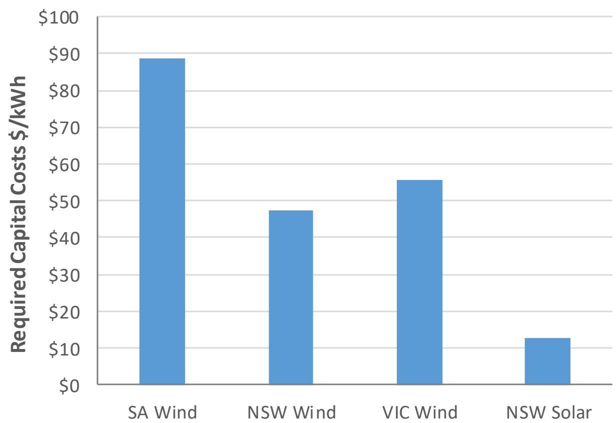
We then found the battery capital cost that would achieve breakeven (an NPV[5] of zero). This is the point at which the project becomes viable as any battery installation cost

[4] CSIRO quotes a 10-year lifetime for a lithium-ion battery using 4,000 cycles

[5] If the net present value (NPV) of an opportunity is positive, for a given rate of return, the opportunity is worth doing.

falling below this threshold will generate a positive project NPV. Using the more favourable 2016 year results, we found that dispatchable renewables will be viable when battery costs fall below $84 /kWh for wind farm retrofits and $12 /kWh for large PV installations. The following graph shows the battery with the best result (the highest capital cost threshold) across each state.

Figure 4: Required battery capital costs for project breakeven ($/kWh)



The CSIRO's *Future Energy Storage Trends* report[6] shows that lithium-ion battery costs will be $171 /kWh in 2035 under their base case scenario. Our results therefore show that batteries used in a dispatchable energy mode are far from being a viable option.

6 Conclusion

Large batteries used as dispatchable renewables are unlikely to be implemented within the timeframes of the current national and state renewable energy targets. They are also unlikely to be part of a least cost solution that resolves current concerns on the intermittency of renewables. There are much cheaper ways to achieve both emissions and reliability objectives than through battery sourced dispatchable renewables. One example is gas turbine generation which can displace existing coal if adequate price signals exist.

Should taxpayers' funds be used to subsidise battery projects in this type of application? We think not. Given the struggling economics, a new renewable generator will not improve its economic viability if it added a battery to the project.

The problem of a future oversupply of energy remains – and indicates a large scale curtailment of renewable energy will occur in the next decade if current state based targets are implemented. In this environment all market participants are worse off. This includes both existing and new generators, and of course the consumer.

However, we do note that energy storage may achieve widespread success in the residential sector. This is because there are greater differences between retail peak and off-peak prices compared to wholesale prices. But this will require the difference between peak and off-peak prices to remain the same over time[7]. More supply from residential batteries in peak periods will lower peak time prices. This indicates the pricing arbitrage opportunity for batteries will, over time, be gradually be eroded.

Batteries may be able to manage power system disturbances by offering ancillary services including frequency and voltage control. Perhaps the market will be redesigned in future to provide greater incentives to technologies providing this service. We are following the current policy developments in this area with interest.

CONTACTS

Bill Nixey

+61 (0)2 8622 2224 +61 (0)2 9436 2555

bnixey@iesys.com www.iesys.com

[6] The CSIRO minimum was $142 / kWh by 2035. This report also assesses the viability of large batteries in a peaking plant mode but finds limited scope for this application before 2035.

[7] The incentive to shift load will be eroded by the extent that cost reflective network pricing allows networks to move their costs into fixed rather than variable charges.