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# How will energy storage impact the National Electricity Market?

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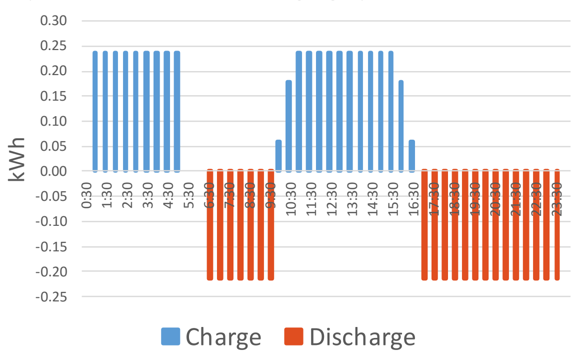
In this edition of IES Insiders we consider what impact energy storage will have on the National Electricity Market (NEM) over the next fifteen years. The focus of our analysis is on storage systems installed at residential and commercial premises. Take-up forecasts of energy storage are modelled in a wholesale market simulation tool. The results show the impacts that energy storage will have on wholesale prices, the generation mix, and greenhouse gas emissions.

## 1 Battery Charging Profiles

The first step in our analysis of storage impacts in the NEM was to construct a half-hourly profile of the charging and discharging patterns of a battery. This battery has a capacity of 5 kWh[i] and is installed behind the meter with a rooftop PV system. Our derived charging cycle is shown below:




This charging cycle assumes that the battery charges overnight and in the middle of the day. Overnight charging is incentivised by currently cheaper off-peak tariffs. Charging in the middle of the day will occur to store locally generated electricity from surplus PV energy. We think that homes with PV and storage systems will have surplus energy to either store or export energy, especially since the average installed capacity of new PV systems is now over 5 kW per site[ii]. With the roll-off of many state based feed-in tariffs, customers will have a greater incentive to store, rather than export their locally generated energy. There is more value in displacing retail consumption tariffs than there is in receiving a small feed-in tariff from a retailer.

Due to diversity effects the average battery is assumed to impact system demand by a maximum of 0.5 kW. Not all batteries in a large population will be charging or discharging at maximum power at the same time.

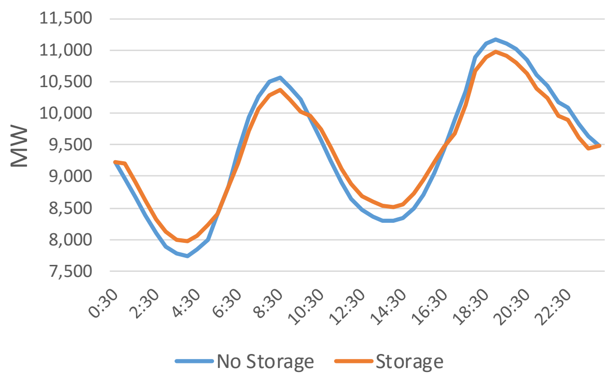
## 2 Energy Storage Forecasts

In its June 2015 Emerging Technologies Information Paper, AEMO published installed capacity forecasts for energy storage systems. We used these forecasts in our NEM modelling. The forecasts included new installations of combined storage and rooftop PV systems but excluded retrofitting batteries to sites with existing rooftop PV systems. AEMO's forecasts of energy storage capacity for each NEM state are shown below.

| *MWh* | **2017/18** | **2024/25** | **2034/35** |
|---|---|---|---|
| **Queensland** | 129 | 982 | 2046 |
| **New South Wales** | 201 | 1043 | 2482 |
| **South Australia** | 2 | 206 | 484 |
| **Victoria** | 188 | 1131 | 2774 |
| **Tasmania** | 9 | 83 | 196 |
| **NEM** | 529 | 3445 | 7982 |

## 3 Demand Profile Impacts

Our battery profile was incorporated with forecasts of the system demand profiles for each NEM state. These system profiles include the impacts of roof-top PV and are constructed using samples of half-hourly PV generation in each state. The total generated energy from rooftop PV is equal to the AEMO medium case forecasts[iii]. The following chart is an example of these forecast profiles - it shows the predicted annual average NSW system demand profile for 2035. One profile includes the impact of rooftop PV, the second includes both energy storage and rooftop PV. In 2035 NSW is forecast (by AEMO) to require 84 GWh of energy and to have 2.5 GWh of storage installed.




As shown above all of the five NEM states will experience significant reductions in demand during the middle of the day due to rooftop PV generation. The effect of energy storage is to flatten the overall demand profile, both during the day and overnight.

## 4 PROPHET Modelling

With half-hourly NEM demand profiles prepared for the 2016 to 2031 period, we can now run our wholesale market simulation to quantify the impacts of storage take-up in the NEM. This model, known as "PROPHET", is an advanced software application developed by IES that simulates energy market behaviour in a wholesale electricity market. It can produce price outcomes, generation trends, revenues, and impact of new investments over a long term forecast period.

The modelling assumptions used include costs for fuel and new generation entry, known plant retirements, as well as the half-hourly demand, rooftop PV, and storage profiles already mentioned. PROPHET can also accommodate various environmental policies such as the Renewable Energy Target and the Safeguard Mechanism by incorporating scheme certificate balances and emissions constraints.

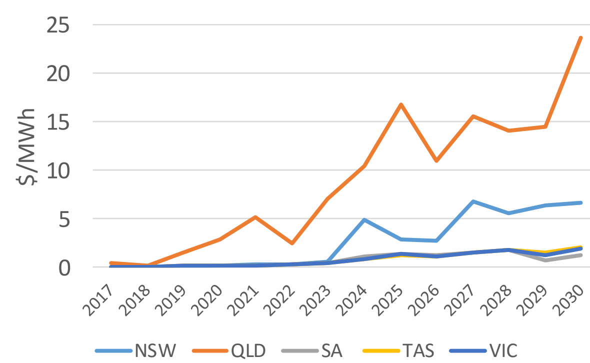
The simulations reproduce AEMO's algorithm for determining the electricity spot price (the National Electricity Market Dispatch Engine) and use it to predict future generator operating behaviour.

## 5 Results

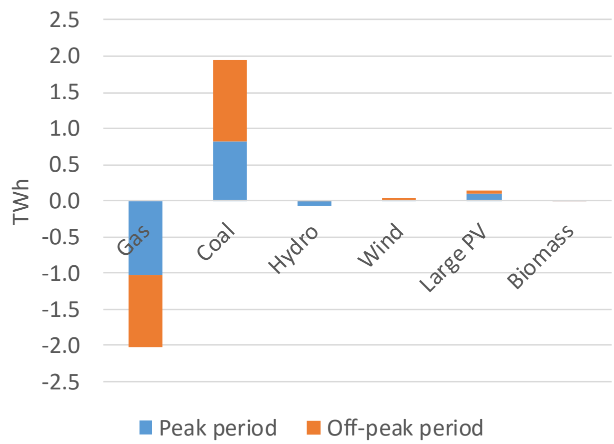
The PROPHET results provide us with the changes in NEM wholesale prices, generator output, and emissions for the next 15 years. This is calculated by comparing a scenario that includes energy storage to one without.

Electricity prices fall as a result of the introduction of energy storage. This is because the demand profiles in each NEM state are flatter due to the anticipated charging and discharging patterns. Less gas generation is required to meet peak time demand. When compared to coal or renewables, gas turbines have a higher marginal cost of generation. If less gas plant is dispatched it will lower the peak wholesale price.

The following graph shows the reduction in peak period wholesale prices as a result of introducing energy storage. The largest price falls are in Queensland which has the highest amount of installed gas generation capacity - both currently and as forecast in PROPHET. Changes to off-peak period prices are less than $2 /MWh in all years (they mostly fall).




As less gas peaking plant is required to meet lower demand peaks, more baseload coal plant is dispatched to meet the higher demand troughs. The largest overall shifts between gas and coal fired generation sources occur in the later years of the forecasts when more storage is installed. The figure below shows the changes in generated energy in 2031 as a result of the flatter demand profiles. Across the NEM, coal generation output increases by almost 2 TWh while gas turbine output falls by 2 TWh. This is about 1% of the total electricity required in the NEM at this time.




A shift away from gas generation has implications for carbon emissions. Gas fired generators have lower emissions intensities than coal fired plant. By the 2031 year, we forecast that energy storage has increased annual NEM emissions by 1.04 million tonnes. The NEM currently emits around 170 million tonnes a year.

## 6 Conclusion

The arrival of new technologies such as energy storage is an exciting development and is likely to enable consumers to reduce the costs they incur for electricity. This can be achieved by either deferring peak time charges or storing locally generated energy for later use.

This analysis applies AEMO storage and rooftop PV forecasts to the current and known operating assumptions of the NEM. AEMO assume that over the next 20 years, 8 GWh of energy storage will be installed in this market. This excludes any retrofitting of existing PV systems or any utility sized storage projects. If this analysis included these components, then the impacts presented here are likely to be greater (and occur sooner).

The results show that as more storage capacity is installed, the more peak period prices will fall. This means that the incentive to take advantage of the peak and off-peak period price differences will be eroded over time (this is separate to any changes to network tariff charges which have different drivers). This in turn will encourage more day time battery charging from locally generated PV energy.

The results also show that energy storage devices installed at residential and commercial premises will increase the total emissions in the NEM. This includes impacts from the energy lost in the battery turnaround cycle (which is greater than the energy losses incurred off the transmission and distribution network). While the AEMO forecasts used here assume that a rooftop PV system is installed alongside a storage device, the emissions reduction as a result of the PV system are already taken into account. Our results show that the net emissions in the NEM have increased by 1.04 million tonnes in 2031.

The opportunity to install a battery won't encourage homes and businesses to install more PV capacity than they otherwise would. Rooftop PV systems are already economically viable and the average installed capacity these systems has been steadily increasing without the addition of batteries (in April 2015 it exceeded 5 kW per site).

In summary, energy storage presents an excellent opportunity to reduce peak period electricity costs for the consumer. However, it will indirectly increase the total greenhouse gas emissions in the NEM as a result of flatter system demand profiles.

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[i] *Data from the AEMO Emerging Technologies Information Paper June 2015 (includes a depth of discharge of 90%, a DC cycle efficiency of 92%, and a maximum power of 2.5 kW).*

[ii] *Clean Energy Regulator postcode data (May 2016)*

[iii] *AEMO National Energy Forecasting Report (June 2015)*