IES INSIDER

ISSUE 24 AUGUST 2016

# Can the National Electricity Market achieve 50% renewables?

Bill Nixey (Lead Consultant) and Ori Agranat (Energy Analyst), IES Advisory Services

In this edition of IES Insider, we assess how a 50% renewable energy target by 2030 would impact the National Electricity Market (NEM). We carried out wholesale market modelling to project changes to the mix of generation sources and future wholesale prices, as well as the impacts on consumers.

Our 50% scheme is assumed to operate under a reverse auction mechanism which gives eligible renewable energy projects long term offtake agreements. At its outset, our assessment of the stakeholder impacts of this target is not intended as an endorsement (or criticism) of any existing emissions abatement policies. This of course includes the policy that the Federal Opposition took to the last election.

## 1 Renewable Energy Policies

This study is a review of the likely costs to consumers and impacts on generators of more renewable generation being connected in the NEM. The existing Large Scale Renewable Energy Target (LRET) targets 33,850 GWh of renewable energy to be installed in Australia by 2020. If this target is achieved on time, about 15% of national electricity demand will be supplied from renewable energy. When rooftop PV forecasts are included, this becomes 20% of the mix by 2020.

The Queensland government has a 2030 renewable energy target of 50% and the Victorian government has a target of 40% by 2025. The implementation details of each of these policies are currently under consideration. But it is clear that a significant amount of new capacity will be required to meet the Victorian and Queensland targets.

Our modelled target is introduced in 2017 and increases to 50% by 2030. The target applies to all generated energy (including rooftop PV) in the NEM and not separately to each state. While we haven't modelled the Queensland and Victorian schemes individually, we provide the results of the renewables take up for these regions if a 50% scheme were to be applied across the NEM.

## 2 The PROPHET Model

IES's PROPHET electricity market model projects future outcomes by emulating market and business logic as well as energy market participant behaviour. It can model generation trends, participant revenues and costs, and the impact of new investments over short or long term forecast periods.

The simulations reproduce AEMO's algorithm for setting the electricity spot price (known as the National Electricity Market Dispatch Engine) to project future generator operating behaviour and, ultimately, future wholesale prices and investment.

To assess the impact on the NEM of a 50% renewable energy target we ran two scenarios; one with the 50% target, and one without. All other assumptions were the same in each scenario. The 50% scenario met the target using an imposed constraint and introduced new NEM renewables in configurations that followed a "least cost" logic. This logic emulates the business case for investment.

# 3 Modelling Assumptions

The PROPHET model uses a wide range of assumptions to replicate the future NEM. These include new entry costs for wind turbines and large PV installations, fuel costs for coal and gas generators, take up of rooftop PV, and consumer electricity demand. The modelling is carried out for each 30-minute trading interval over the forecast term.

**Scheme Mechanism.** Our 50% NEM-wide renewable energy target is modelled using a fixed wholesale electricity price awarded to eligible projects. The mechanism is similar to the ACT reverse auction scheme. Reverse auction incentive schemes are becoming increasingly common internationally[1]. Under the mechanism, the renewable energy projects that win an auction receive long term power purchase agreements for their generated electricity. Projects receive both the wholesale price and a "contract for difference" (CFD), the costs of which are recovered from consumers via higher network charges. In our modelling projects can be developed anywhere in the NEM.

**New Entrant Costs.** The projected costs for new wind or large PV projects are consistent with publicly available information. Large PV systems are expected to achieve cost parity with wind turbines within the 15 year forecast term.

**Renewable Energy Resources.** The amount of wind and solar PV resources varies greatly across the NEM. In the modelling we use actual half-hourly generation data for existing renewable energy sources. These sample profiles vary across each NEM region. As more renewable energy is installed, the capacity factors (and energy produced) for subsequent new builds are lower because the best locations for renewable resources are likely to be taken first.

The profiles for rooftop PV are scaled up using AEMO's 2016 take-up forecasts.

**Demand Forecasts.** The demand for electricity in the NEM over the next 15 years is assumed to follow the latest medium case AEMO forecasts. These forecasts assume no growth over the forecast term once rooftop PV is netted off. On this basis only 195 TWh is predicted to be consumed in the NEM by 2031, which is slightly less than expected amount for the current year.

We note that the AEMO forecasts don't take into account electric vehicles which could provide future growth in electricity consumption.

**Retirements.** Plant retirements are based on public announcements and an assessment of asset age. In addition to the announced retirement of Liddell power station in 2023, one Victorian brown coal fired power station is assumed to be retired during the forecast period. This applies to both modelled scenarios. All other retirements are as current public announcements.

**Gas prices.** Gas pricing is an important assumption given that gas generation can provide backup for renewables. Local gas price movements are expected to be driven by international oil prices by 2018. At this time many existing contracts for gas generators are expected to be rolling off. A forwards oil price curve was used to project gas price changes beyond 2018.

**Plant Investment and Dispatch.** The model was set up to introduce new renewable plant according to a least cost regime that satisfies the move towards a 50% target. This doesn't mean there will be no curtailment of wind or large PV capacity in the model. It may be the case that achieving the target under a least cost approach means that some of the available energy isn't dispatched at all times.

**Energy Storage.** Large energy storage systems are currently not an economically viable option to provide backup for renewable energy. There is also a wide range of forecasts on the rate at which these costs will fall. We take the view that batteries are most likely to be deployed initially to provide short-term ancillary services support for large scale non-synchronous generation and in storage applications for the residential sector.

**Regulated Infrastructure**. A significant number of new renewable energy projects are likely to connect to the transmission network under a 50% target. Transmission interconnectors are modelled with expected limits while any intraregional network congestion over the forecast term is assumed to be minimal.

[1] The governments of Germany, India, Japan, Chile, and UAE adopted the reverse auction PPA model to incentivise new renewable investment.

**Existing Emissions Policy.** Both the existing 33,000 GWh RET and the Safeguard Mechanism baselines remain unchanged.

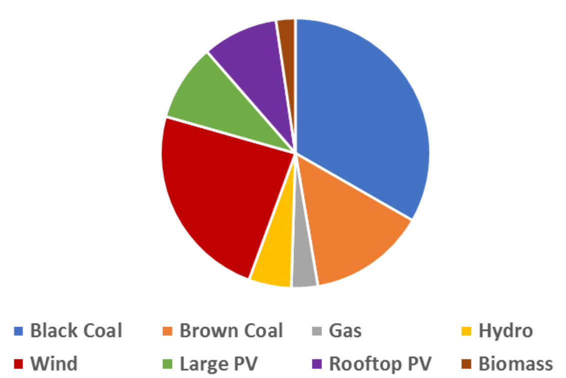
## 4 Results

The electricity demand outlook for the 2017-2030 period has a significant impact on the modelling results. If demand was growing there would be a need for new entrant power stations. However, AEMO's outlook is that demand as seen at the system level will be flat over the forecast term. This creates challenges in an electricity market that is already oversupplied with generating capacity.

Despite this, our assumptions required that the renewables target of 50% be met by 2030. The model solved for the most efficient, or least cost, new build that would meet the target within this timeframe.

The results show that in 2030 the target would be met by new wind turbines and large PV installations. Rooftop PV also makes a significant contribution but rooftop PV take up projections are included as an input and are not modelled. The following chart shows the dispatched energy mix in the year 2030 under the 50% scenario.

**Figure 1: Projected Dispatched Energy Mix in 2030**

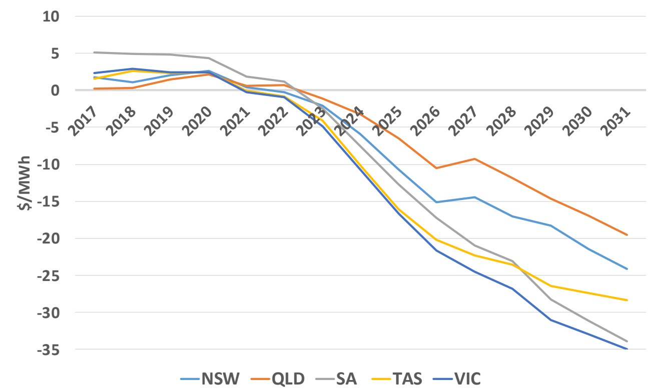



The 50% target was found to reduce NEM emissions by 41% when compared to 2005 levels. The base case achieved 22%. We note that Australia's current emissions target is for a 26% to 28% reduction on 2005 levels to be achieved by 2030.

On a capacity basis, an additional 12.2 GW of wind generation and 12.5 GW of large PV generation is built by 2030. Wind generation was installed ahead of large PV until PV achieved cost competiveness in the 2020s. Our NEM wide target is met by proportionally more PV generation in regions where there is less wind available.

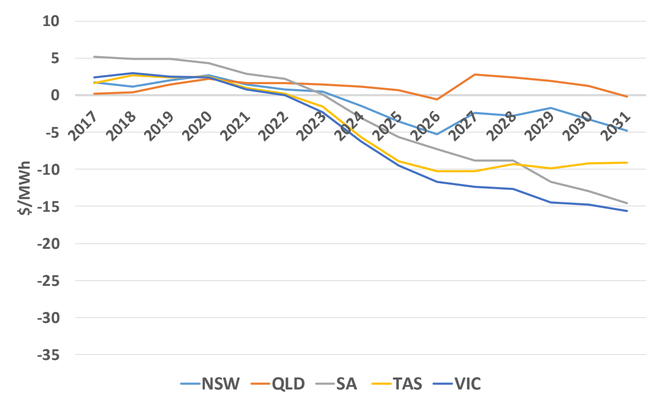
Due to the significant amount of extra capacity, wholesale prices are lower in all states in the 50% scenario. Prices fall the most in states that have more renewables capacity installed. The following chart shows the projected difference in wholesale prices between the base case and 50% scenarios.

**Figure 2: Wholesale Price Impacts by Region**




The renewable projects that form part of the 50% scheme receive both the wholesale and the CFD prices over the forecast term. The CFD costs are recovered from consumers. Adding the CFD costs to the wholesale price impacts gives the net change to consumer retail prices (as shown below). A negative price indicates a benefit to the consumer.

**Figure 3: Retail Price Impacts by Region (curtailment costs are not passed through)**



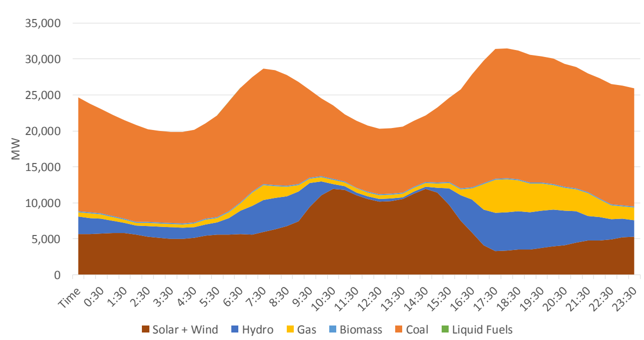

NEM consumers still benefit from lower wholesale prices, but the recovery of scheme CFD costs has eroded much of the benefit.

The modelling shows that there are significant impacts to existing generators (either coal, gas, or renewable) as a result of the lower wholesale prices. Their annual loss of revenue is calculated to be \$4.8 billion in total in 2030 compared to the base case. This is a reduction of 58% of revenue in 2030. Nearly all existing generators are worse off, except a few gas turbines and hydro stations. It suggests that some generators may exit the market beyond what was specified in the modelling.

A subdued demand outlook meant that coal generators were unable to benefit from high prices driven by the dispatch of gas peaking plant. The generator revenue and cost results showed that black coal generators were found to be worse off when compared to brown coal generators. This was in part due to different costs for fuel. It suggests that black coal generators may be retired from service before brown coal generators. Since brown coal is more emissions intensive than black coal, the 50% renewable target is unlikely to be sending the most efficient carbon abatement signal to the market.

The following chart shows the dispatched generation during a typical day in June 2030. Gas, hydro, and coal generation filled the periods when renewables aren't available.

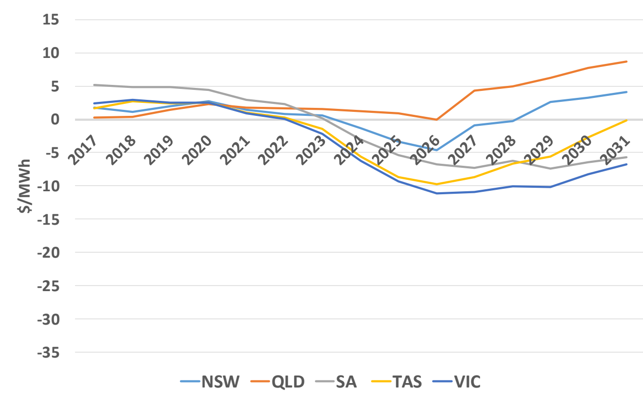
**Figure 4: Example of Dispatched Generation During a Day in June 2030**




We found that during the middle of the day there was surplus energy generated and wholesale prices were very low (averaging \$5 /MWh). This was especially the case on weekends when demand is lower. The modelling results show that 8.6 TWh of large PV energy was curtailed (i.e. not used) in 2030. A further 11.6 TWh of wind generation was curtailed due to excess supply during periods of low demand. It occurs because existing thermal plant are assumed to have minimum generation levels, given the operating characteristic of these generators.

Under a reverse auction scheme, eligible generators may be able to recover their cost of curtailment. We calculate these costs using the amount of energy curtailed and the forgone wholesale and CFD revenue. Over the forecast term the curtailment costs were found to be minimal until the NEM reaches 40% renewables in 2026. The lost revenue to renewables as a result of curtailment was calculated to be \$1.8 billion in 2031. If these costs were recovered from consumers the price impacts would be as shown in the following chart.

**Figure 5: Retail Price Impacts by Region (curtailment costs are passed through)**




We carried out our modelling at a 30-minute level which averages out the demand and supply over this time period. The dispatched energy results may change when running the model at a 5-minute level of granularity. Sudden changes in generation output from renewable sources may create difficulties for the market operator to match supply with demand. We note that currently most existing fast start generation in the NEM cannot be dispatched in under 10 minutes[2]. This highlights the need to promote generation and load curtailment options that operate in time frames of much less than half an hour. The five-minute settlement rule change currently under consideration by AEMC addresses this need.

The modelling shows that no additional gas generation capacity is installed (when compared to the base case). As a result, gas pipeline constraints were not found to be an

[2] Engie Submission to AEMC (5-minute settlement rule change) June 2016

issue in the 50% case. Modelling at the 5-minute level may see a greater need for gas peaking generation. We note that the limited coal retirements and the large installation of renewables meant that system reserve requirements[3] were met without the need of additional gas generation capacity.

In the modelled scenarios, we have assumed that the NEM intraregional transmission constraints are minimal. However, we forecast that 25 GW in total of new renewable capacity connections will be required to meet the target. It is very likely that this would trigger a significant increase in network expenditure. This includes (for example) an expansion of substation capacities or transmission line augmentations. This in turn would increase the network costs recovered from electricity consumers. Possible new interconnections between regions would also add to regulated network costs.

While the 50% reverse auction scheme was modelled on a NEM-wide basis, it is interesting to compare the results to the proposed Victorian and Queensland state-based schemes. Our results showed that Victoria achieves 44% renewables in 2025 while Queensland achieves 34% in 2030. Victoria exceeds its target while Queensland is well below its 50% goal. This suggests that a NEM-wide target can achieve greater benefits than local policies by taking advantage of a wider diversity of renewable energy resources.

Power system frequency and voltage stability were not modelled in this study. System inertia and the contribution of synchronous generation are areas of further separate studies.

## 5 Conclusion

Our modelling found that a 50% renewable energy target can be achieved in the NEM and consumers would be better off as a result of lower wholesale prices. However, if curtailment costs were included in the price impacts consumers would be worse off in NSW and Queensland. Energy curtailment represents a project risk that may eventually increase the CFD costs to be recovered from consumers. However, large energy curtailments do signify that there are likely to be practical limits to renewable generation until cost effective storage technology is economically viable.

The lost revenue to existing generators (some of which are renewable) was calculated to be $4.8 billion in 2030. With such significant impacts to all existing generators we might expect retirements beyond what was included in the modelling. However, these retirement decisions will depend not only on renewable policy but also on the medium to long term outworking of gas prices. It may be that sustained high gas prices will keep most coal plant remunerated and online for some time to come, despite the ongoing penetration of renewables.

All these challenges are more significant in an environment of subdued demand.

The results indicate that increasing renewable energy targets may not offer the most effective form of emissions abatement. A market price signal for emission reduction is an alternative that incentivises the lowest cost abatement possible, and triggers retirement of emissions intensive plant in a logical order.

**CONTACTS**

Bill Nixey

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

bnixey@iesys.com www.iesys.com



[3] The recent AEMO Electricity Statement of Opportunities (ESOO) forecasts low reserve conditions in 2026 under a COP21 scenario with the same demand outlook. The ESOO includes different assumptions on plant retirements and does not add any new generation capacity.