We understand that South Australia Power Networks, the Total Environment Center, St Vincent de Paul Victoria and the Australian Council on Social Services have submitted proposals that owners of solar panels that input power to the grid should be changed a fee for doing so.

We are opposed to these proposals and any others which suggest that solar panel owners are receiving a subsidy from other users by not being required to pay for updating the networks to receive and distribute power from homeowners.

We have read these propels as given in the "Distributed Energy Resources Integration – Updating Regulatory Arrangements" document on the AEMC website and notice that the claims made in these submissions about costs and charges do not provide the evidence for their claims nor include any reference to the financial economic benefits to the nation and **all** consumers which household solar already provides, a benefit which will grow in the future. As well these proposals do not appear to recognize the enormous contributions which consumers have made to the profits of network owners (both government and private) through the years through the "network charge" passed on to every consumer in every bill.

We have been very concerned about the enormous impact of Australias coal fired power on our environment for over 30 years. Electricity generation produces about one third of Australia's emissions, which are widely reconised as contributing to destructive climate change. We decided in 2004 to invest in solar panels to help reduce our emissions and to provide a symbol to our neighbours that citizens can make a contribution to reducing emission. At the time this was not a way to save or make money. Given the low feed-in tariffs and lack of smart meters the return on the panels would not have covered their cost for 20 years. Though the situation has improved slightly in the meantime, it remains the case that solar owners have not been compensated financially for the financial contribution they are making to the community by providing electricity to the grid. This is unfortunately not well known. We refer you to three studies which show that household solar is making a big contribution already, and that charging solar owners is not necessary to fix issues. These are:

1. "Impact of small solar PV on the NSW wholesale electricity market" from Energy Synapse in 2017, accessible from https://energysynapse.com.au/product/impact-of-small-solar-pv-on-the-nsw-wholesale-electricity-market/

   Among other things this report found

   1. Rooftop solar PV decreased the average price of wholesale electricity from $132/MWh to $88/MWh over the one year study period; That is by 33%.
   2. The biggest monthly cost reduction was in February 2017, of at least $740 million
   3. Downward pressure on wholesale electricity priceswas greatest between 1.30pm and 4.30pm the time when solar panels are providing the most power.

   This report shows that solar owners have been providing a substantial support for everyone's electricity cost, support that would have been over several years besides during 2017.

2. The report "Rooftop PV and electricity distributors: who wins and who loses?" by the Victoria Energy Policy Centre also finds that rooftop solar panels bring down power prices for all energy consumers. The VEPC analysed the bills of 7,200 Victorian homes with rooftop solar and found that even the relatively low penetration of rooftop solar in that State brought prices down by $6.4/MWh, 8% off the wholesale price of electricity in 2019. This report is accessible at https://243b2ed8-6648-49fe-80f0-f281c11c3917.filesusr.com/ugd/cb01c4_2155920402f64e74b0f8d70ffd1bd999.pdf

3, "Voltage Analysis of the LV Distribution Network in the Australia" from the Centre for Energy and Environemental Markets of the University of NSW which found that household PV contributes to making the system more stable and at the impact of solar on the networks has been overestimated, and that there are cheap and simple ways of enabling more solar. It is available athttps://cloudstor.aarnet.edu.au/plus/s/yXM0UFtPMJmWcLe

As solar owners we are glad to provide the benefits of household solar to the community. We do not expect any special rewards for doing so, other than being paid a fair price by the electricity retailers. *But we certainly should not be charged for providing these into the future.*

A further reason should be no special cost imposed on generation from solare households is that it would be enormously unfair. Up until now NO generator has bee charged for supplying electricity to the grid.

As well we are aware that network owners have profited enormously from the network charges increase about on 8th November 2015 years ago, as reported by among others the Radio National Background Briefing in "The Big Disconnect" available at https://www.abc.net.au/radionational/programs/backgroundbriefing/the-big-disconnect/6915554 These profits should be invested in making our electricity system "fit for the future", not merely passed out as dividends to the owners as is now the case.

We are in favor of making the benefits of solar electricity to everyone, including households which can not, or can not afford to have panels. This could include:

- Encouraging and enabling the development of Solar Gardens for communities and households
- Legal arrangements which enable renters and landlords both to benefit from installing panels on rental properties.
- Invest in network infrastructure, like community-scale battery storage, so that more homes can invest in rooftop solar.

We encourage the Commission to take account of the enormous contribution of household solar to everyone's financial and environmental well being and not only reject any proposals to in effect put a tax on household solar, but to develop policies with recognise and help further its benefits into the future

Impact of small solar PV on the NSW wholesale electricity market

Approved for Public Release

12 October 2017

ENERGY SYNAPSE

Disclaimer

This report (Report) has been produced by Energy Synapse Pty Ltd ABN 34 616 603 082 (Energy Synapse) on the request of Solar Citizens Australia.

The information, statements, statistics and commentary (together the 'Information') contained in this Report have been prepared by Energy Synapse using data published and/or provided by the Australian Energy Market Operator and the Australian Photovoltaic Institute. Energy Synapse has based this Report on data received or obtained, on the basis that such information is accurate and, where it is represented to Energy Synapse as such, complete.

Energy Synapse does not accept any duty, liability, or responsibility to any person (other than Solar Citizens Australia) in relation to this Report.

Contact Information

For further information about this Report, please contact Marija Petkovic.

To learn more about Energy Synapse, please visit our website and social media:

https://energysynapse.com.au

https://www.linkedin.com/company/energy-synapse

https://www.facebook.com/EnergySynapse

https://twitter.com/EnergySynapse

Executive Summary

Energy Synapse has been engaged by Solar Citizens Australia to perform an independent analytical study to investigate the impact of small solar PV systems on the NSW wholesale electricity market. As per the Service Agreement dated 20 June 2017, this impact has been estimated by constructing a counterfactual case where NSW has zero small solar installed and hence the electricity that would have been produced by small solar is instead serviced by existing centralised generators. This study considered a 12 month period from 1 May 2016 to 30 April 2017. Small solar PV systems in NSW are estimated to have generated 1,540 GWh of electricity during this period.

Despite contributing only 2% to electricity generation, this study found that small solar PV systems put significant downward pressure on wholesale electricity prices in the NSW market. If there was no small solar installed in NSW, we estimate that the volume weighted average price of wholesale electricity would have been $29-44/MWh (33-50%) higher than the actual price of $88/MWh. This equates to a $2.2-3.3 billion cost saving to the NSW market (see Figure 1). Thus, each megawatt hour of power that was produced by small solar lowered wholesale costs by $1,400-2,200. This benefit is shared by all consumers, regardless of whether or not they have installed solar PV systems.

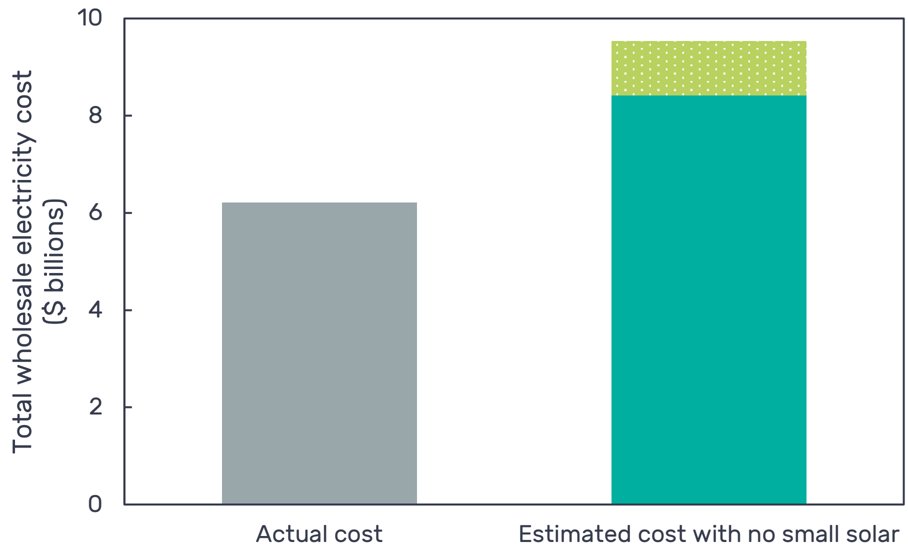

Figure 1: Total wholesale electricity cost for NSW from May 2016 to April 2017. In the no small solar case, teal is the lower estimate, green is the upper estimate.

In addition to electricity pricing, small solar PV was also found to significantly reduce both the severity and length of peak demand. Severity is defined as the maximum five minute electricity demand on a given day. The length of peak demand is the number of hours in a given day that are within 5% of the maximum five minute demand. An examination of the top 10 demand days during the study period found that small solar reduced the severity of peak demand by an average of 432 MW or 3%. Even more significantly, small solar was found to reduce the length of peak demand by 58%, from an average of 5.3 hours to 2.2 hours.

1 Background

1.1 Small solar in NSW

Small-scale solar photovoltaic (PV) systems are defined as solar panel systems with a capacity of no more than 100 kW. They are generally found on the rooftops of homes and businesses, and occasionally as small ground mount installations. This study focuses on small solar PV only and does not consider the impact of solar systems greater than 100 kW.

This study considered a 12 month period from May 2016 to April 2017. During this period, it is estimated that small solar in New South Wales (NSW) generated about 1,540 GWh of electricity. This was approximately 2% of the state's power needs. During peak production periods, small solar generated close to 960 MW of instantaneous power. Figure 2 shows the total monthly electricity generated from small solar PV systems in NSW over the study period. Small solar systems less than 10 kW represent approximately 80% of the installed capacity, and the remaining 20% are systems with a capacity between 10 kW and 100 kW.

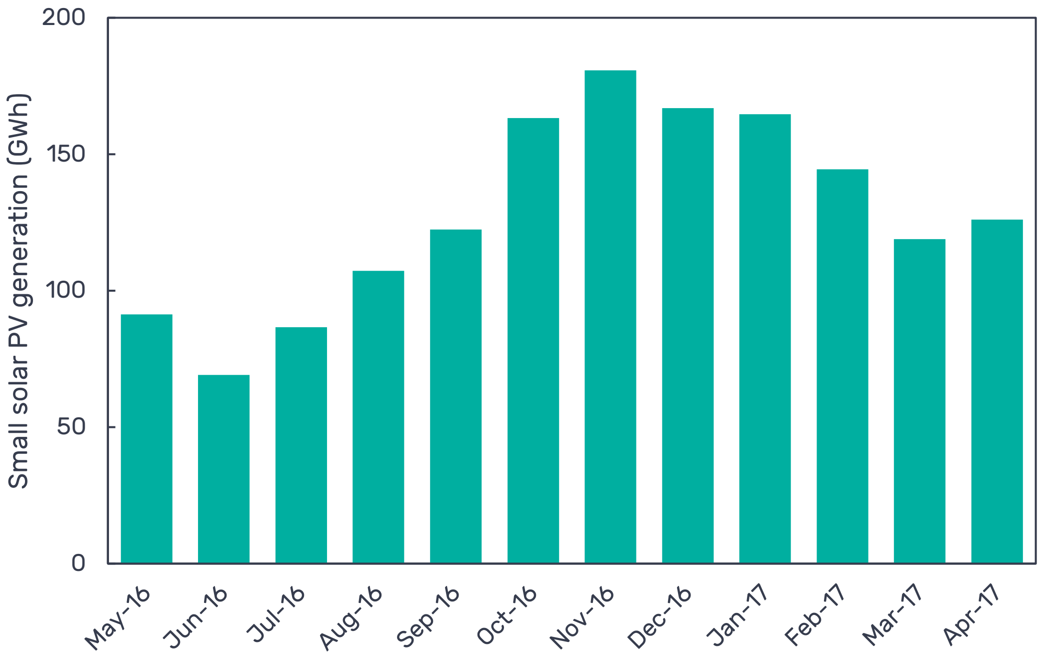

Figure 2: Estimated monthly electricity generation from small solar PV systems in NSW. Raw data provided by APVI (based on installation data from the Clean Energy Regulator published in July 2017).

1.2 How the wholesale electricity market works

The National Electricity Market (NEM) is classified as a real-time energy only market. The NEM is operated to balance the instantaneous demand and supply for electricity, while ensuring safety, reliability, and cost efficiency.

The dispatch process is complicated but to put it in very simple terms: Generators submit offers to the Australian Energy Market Operator (AEMO) for each five minute dispatch period, signalling how much electricity they are willing to provide and at what price. AEMO's central dispatch process then orders these offers from least to most expensive. The least cost generators are then dispatched to serve the demand in the market. The marginal bid (i.e. the last/highest cost generator that is selected) sets the price for everyone in that dispatch period.

The NEM is currently financially settled on a 30 minute basis. Thus, the five minute dispatch prices are averaged to produce the 30 minute Trading Price. All Generators who were dispatched receive this Trading Price from AEMO, and in turn, all retailers pay this price for the electricity that their customers have consumed.

A notable recent event in the NEM is the closure of Hazelwood, a brown coal-fired power station in Victoria, at the end of March 2017. The exit of Hazelwood from the market is reflected in the data used in this study from late March to end of April 2017.

1.3 Relationship between small solar and the wholesale market

Small solar PV systems are not registered as generators in the wholesale market. Instead, their generation is essentially treated as negative demand. Therefore, if there was no small solar installed, there would be extra demand that would need to be met by centralised generators.

Below is a simple illustrated example. In this fictional example, there are three offers to generate electricity for the community. Generator 1 offers to supply 50 MW for $20/MWh. Generator 2 offers to supply 30 MW for $50/MWh. Generator 3 offers to supply 20 MW for $100/MWh. These offers are illustrated in Figure 3.

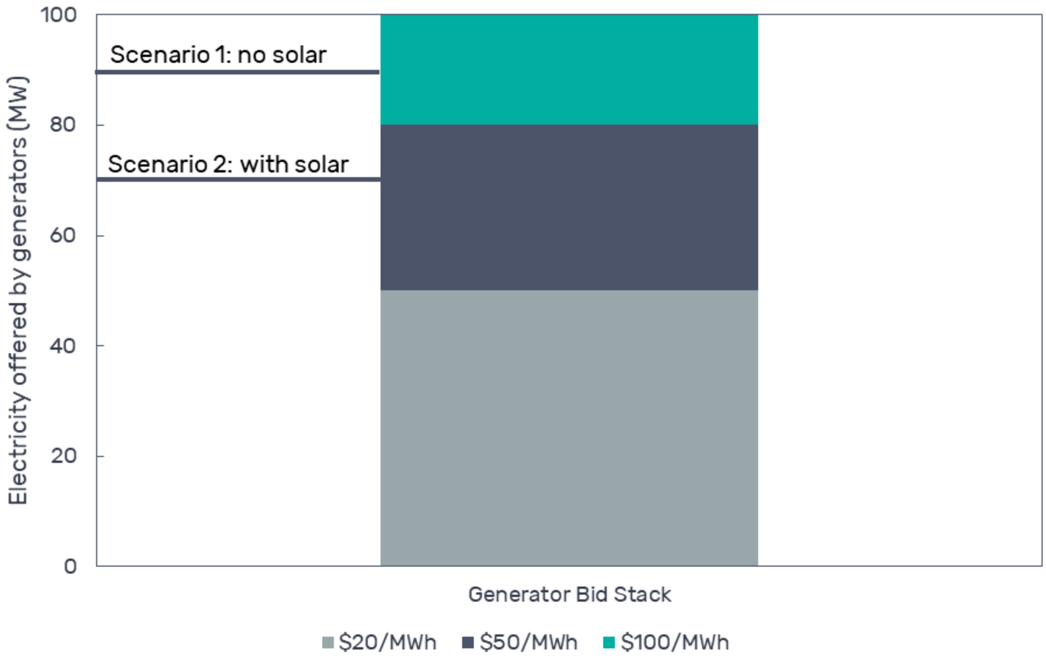

Figure 3: Example of a simple generator bid stack.

In the first scenario, no one in the community has small solar installed and the demand for electricity is 90 MW. According to the bid stack in Figure 3, all three generators will need to be dispatched to meet the demand. The marginal bid is the bid from Generator 3 and therefore all three generators will receive $100/MWh for their electricity.

In the second scenario, the community still needs 90 MW but some people have installed small solar PV systems, which are currently generating 20 MW. Even though the community still needs 90 MW, from the perspective of the wholesale market, this looks like only 70 MW, as 20 MW is being met locally.

If the bid stack is the same as in Figure 3, Generator 3 will not be needed in this scenario, and hence only Generators 1 and 2 are dispatched. Generator 2 is now the marginal bid, meaning that Generators 1 and 2 will both be paid $50/MWh.

In this example, small solar can be said to have reduced the wholesale price from $100/MWh to $50/MWh. This is known as the merit order effect. The reduction in prices from small solar will of course vary depending on how much electricity small solar is producing at any point in time and what the bid stack looks like at that time. The dispatch process in the NEM is far more complicated but this is the basic principle that has been employed in this analysis.

2 Scope and Assumptions

2.1 Construction of new demand profile

Electricity generation from small solar PV systems in NSW has been estimated by the Australian Photovoltaic Institute (APVI) at five minute intervals and provided to us for this study. The estimated data from APVI is based on the July 2017 release of the solar installation data by post code, which is published by the Clean Energy Regulator.

We have added the five minute small solar generation data from APVI to the NSW five minute electricity demand provided by AEMO. This new demand profile forms the basis of the 'no small solar' case.

2.2 Estimation of new set of dispatch prices

The assumptions we have used to estimate the new set of five minute dispatch prices for the demand profile in 2.1 are discussed below.

(a) The availability of NSW generators is assumed to remain the same in the 'no small solar' case as in the actual values seen in the market;

(b) When electricity demand in the 'no small solar' case is less than 13,000 MW, the bid stack for NSW generators is assumed to remain the same as the actual data;

(c) The dispatch price depends on a multitude of factors, but as can be seen from Figure 4, the sensitivity of the dispatch price to the demand increases exponentially when demand is equal to or greater than 13,000 MW. This suggests that we need to take extra care in our analysis at very high levels of demand. For this reason, we have constructed both an upper and lower scenario for possible pricing when demand is greater than or equal to 13,000 MW;

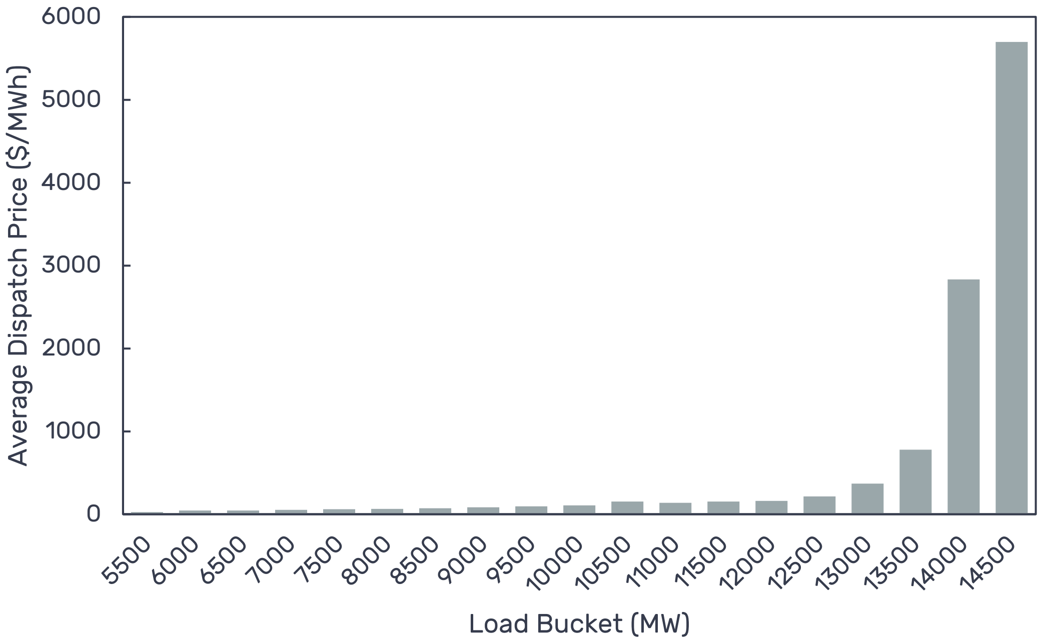

Figure 4: Average actual dispatch price in NSW over the study period for varying load buckets. The bucket labelled 13,500, for example, is the average dispatch price when electricity demand is between 13,000 and 13,500 MW.

(i) The upper estimate of dispatch prices has been calculated by leaving the bid stacks the same as the actual case;

(ii) The lower estimate of dispatch prices has been calculated by considering the load duration curve in Figure 5. A load duration curves measures the percentage of time that electricity demand is at or above a certain value. For the actual data over the study period, electricity demand was greater than or equal to 13,000 MW for 27.4 hours. In contrast, this time is estimated to be more than double, at 57.3 hours in the 'no small solar' case. This means that peaker plants would be able to lower their bid prices and still maintain the same level of revenue. Therefore, for the lower estimate scenario, we have divided the bid prices by 2.09 at demand levels greater than or equal to 13,000 MW. However, we have not changed the bid stacks for the top 2 hours of demand, which corresponds to demand levels at or above 14,334 MW. Given our assumptions around constraints described in section 2.4, and that we have not considered the impacts on fuel costs or the fact that the NEM is a highly consolidated market, meaning that generators are able to exercise market power, we believe that this is very much a lower case scenario. Therefore, the true impact of small solar is likely to be somewhere in between the two scenarios we have constructed;

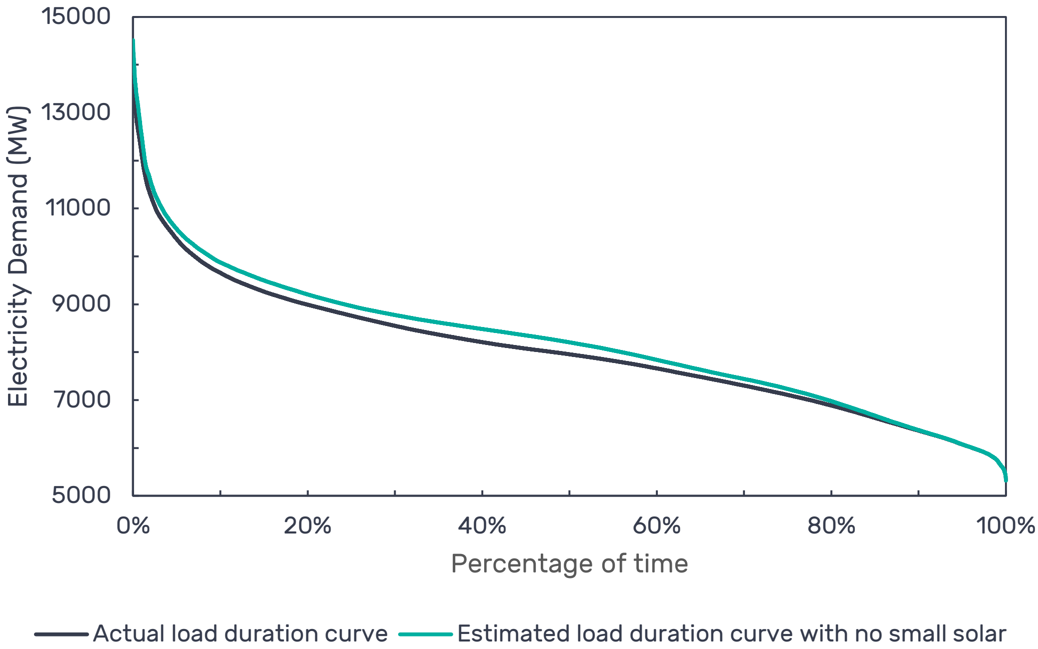

Figure 5: NSW load duration curve from May 2016 to April 2017.

(d) For all scenarios and levels of demand, we have also considered the ability to import electricity from Queensland and Victoria via the interconnectors.

2.3 Comparison of no small solar case with what actually happened in the market

We have estimated a new set of 30 minute Trading Prices for the NSW market by averaging the five minute dispatch prices that were estimated in 2.2. We have then compared this counterfactual case with what actually happened in the market, to estimate a dollar value for the impact of small solar.

2.4 Limitations of the study

The factors below illustrate some of the limitations of this analysis. We recommend that these factors be studied in the future to gain a more comprehensive understanding of the impact that small solar has on the entire electricity system.

(a) If there was no small solar PV installed in NSW, it is possible that there would be an extra centralised generator in the market. This would affect the bid stack and hence the pricing. This possibility was not considered in this analysis;

(b) Explicit consideration has not been given to constraint equations in the dispatch process. i.e. the assumption is that there are no constraints that could reduce the output of NSW generators. The implication of this is that our estimated pricing tends to underestimate the pricing in the market. However, in all but the 'lower estimate' scenario, we have not allowed our estimated pricing to be below the actual pricing in the market. Thus, our assumption around constraint equations acts to dampen the price increases when small solar is generating power;

(c) The NEM is an interconnected system and hence an ideal study would model the dispatch process in every state. We have not given any consideration to South Australia or Tasmania, and have only given rudimentary consideration to Queensland and Victoria;

(d) Costs and benefits to the ancillary services market have not been considered;

(e) Costs and benefits to the transmission and distribution networks have not been considered; and

(f) Costs and benefits associated with the emission of greenhouse gases have not been considered.

3 Impact of small solar on wholesale electricity prices

The results of the modelling suggest that small solar PV depressed the volume weighted average price (VWAP) of wholesale electricity in NSW by $29-44/MWh over the one year study period. This means that the VWAP could have been 33-50% higher than the actual VWAP of $88/MWh. This is a significant impact, seeing as small solar PV only accounted for about 2% of electricity consumed in NSW over the same period.

Figure 6 compares the actual monthly VWAP for NSW as per AEMO data with our estimated VWAP for the case with no small solar. Small solar PV had the biggest impact on pricing during February 2017, where it reduced the VWAP by $119-$258/MWh. This extraordinary reduction in pricing was mainly due to a combination of a) high electricity demand due to an extreme heatwave and b) a very steep supply curve at high levels of demand. This enabled small solar generation to have a bigger impact than at lower levels of electricity demand.

Figure 6: Comparison of the actual NSW volume weighted average price with the estimated price if there was no small solar PV in NSW.

Figure 7 translates the pricing data in Figure 6 into a cost reduction in terms of dollars. It is estimated that the cost to the NSW market, i.e. retailers and hence consumers, was reduced by $2.2-3.3 billion over the study period. Following on from results in Figure 6, the biggest monthly cost reduction was in February 2017, estimated at $0.74-$1.57 billion.

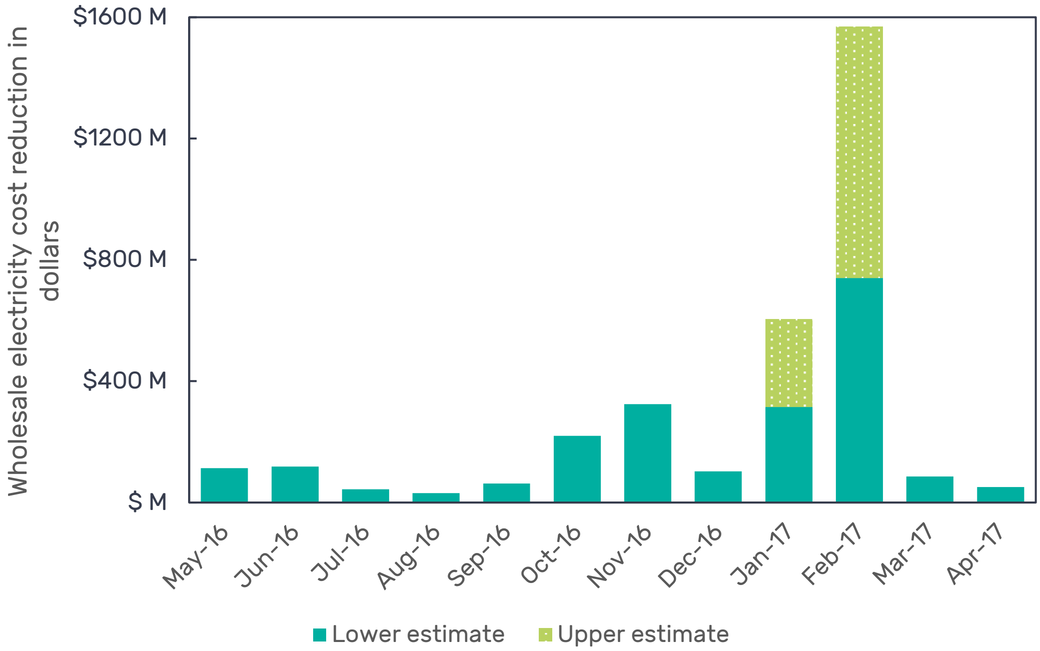

Figure 7: Estimated monthly cost reduction for wholesale electricity in NSW from small solar PV.

The final aspect we examined is how the estimated price reductions vary across different times of the day. Figure 8 shows the average reduction in the NSW Regional Reference Price for each 30 minute Trading Interval over the study period. Generally speaking, the pattern of price reduction is found to follow the pattern of solar generation throughout the day. However, it is worth noting that small solar was able to continue to put significant downward pressure on prices in the late afternoon around 4pm, even though the output of these systems was only at about 40% of max generation.

The other interesting point is that our lower estimate for the 6pm Trading Interval shows an average price reduction of -$12/MWh, meaning that small solar could have produced a higher price (and hence increased cost) in this interval. This is due to our adjustment of bid stacks at high levels of demand to account for peaker plants operating for more hours. Despite this one Trading Interval, the overall effect of small solar PV is to significantly reduce wholesale pricing.

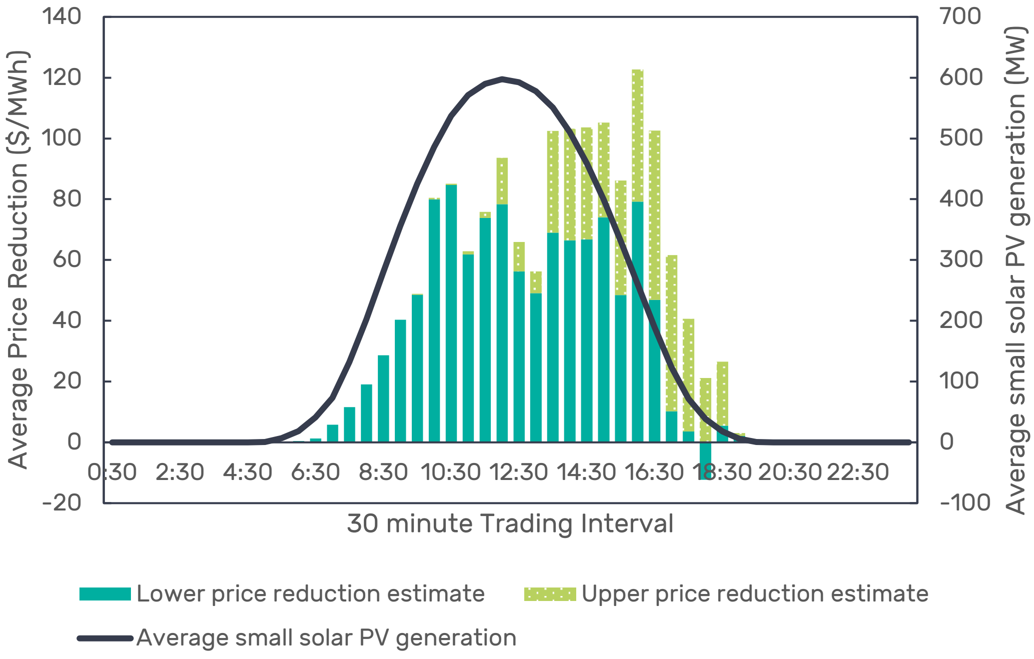

Figure 8: Average reduction in the NSW Regional Reference Price in each 30 minute trading interval compared with the no small solar case. All time stamps in this report are in Australian Eastern Standard Time.

4 Impact of small solar on peak demand

In addition to the impact on wholesale electricity pricing, we examined the impact of small solar on both the severity and length of peak demand in NSW. In this study, severity has been defined as the maximum five minute electricity demand on a given day. The length of peak demand is the number of hours in a given day that are within 5% of the maximum five minute demand for that day.

For this piece of the analysis, we considered the top 10 demand days during the study period, all of which occurred in the months of January and February. The analysis indicates that small solar PV systems reduced the peak demand over these 10 days by an average of 432 MW, from 13,797 MW to 13,365 MW. The full range of reductions over the ten days is shown in Figure 9. On the highest demand day in the study period, 10 February 2017, small solar reduced the severity of peak demand by 406 MW[1].

[1] Please note that AEMO's System Event Report New South Wales 10 February 2017 states that rooftop PV was generating 291 MW at the time of the 17:00 peak. The difference from our number is due to a difference in methodology. In AEMO's report, AEMO first calculates the maximum 30 minute Operational Demand (which does not include small solar) and then reports the estimated small solar contribution for that 30 min Trading Interval. In contrast, our methodology first finds the maximum five minute demand (which has small solar added to it and is found to occur earlier in the day in the 14:40 dispatch interval) and compares this to the maximum five minute demand reported by AEMO at the 16:30 dispatch interval (which does not include small solar).

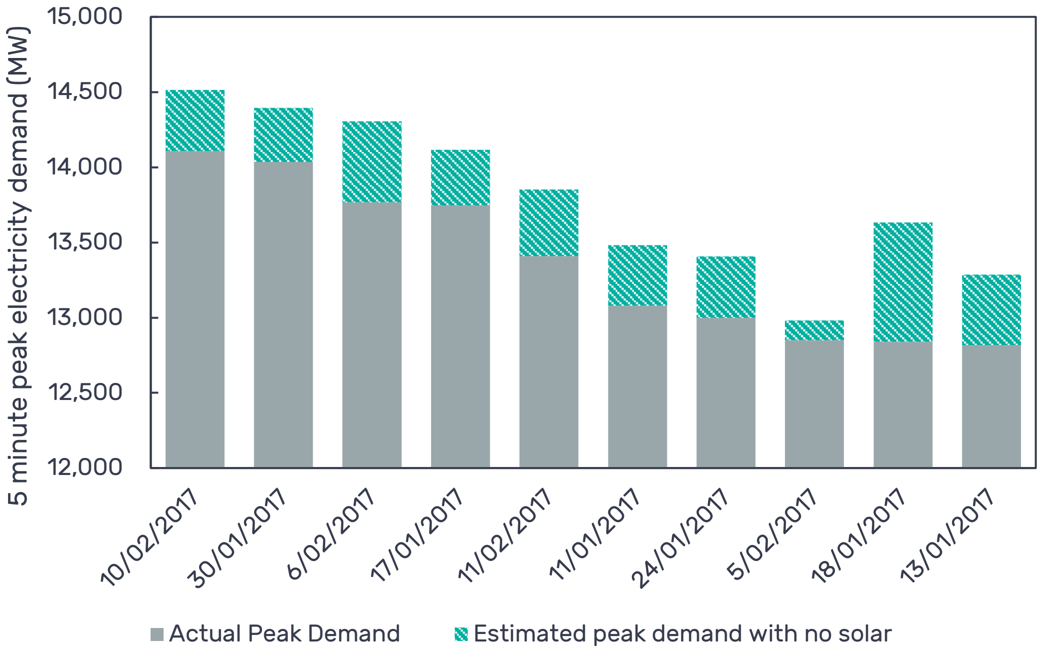

Figure 9: Reduction in severity of peak electricity demand due to small solar on each of the top 10 demand days in NSW from May 2016 to April 2017.

To determine the impact on the length of peak demand, we first calculated the megawatts equal to 95% of peak demand (in the no small solar case) for each of the top 10 demand days. We then calculated the number of hours where demand was equal to or greater than this figure, for both the actual case and the no small solar case. The full distribution of results can be found in Figure 10. An illustration of the calculation for 6 February 2017 is shown in Figure 11.

The results show that small solar PV reduced the length of peak demand by 58% from an average of 5.3 hours to an average of 2.2 hours. This means that the electricity grid is in a state of stress for a much shorter period. Given the small contribution of small solar to total generation in NSW, we consider this to be a very significant result.

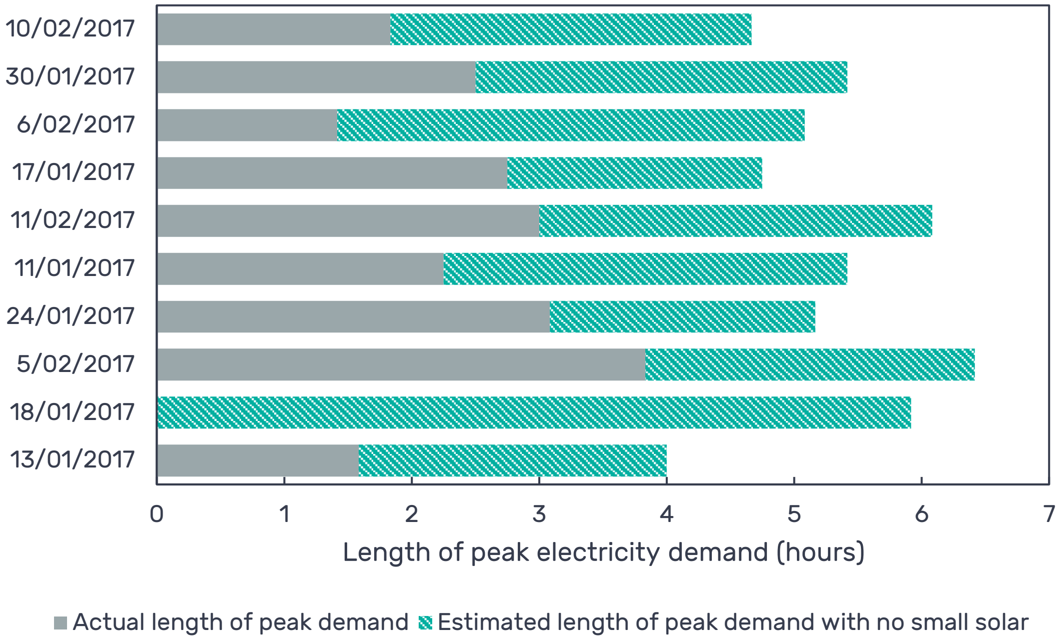

Figure 10: Comparison of the length of peak demand across the top 10 demand days in NSW.

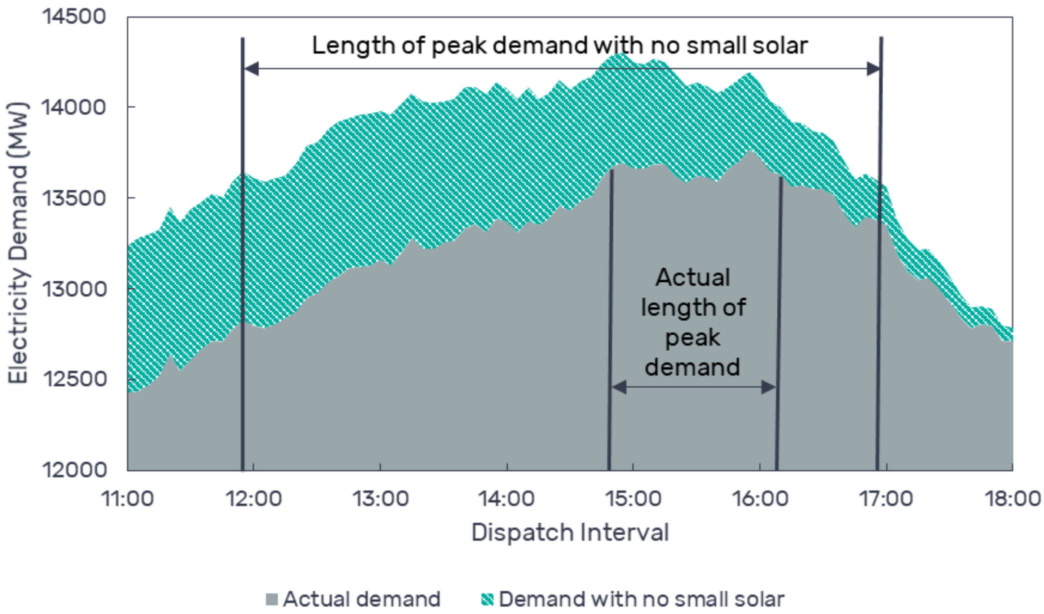

Figure 11: Comparison of electricity demand in NSW with and without small solar on 6 February 2017.

5 Conclusions

Under the assumptions of this study, outlined in Section 2 Scope and Assumptions, the following conclusions were made:

- Despite contributing only 2% to generation, small solar PV systems put significant downward pressure on wholesale electricity prices in NSW via the merit order effect. Over the 12 month study period, the volume weighted average price could have been 33-50% higher without small solar. This means that NSW consumers could have paid $2.2-$3.3 billion more in the wholesale component of electricity bills.

- Small solar PV systems continue to put significant downward pressure on wholesale prices in the late afternoon, particularly around 4pm, despite the generation from these systems declining during this time.

- Small solar PV systems significantly reduce the severity of peak electricity demand in NSW. An average reduction of 432 MW (3%) was found across the top 10 demand days over the study period.

- Small solar PV systems significantly reduce the length of peak electricity demand in NSW. An average reduction of 3.1 hours (58%) was found across the top 10 demand days.