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The reliability of distributed solar in critical peak demand: A capital value assessment

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ABSTRACT

Generation is most valuable when demand is highest. As electricity can't yet be cheaply stored, generation and transmission infrastructure must be built to meet the highest expected demand, plus a margin of error. Reliably producing power at times of critical demand not only offsets the need to use expensive liquid fuels such as diesel or condensate, but also removes the need to build backup power stations and transmission infrastructure that would only be used for a small fraction of the year. Under the most extreme demand conditions, solar has reduced the peak demand seen by retailers and wholesale energy markets. This study compares the capital cost of critical peak availability from gas turbines to the capital cost of critical peak availability from distributed solar in the Australian National Electricity Market (NEM). When compared on this basis, 10–22% of the cost of installing the solar system can be attributed to the capital value of critical peak generation. North–west and west facing PV is worth a further 3–6% of system installation costs when compared to generally north facing PV. Finally, southern states, with longer summer days and more sunshine in the afternoon are found to benefit more from peak supply of solar PV.

1. Introduction

The most recent work conducted in Australia on the value of PV generation has been performed so that regulatory bodies can determine a fair price for household PV exports. The first regulatory work on the value of PV exports is that prepared by Frontier Economics for the Independent Pricing and Regulatory Tribunal (IPART) of New South Wales (NSW) regulatory determination [1]. Frontier's terms of reference were to determine a "fair and reasonable value for the electricity generated by small-scale solar PV units and exported to the grid". Frontier accomplished this by examining the wholesale market value of the electricity exported, choosing FY10/11 as the historical year to evaluate the market value of PV exports. This choice was made over FY9/10 because FY10/11 was closer to a median year in terms of midday spot electricity prices. Solar PV exports valued in the FY9/10 year were worth $135/MWh, whereas solar PV exports valued in the FY10/11 year were only valued at $65/MWh. While it was not a conclusion of the Frontier Economics study, the variability in these results highlights solar PV's value as a hedge against high prices.

Acil Tasman produced a similar analysis for the Essential Services Commission of South Australia [2]. Acil Tasman's study modelled spot electricity prices for the year ahead rather than using historical data. The Queensland Competition Authority (QCA) chose not to regulate the price paid for solar PV exports for most of the state, on the basis that a competitive market for retail electricity supply existed in Queensland (QLD) [3]. The QCA did, however, recommend a fair price for PV exports that was based on an average wholesale energy cost, similar to the methodology used in the other states.

The regulatory studies on the value of PV exports are often constrained by their terms of reference. While the studies accurately calculate the costs avoided by a retailer accepting customers' PV exports, they do not examine the system level benefits of solar PV's ability to supply critical peak demand.

Elliston et al. modelled both the technical feasibility [4] and the least-cost optimisation [5] of a 100% renewable energy grid as a replacement for the National Electricity Market (NEM). This simulation is a valuable contribution to the Australian Energy policy literature because it does take into account the reliability and timing of generation sources. However, a simulation of this scale does make some simplifying assumptions necessary, and one

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weakness of the study is that it only includes north facing solar as a generation source, neglecting to evaluate the time-of-generation benefits from west-facing solar.

Molyneaux et al. [6] also modelled high renewable energy scenarios for the NEM and mentioned the ability of solar PV to reduce summer peak demand. Solar generation output was modelled from historical data on solar intensity in each capital city. No details were given as to how solar correlation with demand was established.

Passey et al. [7] examined the value of PV in West Australian electricity networks. They specifically identify that the benefits of PV are dependent on correlation between output and load. Simulated, rather than measured PV data was used for this study. This study did explicitly model west-facing PV systems and found that the west-facing systems had a higher present market value when the value of offset peaking generation was included.

Liu et al. [8] studied the optimal system size and elevation (but not azimuth) of solar panels in various population centres of Queensland using simulated solar production data.

Maine and Chapman [9] evaluate simulated PV outputs against several individual days of historical prices in the SA wholesale market during 2004. Their simulations show that an ideal PV system under clear skies would generate power in the afternoon on summer days when prices are high. They only evaluate the energy component of the solar PV without regard for option value. In their introduction they state that "…retailers can and do hedge the wholesale costs, giving them some insurance against the possibility of unexpectedly high pool prices but that added complication does not alter this discussion fundamentally" (emphasis added). Crucially, retailers enter into hedging contracts because it lowers their risk of exposure to volatile wholesale prices. A reliable source of energy provides the same insurance value as a financial insurance product and should form part of a valuation methodology.

Watt [10], using NEM data from 2004, also found the west-facing PV arrays provide a better match to residential load profiles than north facing systems. A major benefit of this study is that it uses data from real PV systems. Only 15 systems were available for data collection at the time. Access was obtained to substation level load data and so a focus of the paper was on the value of transmission cost avoidance. The paper found that PV output matched load better for commercial substations, rather than residential area substations and hence was of more network value in a commercial area. A graphical comparison to NEM spot prices was made, but there was no calculation of the commercial value.

This paper aims to assess the value of distributed solar PV's availability in times of critical peak demand, rather than calculating an average value of energy. To compare availability, systems should be assessed on the amount of power they can be depended on to produce under peak demand conditions. Results in this paper extend on previous work by considering each of the four mainland states in the NEM, considering the impact of directional facing on system peak demand availability and using physical rather than simulated results of distributed solar generation.

1.1. Critical peak demand

The top ten maximum demand days in QLD, Victoria (VIC) and South Australia (SA) all occured during summer. In the case of New South Wales (NSW) the three highest demand days occured in February 2011, but there are also three winter days in the top ten from July 2008 and 2007. Since 2008, there have been significant changes to consumers behaviour, which reduce the size of expected winter peaks relative to expected summer peaks. Importantly, gas heating and reverse cycle air conditioners have become more popular [11]. Bar heaters use 2–3 times more energy than a reverse cycle air conditioners used in heating mode. The increased penetration of reverse cycle air conditioners has had the effect of increasing summer cooling peaks while decreasing winter heating peaks.

Ausgrid, the largest distributor in NSW has examined the factors driving peak demand in their own network [12]. Weather (temperature) drives much of the variability year to year. After adjusting demand for weather variation their data confirms that underlying winter peak demand has been declining since 2006. Their data for summer demand shows an increase since 2008 and a flattening over the last few years. While evening demand has historically been high in winter in NSW, the future development of the network and peaking generation capacity will focus on peak summer demand.

Future peaking generation capacity investment in each state will be driven by the requirement to supply summer peak loads.

2. Data methodology

Monthly solar installation data is available from the Clean Energy Regulator [13] with geographic resolution at the postcode level. This data is available because system installers must register the details of a system in order to receive the tradeable small scale technology certificates (STCs) those solar systems are eligible for. STCs are currently worth approximately a third of the total system cost, so the incidence of installers failing to register systems can be expected to be very low.

STCs may be created and registered with the Clean Energy Regulator up to 12 months after the installation of a system, so the data will underestimate the total capacity of residential systems installed in the most recent months. However, installers are motivated by cash flow concerns to register STCs promptly. Fig. 2 shows that the lag in installation reporting lasts only a few months, and that installations not counted due to registration lag are a small component of total installed systems. No attempt has been made to estimate the installed, but not yet reported systems (Fig. 1).

Fig. 3 shows the state breakdown of solar installations. Installations booms can be seen leading up to the end of each financial year (June) as households rush to get installations ahead of the annual reductions in federal incentives by way of the number of STCs issued for each system.

The boom in residential solar installations has been accompanied by the creation of an online community of solar enthusiasts who share real time data on solar system generation. This data is available at http://PVoutput.org/live.jsp. Five and 10 min resolution generation output data is available for several hundred individual systems. The data includes the postcode that each system is installed in, allowing aggregation by state. Also included are the

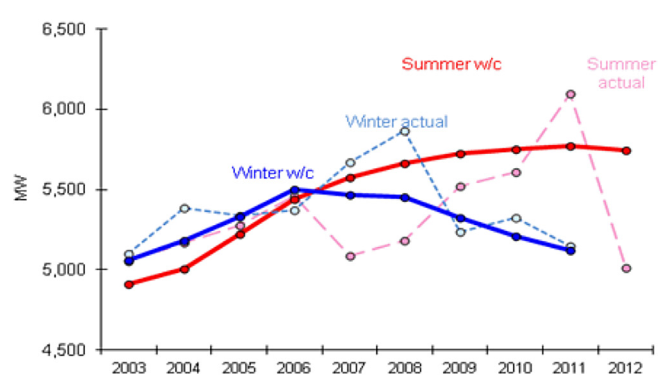

Fig. 1. Ausgrid network peak demand; actual and weather corrected. Reproduced from Smith [12].