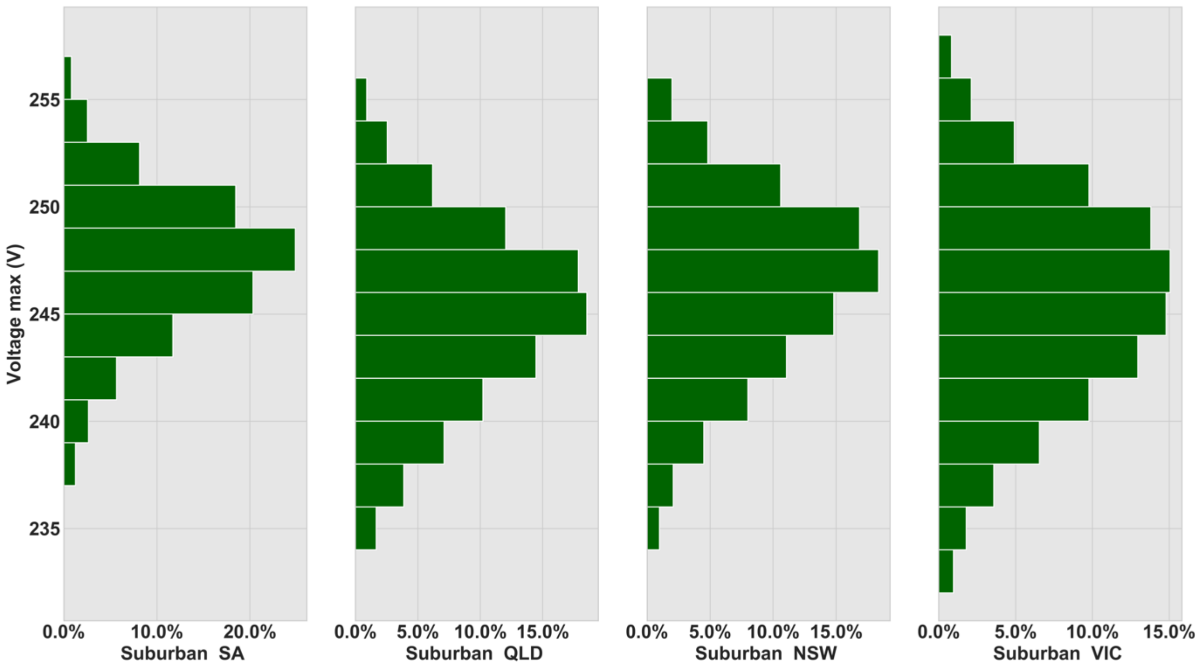
ESB cover note on the UNSW Voltage Report

Summary

The UNSW Voltage Report was prepared for the Energy Security Board (ESB) as part of the DER Integration Workplan. The intent of the paper is to look at the state of voltage across the national electricity market (NEM) and the possible extent of losses to prosumers from high-voltage curtailment of inverters. The key finding of the paper is that, even in the absence of solar PV, there is a significant level of high voltage across all DNSPs in all NEM states as highlighted in the following chart. The nominal voltage standard in the NEM is 230V - more than 95% of readings were found to be higher than this.



Maximum voltages recorded are generally towards the upper bound of acceptable voltage in all States and DNSPs, in all seasons for all daily hours. Minimum voltages at most sites in most regions, seasons and times of day are generally above the 230V nominal standard, in some cases well above.

In South Australia, average maximum voltages frequently sit near the upper bound of 253V over the entire year, although they are generally highest in Autumn and Spring, when State demand is typically lower and PV performance is relatively good.

The data for this review was sourced from a commercial entity (Solar Analytics) who provide solar and home energy management and analysis services. The findings of this data align with previous voltage reviews and also with analysis that the AER is currently undertaking in Victoria.

These voltage issues are due to a range of factors, especially historic circumstances of distribution network operation, i.e. to support additional air conditioning loads installed over the last three decades and an historic 240V nominal standard (from which DNSPs are still transitioning).

In some cases, over-voltage can be addressed relatively simply and quickly by changing the fixed tap position at the distribution transformer or other operational changes. However, there is a need to move towards more dynamic voltage management. The UNSW Report outlines how DNSPs are moving to more advanced voltage management and trialling technologies such as dynamic phase switching.

This finding of high voltages has two regulatory implications: compliance with technical obligations and consumer losses.

Technical compliance

Electricity networks have historically not had access to voltage measurement at the low voltage parts of the network. Where customers have identified voltage problems, the DNSPs have typically investigated using portable devices and rectified those sites where a problem was found.

With the advent of smart devices and smart meters, the availability of voltage data is increasing significantly. Victorian DNSPs now have access to voltage measurement for all residential consumers through the Advanced Metering Infrastructure (AMI) installed in that state. The AER forecasts that a large number of customers in other states will also have voltage measurement available through smart meters by 2025.

The UNSW Report appears to point to a material level of technical non-compliance, but this may depend on how the data is viewed and how the respective standards are applied in each jurisdiction. Technical compliance of networks is established in most states and territories through an obligation to comply with Australian Standard AS61000.3.100.

Voltage compliance is not achievable in all locations at all times due to the variable nature of load, generation, weather, etc. As such the AS61000 allows for a 99% compliance obligation in terms of over and under voltage – i.e. the voltage must be 253V or lower 99% of the time and 215V or greater 99% of the time. The UNSW analysis does not allow for precise calculations about non-compliance as it is only across a sample of sites in each jurisdiction.

The question of compliance with the codes is an important matter to consider. There would appear to be a backlog of compliance issues and therefore works needed based on the information contained in this report. The costs and the timing for the DNSPs to achieve compliance will also need to be agreed.

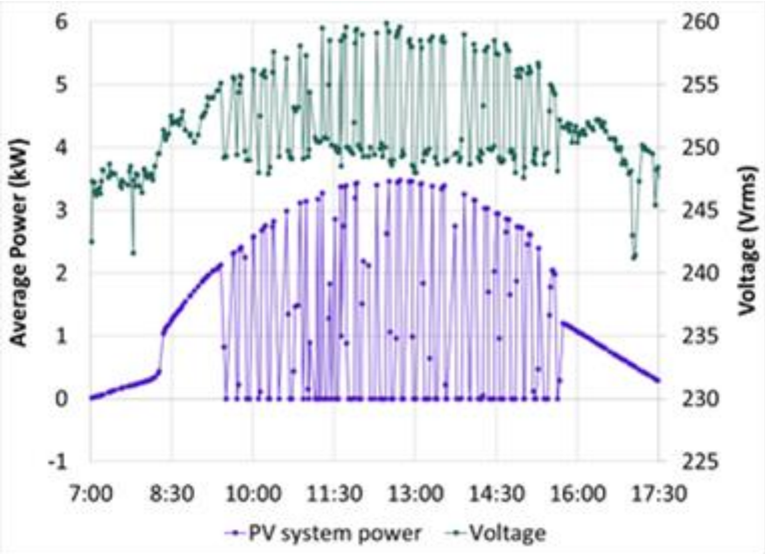
From the analysis provided in the report, there would appear to be a greater degree of non-compliance on the high-voltage side than the low-voltage side. This may mean that there are relatively simple options available to DNSPs to lower the overall system voltage experienced by customers and improve overall compliance levels. Improving compliance with voltage would create additional ‘head room’ for solar PV and other DER exports to the grid.

The report also notes that the increasing level of output from solar PV is, in turn, slightly increasing the voltages on most electricity networks. However, the report also finds that many sites experience higher voltages during the night when solar PV is not operational. The connection of electric vehicles (EVs) and battery storage to the electricity networks has the potential to reduce the impact of solar PV, as well as help to solve voltage issues unrelated to PV. The right pricing signals will be critical in providing EV and battery storage customers with the right signals in terms of operating these devices.

Consumer losses

The report was commissioned by the ESB to understand how network voltages were impacting residential solar systems and whether they were reducing the output of these systems.

Higher voltages will cause residential solar PV systems to reduce output or turn off altogether. This causes a loss of solar production and means that the impacted consumers are then required to source all their electrical energy from the grid. In the future, this will also impact battery systems and electric vehicle operations. The chart below shows a typical solar output curve being impacted by high network voltages.



Export from DERs (distributed energy resources, including distributed rooftop PV) was found to be associated with increasing both minimum as well as maximum voltages. As the report puts it ‘PV generation adds to an already complex existing mix of drivers and establishing clear causation for the different factors is a challenging task’.

The UNSW analysis showed that although sites in some postcodes experience significant voltage rises per kW of site PV export, most are lower than 2 V/kW export. At both the state/territory and DNSP level, the median voltage impact at ranges from 2V to 5V. There is an impact on voltage from solar PV, and particularly the distribution of higher voltages. In turn, voltage impacts solar PV exports.

Included in the report is an analysis of curtailment of solar PV generation in South Australia over 24 clear sky days using a sample of sites (over 600 - 1300 households depending on the time of year) that indicates that on average only one per cent of generation is being curtailed over all systems on all days studied. Highest levels of curtailment occur in late winter and spring.

The report finds that the majority of prosumers in the sample do not suffer significant PV curtailment, with approximately $3 - $12 per year per site on average in lost generation value (assuming a typical 5kW system), noting that the analysis only considers clear sky days and that further work is required. However, there is a small number of prosumers which are significantly impacted and can experience considerable financial penalty. The most impacted prosumer is estimated to lose approximately of the order of 30-90 per cent per year.

On the assumption that the network is technically complaint (with AS61000), there will always be solar PV that is sometimes constrained in some locations. In other words, any PV curtailment issues are highly localised. In many cases, it would simply not be economical to augment or manage the network in a way that would remove all of these solar losses. Rural and remote areas are where the greatest levels of solar PV curtailment are likely to manifest, and they are also the most expensive to rectify.

The report does not explore the potential losses to consumer associated with appliance degradation and increased energy consumption. It is recognised that high voltages will cause electrical appliances to “wear out” more quickly, and that higher voltages will result in an overall increase in energy consumption. The paper does not quantify the impact these factors have on costs for consumers. United Energy recently demonstrated a 3 per cent reduction in consumer demand through a voltage management program - even a 1 per cent reduction in overall consumption would have a material impact on total energy costs. This may be an area of future research.

Relevant action by the Energy Market Institutions

AEMO's Distributed Energy Resources (DER) Register went live on 1 March. Data on DER devices such as rooftop solar, batteries, electric vehicles, air conditioners and pool pumps must now be provided to AEMO’s DER Register within 20 days of system commissioning or activation which will improve DER visibility.

Energy Market Institutions are working to address voltage issues in the NEM, including in the following ways:

- AER is developing Guidelines for Assessing Distributed Energy Resources (DER) Integration Expenditure;
- AEMO is working with the Clean Energy Regulator to address the substantial legacy fleet of inverters which do not respond to out-of-range voltage, and
- AEMC is working on DER access and pricing which will address the obligations of DNSPs to provide DER export capacity.

The AER’s “DER Guideline” is aimed at supporting DNSPs in analysing and forecasting the economic level of network (or third party) works to alleviate solar PV constraints. This project is collating consumer and industry feedback on the issues paper and will release a draft guideline later in 2020.

In addition, there are numerous related trials supporting rooftop solar PV integration detailed in the UNSW report. This includes, for example, the calculation and publication of operating envelopes for DER to identify and ease congestion within distribution networks.

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