Consumer Benefits of Improved Voltage Management

Accompanying paper to University of Wollongong's project report

April 2025

AUSTRALIAN ENERGY REGULATOR

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AER reference: 18,048,985

Amendment record

Version	Date	Pages
1	15 April 2025	8

1 Purpose

The University of Wollongong (UoW) report, *Consumer Benefits of Improved Voltage Management Project Report*, examines the impacts of distribution network service providers (DNSPs) maintaining a supply voltage magnitude above the nominal value of 230V in low voltage networks and considers the potential consumer benefits if the supply voltage magnitude is lowered to 230V.

The AER has prepared this accompanying paper to be read in conjunction with the UoW report. This document:

- provides background on why the UoW report was developed
- highlights key aspects of the UoW report to note when considering the potential costs and benefits of voltage management
- reflects on the suggested actions from the UoW report in the context of DNSPs seeking to expand their voltage management capabilities.

2 Background

Australian standards require electricity to be supplied at 230V (+10% to -6%), providing an allowable low voltage supply range from 216V to 253V. In practice, Australian voltages can often be above and below 230V and vary across the network. Other standards for voltage management – including for high voltage and extra high voltage - are set for different aspects of the electricity system variously within the National Electricity Rules (NER), Australian Standards, and by jurisdictional regulators.

DNSPs operate their networks to target the low voltage standard of 230V. However, because of the size of networks, the limited visibility of the network voltage and the dynamic variability of demand across each day, it is not economically feasible to maintain this voltage throughout the network at all times.

The Energy Security Board (ESB) originally proposed to examine the potential benefits for consumers if DNSPs attempt to maintain average supply voltage magnitude at 230V (the voltage standard). This was part of a combined workstream in the ESB's Data Strategy which sought to study the impacts of overvoltage and of network visibility. The ESB's combined workstream aimed to support efficient assessment of network monitoring systems.

In mid-2023, the AER took on the combined workstream when the ESB transitioned into the Energy Advisory Panel (EAP). The ESB asked the AER to engage a consultant to deliver initial research and a report to support the development of a methodology to estimate the impacts of overvoltage and to identify any consumer benefits resulting from improvements in the management of voltage supply. The AER commissioned the Australian Power Quality Research Centre at UoW to undertake this research. The AER's role has been to deliver critical oversight and we have provided feedback to UoW throughout their literature review and the development of this report.

The AER notes that while this project has been referred to as an 'overvoltage' study, it is a study of the benefits of managing voltage within the standard closer to the 230V level. It is not a study of the management of excursions above the allowable voltage range.

Under the NER, the AER regulates the revenue that DNSPs may earn through assessment of their expenditure proposals. We assess whether DNSPs' proposals demonstrate prudent and efficient costs to supply network services in accordance with regulatory obligations, which include voltage standards. Therefore, if a DNSP includes expenditure to improve voltage management in their regulatory proposal, the AER must assess these costs and may approve them only if we consider the expenditure to be prudent and efficient.

Although the AER assesses and approves network expenditure proposals, we do not prescribe how DNSPs must comply with voltage management standards so that these might deliver benefits to consumers. We note that some DNSPs have included costs associated with voltage management in regulatory proposals submitted to the AER to date.

3 Potential benefits of voltage management

In their research, UoW investigated the potential benefits for consumers if the nominal voltage is maintained closer to 230V, instead of at the higher end of the allowable voltage supply range. The UoW report considers three broad categories of potential consumer benefits and concludes:

> *Overall, the literature review identified that there is compelling evidence that supply at voltage magnitude above the nominal or rated voltage will lead to additional energy usage (and associated additional carbon emissions) as well as decreased appliance lifespan:*
>
> - *When estimating the impact of supply at voltages above the nominal value, there appears to be sufficient data available to characterise the relationship between supply voltage magnitude and energy consumption for the devices which comprise the domestic load.*
> - *When characterising the relationship between supply voltage magnitude and appliance loss of life, the available data is much more limited and is restricted to loss of life for incandescent lighting along with the electrolytic capacitors, with the latter being an integral component of switch mode power supplies.*
> - *With respect to the impact of supply voltage magnitude on curtailment of consumer energy resources (CER)... The evidence suggests that the economic impact is small at present and is unlikely to increase significantly over time.*

3.1 Reduced energy consumption

The UoW report concluded that there is sufficient data to demonstrate benefits in the form of reduced energy consumption when voltage is maintained closer to 230V. UoW has provided an approach to quantifying these benefits.

We note that UoW's study assumes that voltage would be supplied consistently at 230V, however, in practice, voltage levels vary across a DNSP's network. As a result, the benefits associated with reduced energy consumption are likely to differ based on location and may

be difficult to calculate due to the variable nature of voltage across the network and across time and limited visibility of network voltages.

We also note that consumers would see any benefits from reduced energy consumption on the variable component of their bill, and that the fixed components will not vary based on energy consumption.

We recognise that DNSPs are best positioned to assess the potential to reduce voltages across their network. DNSPs can consider the costs and benefits associated with voltage management in areas of their networks, in order to determine which areas may deliver net benefits for consumers and justify expenditure.

3.2 Appliance loss of life

The UoW report discusses potential benefits of reduced voltage that are associated with increased appliance lifespan and provides a preliminary algorithm to illustrate these benefits.

The report notes that the consumer benefit calculated using this algorithm is less reliable as it is based on limited data and specific consumer behaviours. Given these limitations, UoW has not calculated a quantitative estimate of the consumer benefits related to the loss of life in consumer appliances.

The report also notes that development of a comprehensive model requires further research to establish relationships between supply voltage magnitude and the lifespan of devices which contain motors and complex electronic loads.

The AER agrees with UoW's findings and the caveats that they have noted in their report.

3.3 Reduced curtailment of consumer energy resources

Exports in power from rooftop solar during mild, sunny weather may exceed the capacity of network assets across parts of the network, including as the volume of rooftop solar continues to grow. This may also create power system security risks that are managed by AEMO. When this occurs, DNSPs need to limit customers' solar output in the middle of the day to manage these risks. This 'curtailment' reduces the feed-in tariff benefits for solar customers and reduces the amount of low-cost renewable energy in the system for others.

The UoW report finds that the economic impact associated with curtailment of CER due to supply voltage magnitude is likely to be relatively small on average, decreasing over time, and considerably smaller than the impacts associated with increased energy consumption and appliance loss of life[1].

Given the variation in voltages across different networks and regions, the AER notes that the potential benefits for voltage management to reduce CER curtailment are likely to vary based on location. As with the potential benefits from reduced energy consumption, the AER notes that DNSPs are best placed to consider the costs and benefits associated with voltage

[1] Additionally, we note that the report does not develop an algorithm to measure avoided CER curtailment benefits, as the customer export curtailment value methodology (CECV) has already been developed by the AER for this purpose, and is available for networks to apply in estimating curtailment benefits in expenditure proposals.

management in areas of their networks, and to determine which areas may deliver net benefits for consumers and justify expenditure.

The UoW report observes that in regions other than Victoria, jurisdictional agencies are not able to effectively monitor supply voltage due to limited penetration of smart meters. The AER notes that the Australian Electricity Market Commission (AEMC) made a final rule requiring universal smart meter deployment across the National Electricity Market by 2030[2]. This program of work will increase the amount of information that is available which may be used for monitoring supply voltage magnitude.

Another key conclusion drawn from UoW's report is that consumers have already experienced some benefits of reduced curtailment of rooftop PV through the lowering of supply voltage via existing compliance measures. This has led to a reduction of voltage complaints for some jurisdictions.

Voltage data monitoring in Victoria

The Essential Service Commission of Victoria (ESCV) requires DNSPs in Victoria to submit voltage performance data every quarter, which is required under Schedule 6 of the Electricity Distribution Code of Practice. The ESCV actively monitors compliance with voltage performance standards and publishes the associated voltage performance data, which shows Victorian DNSPs periods of overvoltage and undervoltage in weekly intervals[3]. The data demonstrates that over time, Victorian DNSPs appear to have improved their overall compliance with Victorian voltage performance standards. We have heard anecdotally from ESCV that the increased transparency and availability of voltage performance data may be delivering benefits, in terms of reduced emissions and costs for consumers.

The Victorian Department of Energy, Environment and Climate Action (DEECA) conducted an inquiry into voltage management[4]**.** In their consultation paper, DEECA presented an "analysis of 2020 and 2021 voltage data which showed average voltages were trending down across all Victorian distribution businesses since reporting began". Subsequent analysis of the 2022 average voltage data from Victorian DNSPs indicated that this trend continued. DEECA concluded in their Directions Paper that "This trend is driving down energy costs for all Victorian consumers by enabling more solar and reducing energy consumption"[5].

4 Suggested actions

The UoW report suggests that consideration should be given to the following:

- Development and implementation of a framework that can be used by DNSPs to estimate the consumer impact associated with the additional energy consumption related to supply voltage magnitude.

[2] AEMC, *Accelerating smart meter deployment,* November 2024

[3] ESCV, Voltage performance data

[4] DEECA, Voltage Management in Distribution Networks Consultation

[5] DEECA, Voltage Management in Distribution Networks Directions Paper

- Development and implementation of a framework that can be used by DNSPs to estimate the consumer impact associated with the relationship between supply voltage magnitude and loss of appliance lifespan.
- Development of a framework to allow the above to be incorporated into DNSP regulatory submissions.
- Enabling actions to allow DNSPs better access to supply voltage magnitude data.
- How the research required to develop a more robust algorithm to estimate the relationship between supply voltage magnitude and appliance lifespan can be undertaken. This may include engagement with appliance OEMs or organisations managing warranty claims and repair to better understand appliance failure rates and mechanisms.

We note that the first three considerations relate to DNSP network investment relating to voltage management.

DNSPs have extensive experience in managing voltages, balancing the risks of both undervoltage and overvoltage. As the level of distributed energy resources increase, particularly consumer energy resources, the task of voltage managing is becoming an increasingly complex and dynamic task for DNSPs.

There are a variety of ways that DNSPs can monitor and estimate voltages across their networks, which will continue to improve as smart meter penetration increases. When considering whether to invest in addition voltage management measures, a DNSP will need to consider the investment required relative to other network priorities.

The regulatory framework permits investment in voltage management. The AER assesses DNSPs' revenue proposals, including any expenditure related to voltage management, on a case-by-case basis and will consider voltage trends across the relevant DNSP's network. DNSPs may propose expenditure on voltage management activities as part of their revenue determination proposals if they can demonstrate the expenditure is prudent and efficient. Networks have undertaken voltage management as part of provision of distribution services and the AER has seen networks propose expenditure for voltage management activities in the past, such as dynamic voltage management systems (DVMS).

While the AER has published guidance related to the integration of CER and investments that increase network hosting capacity[6], we have not provided specific guidance at this point in time on how DNSPs should propose costs associated with voltage management. The direct benefits of voltage management proposed by DNSPs to date, such as reductions in electricity use, have been relatively low.

If we start to see a significant number of voltage management proposals from DNSPs, the AER will consider whether more specific guidance will assist DNSPs in relating these benefits to their revenue proposals.

The AER notes that DNSPs would need to determine the economic efficiency of incurring additional costs to reduce supply voltage magnitude, in order to deliver the potential benefits

6 AER, *Final DER integration expenditure guidance note,* June 2022

suggested in the UoW report. DNSPs would need to assess whether these costs would deliver benefits that outweigh the accompanying costs to consumers.

The fourth consideration relates to DNSPs accessing supply voltage magnitude data. The AER notes that data accessibility will improve as the roll out of smart meters proceeds and more precise data becomes available.

The AER continues to support enabling changes that will support higher penetration rates of smart meters, which are critical in enabling future market services. Further information on the AER's position on this reform can be found in our submission to the AEMC's Accelerating smart meter deployment rule change[7].

As data accessibility improves, policymakers may wish to consider further engagement with jurisdictional agencies to better understand regional challenges, the efficacy of compliance measures already in place, and better understand how the potential benefits of voltage management apply within each region.

The final consideration relates to further research into the algorithm developed by UoW to estimate the potential benefits of reduced voltage that are associated with increased appliance lifespan. The AER agrees that additional research into claims that consumer appliances are failing or have shorter lifespans due to voltage issues would be needed to understand these potential benefits.

[7] AER, *AEMC rule change - Accelerating smart meter deployment,* June 2024