30 November 2023

Ausgrid's 2024-29 Revised Proposal

Attachment 5.7.2: CER Augmentation CBA Model Basis of Preparation

Empowering communities for a resilient, affordable and net-zero future.

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Contents

1. Introduction

This Customer Energy Resource (**CER**) Cost Benefit Analysis (**CBA**) Model Basis of Preparation (**BOP**) has been developed to outline steps involved in developing and justifying the proposed CER augmentation investment for Ausgrid's 2024-29 Revised Proposal to the Australian Energy Regulator (**AER**).

This BOP covers references and model instructions for three models outlining CER augmentation CBA:

- Att. 5.7.3 - CER CBA total view model - 30 Nov 2023 – Public

  This model brings together results from the Electric Vehicle (**EV**) CBA model, Rooftop Solar CBA model and provides a total Net Present Value (**NPV**) view relating to Ausgrid's revised 2024-29 regulatory submission.

- Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential

  Augmentation required to address curtailment risk driven by increasing penetration of rooftop solar, justified by Customer Export Curtailment Values (**CECVs**)[1]. Our approach to calculating voltage non-compliance is reviewed by and references **Ausgrid - Att. 5.7.4 - UNSW CER integration independent review - 30 Nov 2023 - public**[2] and **Ausgrid - Att. 5.7.6 - UOW Review of Curtailment Methodology and Alignment to Australian Standards - 30 Nov 2023 - public**[3]**.**

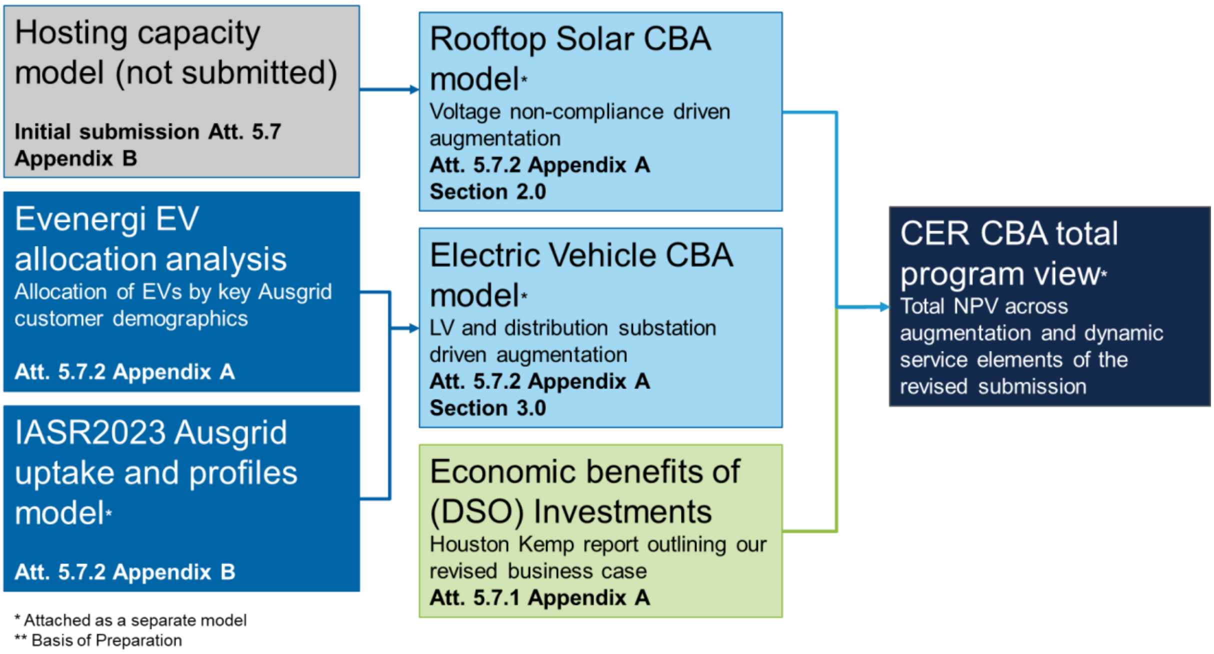
- Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential

  Augmentation required to address network performance risk from low voltage (**LV**) network overloads caused by increasing penetration and geographic clustering of EVs. We engaged Evenergi and Deloitte Access Economics (**DAE**) to explore the relationship between EV adoption due to key adoption factors (see **Ausgrid - Att. 5.7.5 - Evenergi EV Owner Survey Demographics and Charging Behaviours - 30 Nov 2023 - public** and **Ausgrid - Att. 5.7.7 - Deloitte Access Economics EV uptake report - 30 Nov 2023 - public**[4]**).** Evenergi's allocation of EVs by key factors such as wealth, dwelling types and access to offstreet parking was used as inputs to the EV CBA model (see Appendix A).

A summary of the focus of this document within the wider process is shown in the figure below.

[1] AER FY23 updated Customer Export Curtailment Values https://www.aer.gov.au/industry/registers/resources/guidelines/customer-export-curtailment-value-methodology/update
[2] University of NSW
[3] University of Wollongong
[4] Deloitte Access Economics

Figure 1: Process diagram of different CBA elements. This document focuses on the basis of preparation and model instructions for CER augmentation models.



2. Rooftop solar CBA augmentation model

The **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential** calculates the costs and benefits of investing in network augmentations to increase solar PV hosting capacity and reduce curtailment of rooftop solar PV exports.

The model does this by first determining the 'base case' state of the network outlined in **Att. 5.7 - Ausgrid CER augmentation business case - 30 Nov 2023 - public**, forecasting the cost of curtailment valued using CECVs over the period FY25-44. The model then recalculates the cost of curtailment for each investment option based on the forecast alleviation profile of each included investment. The forecast allevation profile is the estimated additional hosting capacity each investment adds.

The model uses results from Ausgrid's hosting capacity model, which simulates customer behaviour and CER adoption forecasts aligned to the Australian Energy Market Operator's (**AEMO**) Integrated System Plan (**ISP**)[5] step change, to forecast customer voltage non-compliance and calculate curtailment volumes consistent with current inverter standards (AS4777:2020). This methodology is supported by a report by the University of Wollongong, **Att. 5.7.6 - UOW Review of Curtailment Methodology and Alignment to Australian Standards - 30 Nov 2023 - public.**

Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential produces a portfolio of prioritised investments by economically evaluating the benefit of alleviated curtailment and assessing it against the cost of the investment. The outputs are then summarised in **Att. 5.7.3 - CER CBA total view model - 30 Nov 2023 – Public 'Solar PV'** tab.

Appendix C outlines a process flow diagram summarising how curtailment and network augmentation are calculated as outputs from the **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential**.

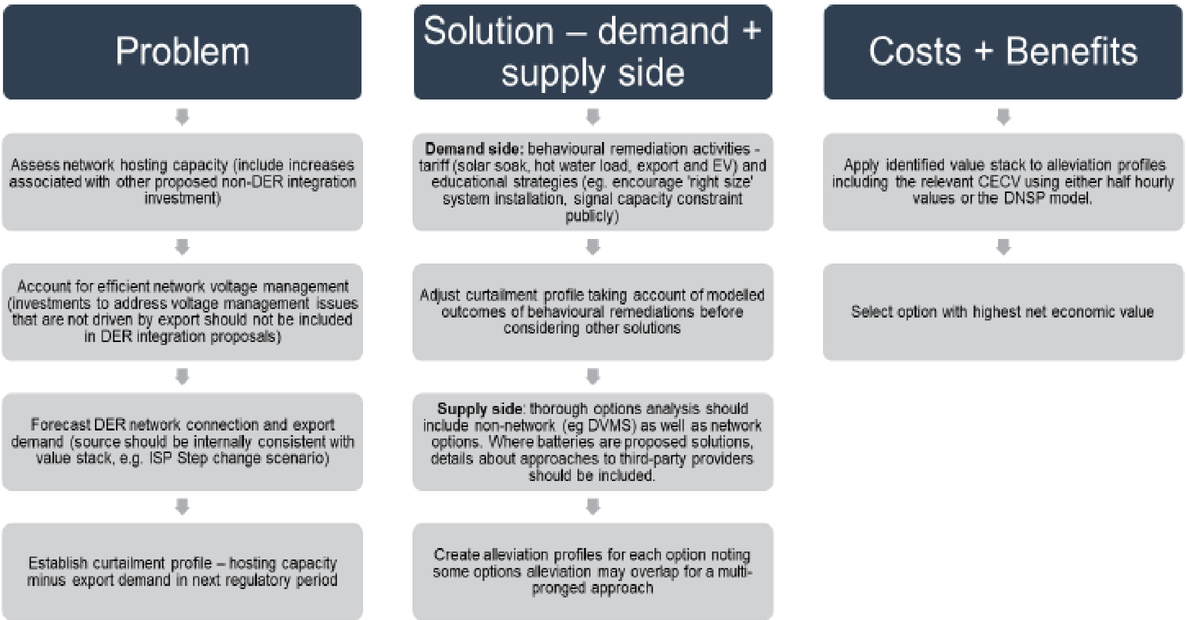
2.1 CBA Methodology

The modelling process to determine CER augmentation consists of 2 key steps outlined in the sections below. The first step is identifying the extent of customer curtailment in terms of both volume and value – the problem – and the second is determining an optimum set of solutions to address the curtailment, which are prioritised using a benefit-cost ratio.

Our cost benefit analysis approach is consistent with the AER's DER Expenditure Guidance Note's approach to quantifying risks and benefits **Figure 2**.

[5] AEMO 2023 ISAR Assumptions Workbook

Figure 2: The CBA methodology outlined in the AER's DER expenditure guidance notice[6]



There are three tables in the **Att. 5.7.3 - CER CBA total view model - 30 Nov 2023 – Public 'Solar PV'** tab summarising outputs from the **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential** model.

Table 1 quantifies the cost and benefits associated with the proposed set of solutions for the options, where:

- **Value of curtailed energy if "Do-Nothing":** Volume of curtailment on the network multiplied by the value of CECV and emissions per unit of volume when no investment is made and there is no alleviated curtailment, i.e. Option 1.
- **Value of alleviated curtailment:** Volume of curtailment alleviated (where the annualised CECV and emissions benefits are greater than the annualised cost of solutions across the 5 year period from FY25-29) multiplied by the value of CECV and emissions per unit of volume. Alleviated curtailment for the following regulatory periods is the avoided curtailment enabled by investment made in the FY25-29 period.
- **Value of curtailment with investment:** Value of curtailed energy if "Do-Nothing" minus Value of alleviated curtailment
- **Cost of investments:** Total cost of all solutions (total of Table 2 for each year).
- **Net cost:** Value of curtailment with investment plus Cost of investments

Table 2 provides a breakdown of the cost of solutions across 5 categories of solutions that can be invested in to augment the LV network. These solutions include tap changes and phase-

[6] Australian Energy Regulator, June 2022, https://www.aer.gov.au/system/files/Final%20DER%20integration%20expenditure%20guidance%20note%20-%20June%202022.pdf

rebalancing, small LV distributor upgrades (sub 400m), large LV distributor upgrades and distribution substation upgrades. This is an input from the **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential**.

Table 3 provides the count of proposed solutions selected for the 5-year investment period FY25-29.

2.2 Forecast Value of CER Curtailment

The value of CER curtailment is the quantity of energy curtailed multiplied by the value of the curtailed energy. It includes a CECV and an avoided emissions value.

2.2.1 Curtailment volume

The quantity of energy curtailed is calculated by determining the volume of curtailment consistent with voltage settings outlined in AS4777:2020. We have engaged the University of Wollongong (**UoW**) to provide an independent review of our application of the standard, the resulting report is submitted under **Att. 5.7.6 - UOW Review of Curtailment Methodology and Alignment to Australian Standards - 30 Nov 2023 - public.**

In our revised proposal we have applied the AS4777:2020 volt-watt response curve to all non-compliant solar on each applicable LV distributor as outlined below in **Figure 3** where V_{W1} = 253V and V_{W2} = 260V respectively. This is consistent with UOW's interpretation of the standard with confirmation our revised proposal methodology is consistent with Endeavour Energy's and Essential Energy's approach. Although a large proportion of the existing inverter stock would likely use AS4777:2015 default settings, AS4777:2020 is appropriate for forecasts extending into the FY2024-29 regulatory period and beyond.

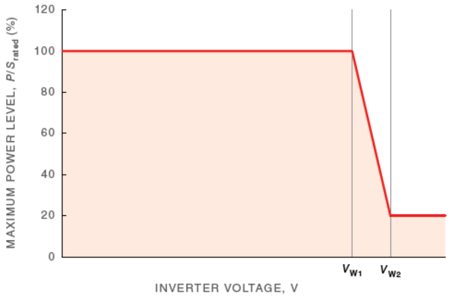


Figure 3: Volt-Watt response curve from AS4777:2020

In its review, the AER's consultant, EMCa, indicated that modelling curtailment from 253V at the inverter was conservative, taking into account the volt-var response of compliant inverters. Due to limitations of the hosting capacity model and a lack of more granular voltage data we are unable to accurately assess the volt-var response of inverters as outlined in the AS4777 standards. This is consistent with an independent review by the University of NSW (**UNSW**) (see **Att. 5.7.4 - UNSW CER integration independent review - 30 Nov 2023 - public)**, which observed 80% of inverters did not show a volt-var response among sample sites. UNSW confirms that observed curtailment begins earlier than the either the 2015 or 2020 standard indicates, with voltage set points observed at 248V and inverter tripping occurring lower than 255V (see **Figure 4**). We have taken a conservative approach by assuming compliant 4777:2020 inverters will ultimately avoid inverter tripping through a volt-var response and have instead applied a 20% factor across all voltages above 260V.

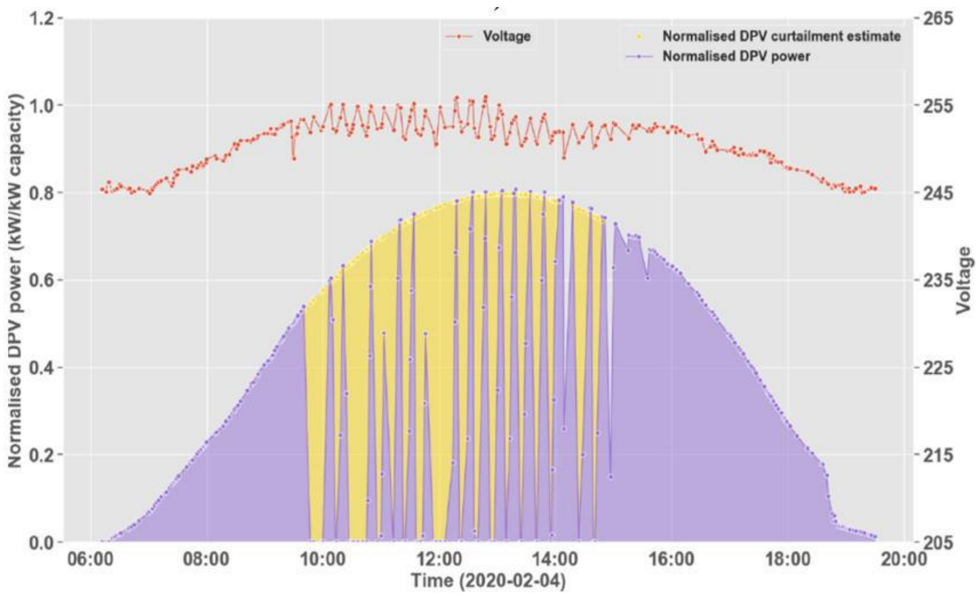


Figure 4: Example of instantaneous tripping Figure 1 of the UNSW independent report

The UNSW and UOW reports support modelling a 2% voltage drop from the Point of Common Coupling to the customers' inverter (**Att. 5.7.6 - UOW Review of Curtailment Methodology and Alignment to Australian Standards - 30 Nov 2023 – public** section **5.i**). UOW references the NSW Service Installation Rules which limits voltage rise to 2% from embedded generation between the point of common coupling and the customer inverter.

Appendix C outlines other key factors used to forecast customer inverter curtailment using inputs from the hosting capacity model. They include:

- **Non-compliant solar (kWs):** Output from the hosting capacity model estimating volume of solar for customers with solar units experiencing curtailment.
- **Percentage of time non-compliant:** The percentage of time during each year that the voltage is above the minimum curtailment level correlates to the annual maximum voltage. The higher the maximum voltage on a distributor, the higher the percentage of time the voltage will be above the minimum voltage curtailment threshold. This relationship was established from a statistical analysis of smart meter data, interval meter data and field devices.
- **The volume of curtailed energ**y: Calculated by multiplying the annual expected output of an unconstrained rooftop solar system by the percentage of time that voltage is in a range that curtails solar exports.

2.2.2 Curtailment Value

The value of curtailed energy is made up of two components:

1. **CECV** – the value of the curtailed energy to the electricity system
2. **Emissions benefits** – the value to society of the avoided carbon emissions that would have resulted from the use of clean energy had that energy not been curtailed.

Each of these are summarised as a $/kWh value and are summed together to produce the total value of curtailed energy, Per unit of energy curtailed.

Ausgrid's approach for estimating each value is detailed below.

CECV calculation

The CECV forecast used to value each kWh of curtailed solar PV is calculated from the AER's published CECV values (FY23 update)[7].

The CECV for curtailed solar was calculated as a solar PV output weighted average of CECV values during times of day of peak solar curtailment. The CECV value was recalculated for each year of the forecast to account for changing CECV values in the AER data and changes to the peak solar curtailment times.

Peak solar curtailment times were calculated from Ausgrid's hosting capacity model, which produces estimates of solar curtailment for each half hour of the year for a sample of distribution feeders. This data was summarised as a network wide curtailment start time and end time. The peak times are calculated for each year of the forecast, with the curtailment window generally widening over time.

Emissions benefits calculation

The value of emissions benefits is calculated as if the curtailed solar PV would be replaced by proportionally increasing the output of each generator in the NSW grid. This is a conservative assumption as the marginal generator is typically gas or coal, so the average intensity of the extra generation used to replace the curtailed energy is likely to be significantly higher than the average emissions intensity of NSW electricity used by Ausgrid.

Ausgrid trended the historical emissions intensity (measured in tCO2/kWh) forward and calibrated the forecast to the report: *GBCA – A practical guide to electrification*[8].

Emissions are valued at a constant and conservative figure of $30 per tonne of CO2e.

2.3 Investment Calculation

Investments are determined by network characteristics and unit rates outlined in the **'Inputs and Investments data'** tab of the **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential**.

Investment options are grouped on circuit length, length of overhead sections, number of NMIs and ratings, including:

- Distribution substation tap changes and LV phase balancing;
- Small LV distributor upgrades: includes planned investigations and low-cost replacement and repair of overhead and underground LV feeders (including terminations). For feeders below 400m in total circuit length;
- Larger LV distributor upgrades for circuit lengths exceeding 400m; and
- Distribution substation upgrades.

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[7] https://www.aer.gov.au/system/files/Oakley%20Greenwood%20-%20CECV%20workbook%20-%202023_v2.xlsx
[8] GBCA A practical guide to electrification page 6 Grid electricity Scope 2 & 3 GHG emissions factor (kgCO2e per kWh)

Cost and benefits of the potential solutions are selected based on the ability to enable additional exports on the network. An optimised set of solutions are selected for each LV distributor based on the following criteria:

- Availability of a distribution substations to address voltage non-compliance through voltage tap changes or LV open point configurations; and
- If a tap change is not available or a tap change does not sufficiently alleviate curtailment risk, alternative investments are prioritised.

All solutions are then ranked based on their benefit to cost ratio (**BCR**), solutions with higher BCRs are selected first for investment.

The annualised cost of each solution is calculated as the first-year financing cost of the investment using Ausgrid's standard unit rates and weighted average cost of capital and the benefit unlocked by the investment is calculated annually as per the methodology described above.

3. EV CBA Augmentation Model

The **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** calculates the impact of increasing EV penetration in the form of risk of overload and supply interruptions on the LV network.

Sydney is forecast to be a leader in the electrification of transport, in particular residential EVs. We engaged Deloitte Access Economics and Evenergi to confirm factors driving investment in our model and revise key assumptions based on their independent review. Key factors such as wealth, access to charging infrastructure and dwelling types that correlate with higher adoption rates of EVs will lead to geographic clustering of EVs in urban centres with mixed underground and overhead networks. Our analysis utilises Evenergi data to revise the allocation of EVs in Ausgrid's network and aligns to AEMO's updated FY2023 IASR[9].

Spot loads will drive augmentation in other network areas including urban centres such as the Newcastle CBD, but also long sections of overhead network that account for 33% of LV feeders identified for overload.

This model shares similarities with existing BAU models that unpin investment in HV and LV augmentation programs, with clear governance ensuring that we exclude investment triggered by BAU overloads. **Figure 5** below outlines how separate investment is determined from the existing HV and LV programs for the CER integration program and excluded.

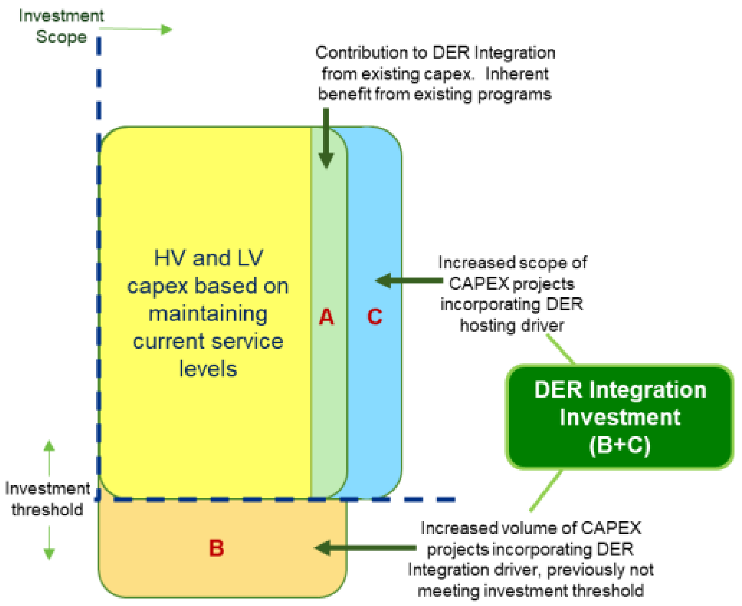


Figure 5: Excerpt from the initial submission attachment 5.6.d: HV & LV augmentation programs

[9] Australian Energy Market Operator (AEMO) Inputs Assumptions and Scenarios Report (IASR) https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios

Investments to address EV driven network overloads on each distributor are identified based on network characteristics such as circuit length, length of overhead sections, number of NMIs and ratings.

They are identified for investment having excluded overlaps between the **Att. 5.7.8 - Rooftop Solar CBA model - 30 Nov 2023 - Confidential** model and our BAU **LV/HV augmentation program**[10].

3.1 Key changes to inputs for the revised submission

This section details revisions to our CBA approach as part of the revised submission. Ausgrid had previously submitted **IR032 - Att A. CBA total program V1.2 - 20230609 – Confidential** and **IR032 - Att B. CBA EV analysis - 20230609 - Confidential** following an information request.

The revised submission uses figures from AEMO's FY23 IASR[11], which include updated EV forecasts by volume, charging type and charging behaviour since the FY22 ISP that supported the January 2023 submission. We have provided the model that uses these figures and produces inputs in into the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential**.

Table 1: Key global assumption inputs into Att. 5.7.9, and an explanation as to what has changed since the initial submission

Key input	Description	What has changed	Location in document
Volume of EVs	Forecast EV penetration for the modelled year	Aligns with AEMO's updated FY2023 IASR[12]	**Appendix B.** Refer to **Att. 5.7.10 - Ausgrid IASR2023 Ausgrid Uptake and profiles model - 30 Nov 2023 - Public** for more details.
EV contribution to peak	Contribution to forecast peak load	Aligns with AEMO's updated FY2023 IASR and re-aligned Ausgrid's peak based on average daily profiles (6-9pm). Applied a weighted contribution based on 30min intervals.	
EV charging profiles	The extent to which EV types, the type of charging they are forecast to use and how they will use it impacts peak load.	Previously assigned a weighting based on FY22 IASR figures and only included residential. Now aligns with AEMO's updated FY2023 IASR	
Effectiveness of tariffs	The extent to which tariffs shift EV load (applied as a factor)	Previously estimated between a factor of 0.5 and 1.5. Now factored into the	

[10] Attachment 5.6.d: HV & LV augmentation programs, Ausgrid's 2024-29 regulatory proposal
[11] Australian Energy Market Operator (AEMO) Inputs Assumptions and Scenarios Report (IASR) https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios
[12] Australian Energy Market Operator (AEMO) Inputs Assumptions and Scenarios Report (IASR) https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios

		charging behaviour of customers and the different types of EVs they use.	
Impact of customers with solar and batteries in offsetting peak impact	Forecast kW contribution of customers to reducing peak load by penetration and contribution to peak.	Revised based on existing customers export profiles aligned to the revised FY2023 IASR.	
Geographical allocation due to income	Clustering of EVs based on customer income.	Revised allocation of EVs for Ausgrid's network taken from Evenergi analysis.	**Appendix A** Refer to the **'Evenergi Allocation'** tab in the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** and **Att. 5.7.5.**

3.2 CBA methodology

The EV CBA methodology aligns with the AER' DER Expenditure Guidance Note's approach to quantifying risks and benefits (See **Section** Error! Reference source not found.). The CBA m ethodology can be broken down into 4 steps:

1. Identify the problem using a methodology based on the existing LV/HV program. LV distributors at risk of overload are identified by forecasting the impact of EVs on historical maximum load. This impact is calculated as outputs from the **Att. 5.7.10 - Ausgrid IASR2023 Ausgrid Uptake and profiles model - 30 Nov 2023 - Public** which uses AEMO's updated IASR FY23 forecast data to simulate the impact of different charging types and charging behaviour, factoring in the impact of incentives. It includes offsets to peak load contributions by coincident solar exports and battery storage.
2. Quantify the problem by calculating the annual cost of load at risk due multiplied by historical network performance. Apply the Value of Customer Reliability (VCR) to determine total forecast Expected Unserved Energy (EUE).
3. Identify a prudent solution per distributor based on network characteristics such as circuit length and whether the network is above or below ground.
4. Justify and prioritise investment at the distributor level, only including investments above a benefit-cost ratio of 1.

There are three tables in the **Att. 5.7.3 CER CBA total view model 'EV CBA'** tab summarising outputs from the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** model.

Table 1 quantifies the cost and benefits associated with the proposed set of solutions for the options, where:

- **Value of unserved energy if "Do-Nothing":** Volume of unserved energy on the network multiplied by VCR when no investment is made and there is no avoided unserved energy, i.e. Option 1.
- **Value of avoided unserved energy:** Volume of avoided unserved energy (where the annualised benefits are greater than the annualised cost of solutions across the 5 year period from FY25-29) multiplied by VCR. Avoided unserved energy for the following regulatory periods is the avoided unserved energy enabled by investment made in the FY25-29 period.
- **Remaining value of unserved energy with investment:** Value of unserved energy if "Do-Nothing" minus Value of avoided unserved energy.
- **Cost of investments:** Total cost of all solutions (total of Table 2 for each year).
- **Net cost:** Value of curtailment with investment plus Cost of investments.

Table 2 provides a breakdown of the cost of solutions across common groupings of solutions consistent with those in the PV tab. These solutions include small LV distributor upgrades (sub 400m), large LV distributor upgrades, distribution substation upgrades. This is an input from the **Ausgrid - Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential**.

Table 3 provides the count of proposed solutions selected for the 5-year investment period FY25-29.

3.3 Forecast value of Expected Unserved Energy (EUE)

LV distributor data including historical maximum demand and network characteristics is imported into the '**Network Analysis'** tab of the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** from internal asset management systems. Historical maximum demand is calculated from Ausgrid's Load Information System (LIS).

The forecast impact of EVs is calculated using outputs from two sources:

1. **Att. 5.7.10 - Ausgrid IASR2023 Ausgrid Uptake and profiles model - 30 Nov 2023 - Public:**

- The per kW impact of EVs on maximum demand, taking into account AEMO's forecast of uptake of different charging types (i.e. convenience, controlled) and behaviour change (i.e. tariff price signals).
- Offsets to the per kW impact of EVs by forecast battery, solar and observed peak demand periods from Reposit data.

2. **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** tab **'Evenergi Allocation':**

- Composition of residential and fleet types using data from recent analysis by Evenergi (See **Appendix B**).
- Allocation of EV forecasts based on key EV adoption factors such as wealth, availability of off-street parking and dwelling type using data from the Evenergi engagement.

Load at risk is calculated with the additional EV loads included. This is then multiplied by historical network performance and the VCR[13]. Expected EV driven outages are typically due to LV fuses operating due to overloading but may include cable termination failures. EUE is for three groups of customers:

1. **EV customers impacted by an EV driven outage**: The proportion of customers driving load above overload level and causing an outage.
2. **All customers impacted by an EV driven outage:** includes both EV and non-EV loads supplied by an affected feeder.
3. **The subset of all customers impacted by EV driven outages that are EV owners**: Includes load below peak utilisation contributed by EVs.

The AER raised a concern that Ausgrid was valuing unsupplied EV loads at the same VCR as other customer loads. The AER believes that these EV loads are more flexible than other customer loads and therefore have less risk of overload and supply interruption to customers from being unserved for short periods of time (i.e. a typical LV fault restoration time).

As a conservative factor the revised model assigns zero benefits to EV customer groups (groups 1 and 3 above), recognising the primary risks of unserved energy applies to all customers.

3.4 Investment prioritisation

Investment options are summarised in the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential 'Investment options'** tab, which ranks all potential investments based on the Benefit-Cost Ratio (BCR). Investments to address the forecast network overloads on each distributor are identified based on network characteristics such as circuit length, length of overhead sections, number of NMIs and ratings.

The **'Option 2 investments'** tab limits this list to low cost, high benefit LV distributor upgrades such as investigations and low-cost repairs (i.e. termination repairs and LV board upgrades). The intent of option 2 is to align with the AER's alternative forecast which focuses on low cost augmentation to address CER related impacts.

Investment options prioritise investment according to the highest BCRs for each LV distributor in the **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential** model **'Network analysis'** tab**.**

[13] Australian Energy Regulator, December 2022, https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20customer%20reliability%20%20update%20summary%20-%20December%202022.pdf

4. Appendices

4.1 Appendix A: Reallocation and clustering of EVs based on key uptake factors

Evenergi has developed an EV-grid impact modelling platform called GridFleet™ which emulates the impacts of electric vehicles on the grid at a granular postcode level. This tool was developed in collaboration with Ausgrid in 2020 and further improved in 2021 and 2023. Ausgrid engaged Evenergi in October 2023 to remodel its service area covered by 225 postcodes for a granular EV uptake projection using the GridFleetTM platform. Ausgrid used these postcode-level EV projections, along with an allocation methodology provided by Evenergi, in order to estimate granular projections of residential and fleet EVs by SA1 and distributor.

4.1.1 GridFleet granular postcode level EV uptake allocation methodology

GridFleet™ platform enables DNSP forecasting teams to spatially allocate EV uptake projection and associated charging demand to specific geographical areas. It derives the EV uptake for the specific postcode area from top-down EV uptakes for the entire state. The following sections describe the methodology for residential and fleet EV uptake allocation to a granular postcode level.

4.1.2 Residential

Evenergi has identified the following key demographic factors which influence the uptake of EVs (informed by a literature review of numerous national and international studies):

1. Affluence,
2. Dwelling structure, or availability of off-street parking, and
3. Number of vehicles owned.

Studies suggest that affluence is the most sensitive demographic parameter that decides the uptake of EVs in the respective postcode. The dwelling structure statistics are used to determine the ease with which an EV charger can be installed at a dwelling. A postcode with a high percentage of separate dwelling structures and high-income earners is likely to have stronger EV uptake, for example. It is assumed that residents of a specific postcode with at least one car in their ownership, are highly likely to buy an EV as their second or third car. These demographics are published by the Australian Bureau of Statistics (ABS). Statewide EV uptake forecasts, published periodically by AEMO, are adjusted by these scaling factors to determine granular postcode-level EV uptakes. Key inputs and data sources for the residential model are listed below.

Key inputs	Key data sources	Collection Method	Manual adjustments
Demographics - median income, employment, dwelling structures, and vehicle ownership	Australian Bureau of Statistics	Direct download	**None required**

Vehicle registrations	Australian Bureau of Statistics	Direct download	**None required**
Electric vehicle registration	**Transport for NSW**	**Direct download**	**Data was only available at LGA level. Data correspondence blocks (provided by ABS) and Ausgrid customer connections were used to translate the data to respective postcodes from LGA.**

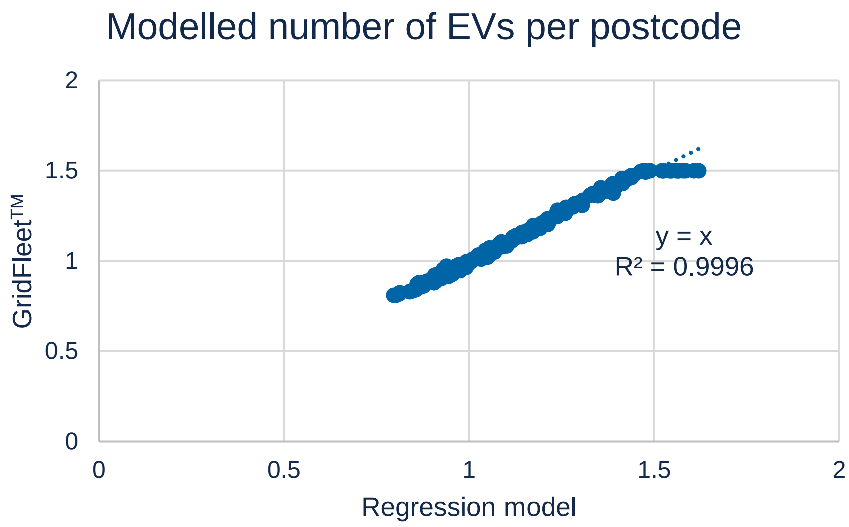
4.1.3 Fleet

The fleet typology is based on the number of businesses in a postcode having a fleet of vehicles. This includes commercial pool vehicles, logistics, heavy vehicles and other business-associated vehicles. The model only accounts for charging fleet vehicles at the depot. Fleet vehicles that are charged at home are counted by the residential model. This is achieved by using ABS census data, which captures the number of vehicles garaged at a specific postcode regardless of their registration postcode. The following table lists the key model inputs used for fleet EV uptake allocation.

Key inputs	Key data sources	Collection Method		Manual adjustments
Total number of businesses	Australian Bureau of Statistics	Direct download		**Data for business was only available at SA2 level. Data correspondence blocks (provided by ABS), were used to translate the data to respective postcodes from SA2.**
Percentage of businesses having fleet	Australasian Fleet Management Association	Direct download		**None required**
Number of vehicles per fleet	Australasian Fleet Management Association	Direct download		**None required**
Number of electric vehicles per fleet	**National map**	**Direct download**		**None required**

4.1.4 SA1 and Distributor EV allocation from Postcode-level EV uptakes

Based on the latest EV uptake projections published by AEMO (IASR2023) and postcode-level demographic factors, Evenergi's GridFleetTM platform estimates the EV uptake projections for Ausgrid's 225 postcode areas. GridFleetTM is not an open-source platform, hence Evenergi has provided Ausgrid with a highly significant regression model, which can determine the aggregated impact of granular demographic factors on relative EV uptake for a granular geographic area in comparison to state-wide EV uptake. The following plot illustrates the accuracy of this regression model to accurately estimate the relative EV uptake for a granular geographic area with respect to EV uptake in NSW.



Ausgrid used this regression model for a top-down EV uptake allocation from postcode to SA1 regions and then from SA1 regions to its distributors. ABS publishes the demographic factors required for this top-down allocation (listed in the above tables) by SA1, so Ausgrid used the top-down EV uptake allocation regression model provided by Evenergi to estimate granular SA1-level EV uptakes until 2030. The accuracy of the allocation approach is further illustrated in the example listed below for two SA1s within the same postcode (2210). As shown in the example, the allocation model allocates higher EV uptake to the SA1 with a higher percentage of high-earning households with one or more vehicles and the availability of off-street parking (i.e., a higher percentage of separate and semi-detached houses).

SA1	SA1 demographic factors								EV uptake % in 2030
	No vehicle household	Single vehicle household	Multiple vehicle household	Low earning population	High earning population	Separate house	Semi-detached house	Flat	
11903137318	13%	48%	30%	36%	24%	34%	4%	59%	19%
11903137312	7%	42%	40%	34%	41%	66%	27%	8%	25%

As the input demographic factors are not available at the Ausgrid distributor level, hence, for further granular EV uptake allocation to the distributor level, it is assumed that demographic factors are identical among all the distributors within a particular SA1. Therefore, SA1-level EV uptakes are allocated to the distributor within each SA1 in proportion to residential and commercial customers connected within the distributor, i.e.:

$$\text{EVs within a distributor} = \left(\frac{\text{Customer within a distributor}}{\text{Customer within a SA1}}\right) \times \text{EVs within a SA1}$$

4.2 Appendix B: IASR2023 Ausgrid uptake and profiles model BOP

In this section we explain the method we used to estimate the average kW contribution of individual EVs and the export kW from solar and batteries in Ausgrid's distributors' load during the peak demand period. It is a basis of preparation for the **Att. 5.7.10 - Ausgrid IASR2023 Ausgrid Uptake and profiles model - 30 Nov 2023 - Public** model attachment, which produces inputs to **Att. 5.7.9 - Ausgrid EV CBA model - 30 Nov 2023 - Confidential**. The analysis is based on a model utilising AEMO's latest ISP IASR2023.

The comprehensive inputs and assumptions provided by AEMO in their IASR2023 published in July 2023 which will form the foundation for the ISP 2024 has been used in our modelling. This includes the forecast of electric vehicle adoption, categorising various vehicle types, charging types, and charging profiles as well as the PV and behind the meter storage uptake forecast. The future uptake under different scenarios have been provided, allowing us to capture a range of potential futures.

In order to contextualise the AEMO data within the specific parameters of Ausgrid's network, a dedicated model has been devised. This model employs Evenergi's uptake model, a tool recognised for its accuracy in scaling EV adoption forecasts to regional contexts. By utilising this model, we can estimate the distribution of EVs across different segments within Ausgrid's network. This segmentation is essential as it allows us to focus on the residential and light commercial sectors, providing a more targeted analysis relevant to the local network.

Defining the peak period is a critical aspect of our analysis. After careful consideration, we have identified the hours from 6pm to 9pm as the peak time, aligning with the average peak day profile of Ausgrid's network. To capture the nuances of load variations during this period, a weighted contribution for each 30-minute interval has been implemented. This approach ensures that our analysis reflects not only the overall load but also the specific dynamics of the load curve during these crucial hours.

The core of our analysis involves calculating the average kW load of EVs during the defined peak time. This process integrates the scaled uptake model and considers the diverse charging behaviours exhibited by EV users, namely convenience charging, day charging, and night charging. By focusing on residential and light commercial vehicles, we aim to provide a detailed assessment of the additional load placed on Ausgrid's network during the peak hours, allowing for targeted infrastructure planning.

We also estimate the impact of PV and battery systems. Building upon the IASR2023 forecasts for PV and battery uptake, we map these projections to Ausgrid's network for the financial year 2030. We leverage existing PV and battery customer export profiles from a set of our customers who have battery and have solar and battery data, providing insight into the average kW offset during peak periods by the solar-only and solar-battery customers. This approach enables a comprehensive understanding of the combined impact of EVs, PV, and batteries on individual Ausgrid's distributors, to be used for the global EV impact analysis.

4.3 Appendix C: Process Flow Diagram of Rooftop Solar CBA Model

Figure 6: Process flow diagram explaining how curtailment and network augmentation is calculated in the Rooftop Solar CBA model.