31 January 2023

Attachment 5.7: CER integration program

Ausgrid's 2024-29 Regulatory Proposal

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

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Contents

1. Executive Summary

1.1 Background

The way that society produces and uses energy is rapidly changing in response to environmental factors, increasing energy costs and the availability of new technologies. The Australian Energy Market Operator (**AEMO**) predicts that 50% of customers nationwide will use a form of Customer Energy Resource (**CER**)[1] by 2030, with further increases expected beyond then. In Ausgrid's service area we're anticipating that additional pockets of communities will rapidly reach or exceed these levels, while others will develop more slowly (due to factors like roof space and home ownership), but still achieve considerable growth over time.

1.2 Impact on the Ausgrid network

These changes are increasing the complexity of power flows and the way that electrical networks operate, creating challenges in managing the network on a day-to-day basis and in forecasting future usage. Ausgrid must therefore de-risk the increasing complexity and support the transformation of energy services that customers desire, while continuing to provide essential network services such as connecting customers and responding to incidents and complaints.

Ausgrid's network does not currently have sufficient hosting capacity to meet current and forecast levels of CER and our processes and systems are not yet set up to deal with this influx. Supporting the transition will require fundamental changes to how we manage our network, interact with customers and support the stability of the end-to-end system.

Ausgrid has a non-homogeneous network topography, geography and customer base that influences both the value of CER/DER (**VaDER**) and the rate at which our customers adopt CER. This requires Ausgrid to understand a range of benefits and implement a variety of responses to enable CER integration.

Notable areas of difference are the Sydney and Newcastle urban areas compared to the more rural areas within the Hunter region. We expect urban Sydney and Newcastle areas to lead transport electrification with relatively limited potential for distributed generation to offset load growth at a local level. Conversely, while the Hunter region has rural areas with plentiful solar resources available, it is expected to have slower uptake of electric vehicles (**EVs**) and has lower levels of network security and flexibility. These differing scenarios require very different enabling actions on the network.

1.3 What our customers and stakeholders have told us

Customers are telling Ausgrid that they plan to invest more in CER and that they support a proactive approach to Ausgrid enabling those investments. During engagement in the lead up to our regulatory proposal, our customers and stakeholders have expressed clear expectations that Ausgrid will leverage existing assets to deliver reduced total energy costs, continue to provide a safe network, increase resilience in face of a changing climate and help communities achieve net zero targets.

> **'Proactive investment needs to happen, and Ausgrid is well-positioned to do it'**
>
> **Customer quote from Voice of Community Panel 2024-29 regulatory reset engagement**

> **'We need to get off coal sooner rather than later. If we are moving to net zero, we need to start here … without solar hosting, customers will not be able to choose solar power'**
>
> **Customer quote from Voice of Community Panel 2024-29 regulatory reset engagement**

The NSW Government is actively targeting a 70% reduction in carbon emissions by 2030 leading to net zero by 2050 and has several strategies in place to reach this goal, including renewable energy and electrification of

[1] Previous public discussion of this area has used the term Distributed Energy Resources (**DER**). More recently this has evolved to Customer Energy Resources (**CER**).

transport, industry and domestic energy usage. Electricity distributors like Ausgrid have a key role in working with the NSW Government and wider stakeholders to deliver these strategies.

These expectations are reflected in Ausgrid's corporate vision '***for communities to have the power in a resilient, affordable and net zero future***' and the CER integration program has been developed to be consistent with that vision.

Achieving net zero will require significant electrification of business, industrial and transportation processes, resulting in significantly higher electrical loads, supplied from an increasing base of renewable energy. Effective CER integration involves unlocking the flexibility of load and generation to operate during low utilisation periods away from times where Ausgrid's network would be most heavily loaded, and we would otherwise need to constrain customers from using or exporting energy. While these opportunities are available, harnessing them requires Ausgrid to enhance existing and develop new capabilities (people, processes and systems).

Ausgrid's CER vision is to **'*Utilise Ausgrid's network as a platform to safely, efficiently, and equitably enable CER in a way that meets the need of customers, stakeholders and facilitates a net zero future*'**.

Our focus is on allowing customers to invest in CER and take part in new energy solutions as they choose, while providing incentives for customers to manage their usage in ways that optimise network utilisation to achieve the most efficient balance of cost, safety, and reliability for all customers. This Strategy has been developed to be consistent with the Australian Energy Regulator's (**AER**) DER Integration Expenditure Guidance Note.[2].

Ausgrid's approach to CER integration out to 2039 is summarised in **Figure 1.**

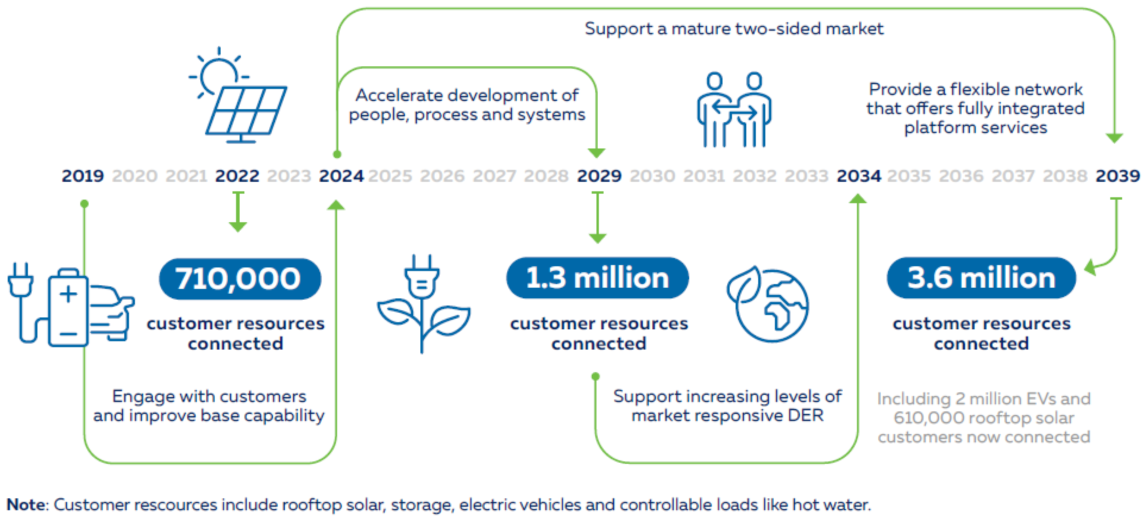


Figure 1 Ausgrid CER Integration approach

Ausgrid has identified a series of capability gaps we need to close to deliver these customer outcomes. The journey has already commenced, but we must maintain momentum through to the end of the next regulatory cycle and beyond to transform from 'network provider' to 'system operator' in time to facilitate a cost-effective transition to net zero by 2050.

Prudent CER integration investment in the categories below will uplift our capability and leverage our existing assets to deliver net economic benefits to our customers and the National Electricity Market (**NEM**):

1. **Network visibility and modelling uplift** – increased measurements or data sources to give visibility of what is happening on the network, combined with more sophisticated modelling that can integrate with more real time data, to dynamically predict network outcomes under different CER scenarios.
2. **Dynamic service capabilities** (including Dynamic Pricing and Dynamic Operating Envelopes (**DOE**)) – which can reflect the changing nature of network limits with changes in generation output and loads to give more headroom, by moving away from only assessing system limitations at peak times only to assessing them on a dynamic basis. DOEs and Dynamic Pricing are part of our journey towards

[2] AER (2021). DER Integration Expenditure Guidance Note.

increasingly cost reflective tariff arrangements which provide incentives for customers to act in a way that makes the most efficient use of network assets.

3. **Connections and compliance uplift** – using data, analytics and modelling tools to simplify connection of CER within required timeframes by increasing the proportion of automatically approved connections, streamlining those connections that require further assessment and making connection data more readily available to enable optimised network planning and operations. This category also includes customer education to raise awareness of the choices available to customers in terms of initial installation and ongoing tariffs.
4. **Innovation** – a series of pilots and trials of innovative technologies and advanced analytical approaches with the potential to provide further alternatives or improve the effectiveness of CER integration.
5. **Augmentation solutions** – where the above sophisticated network management tools are unable to address limitations, augmentation of the network is an option – using more traditional solutions such as transformer or mains upgrades, or via newer technologies such as STATCOMS.
6. **Community batteries** – can be deployed as an alternative to traditional augmentation solutions to manage loads and voltage levels in the network to relieve network constraints at a local level. They also offer opportunities to partner with others who can access additional parts of the value stack and reduce the cost of community battery solutions to Ausgrid customers.

1.6 Outcomes for customers

Our proactive approach to CER integration, as proposed by this strategy and supported by our customers, will deliver the following customer outcomes:

- Enable customers to get the most value out of their investment in CER, with adoption expected to reach an additional 620,000 customer energy resources by 2029[3];
- Reduce costs for all customers by improving network utilisation;
- Support connection of additional rooftop solar, achieving a low-cost, low-carbon generation mix by reducing the curtailment of customer's solar output by at least 85% for new and existing CER customers;
- Reduce the cost of connecting CER by 50% compared to our base case, by implementing new technology solutions and dynamic services rather than relying solely on traditional augmentation; and
- Enable our customers' and communities net zero ambitions, as well as a 50% reduction in our own scope 1, 2 and 3 emissions by 2030 and net zero emissions by 2045.

1.7 Options we considered

Table 1 outlines alternative investment options in response to AEMO's central 'Step Change' scenario. This 'proactive investment' approach responds to customer and stakeholder expectations by incorporating the ability to manage and incentivise two-way power flows, solve network constraints in place of traditional network augmentation through dynamic management of the network and share the benefits of CER with all customers through innovative services such as community batteries. This proactive investment option is the recommended investment option of the CER integration program.

Table 1 Alternative investment options in response to AEMO's 'step change' scenario

Capability	Investment Options (real $m, FY24)		
	Option 1 Base Case	Option 2 Preparatory investment	Option 3 Proactive investment
Network visibility and modelling uplift	-	29.7	32.1
Dynamic service capabilities	-	-	12.1
Connections, compliance and education	3.0	13.9	13.9
CER innovation projects	-	20.9	20.9

[3] In line with AEMO's ISP step change scenario.

Augmentation - new technology	-	-	10.0
Augmentation - traditional	47.3	60.6	27.3
Community Batteries	-	-	9.8
Total	**50.3**	**125.0**	**126.1**
Net Present Value (NPV)	**-2.9**	**48.8**	**169.4**

2. Background

2.1 Defining Customer Energy Resources

Customer Energy Resources (**CER**) are generation and controllable loads connected at the distribution network level. Often these assets can provide value to the energy system, beyond simply meeting the primary needs of those with direct access.

CER most commonly operates on the 'customer side' of the meter and most commonly includes:

- Rooftop solar generation;
- Battery storage; and
- Flexible loads such as Electric Vehicles (**EVs**), hot water and space heating.

Enabling CER flexibility will depend on the success of customer engagement, cross industry collaboration, access to the full value stack of benefits and appropriate standards-based technology that interfaces with the energy system.

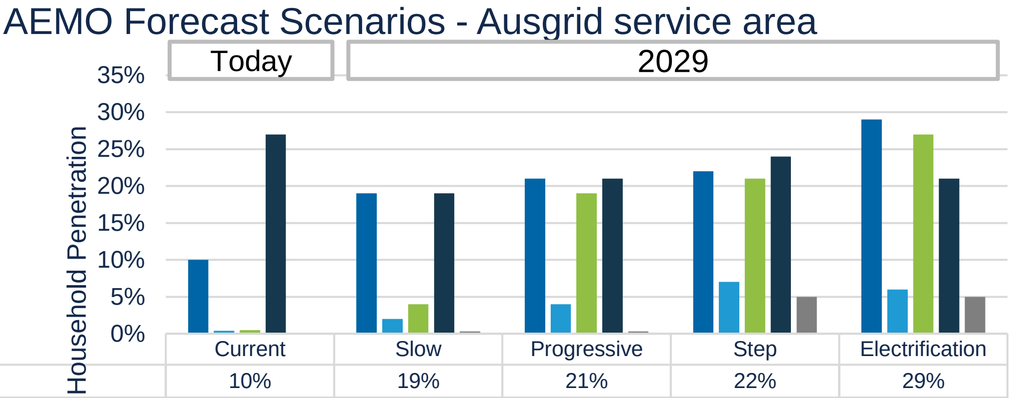
2.2 Changing customer needs

Customer wants and needs are changing rapidly. Ausgrid's recent Voice of Community engagement for our 2024-29 period confirmed that customers have a strong awareness of CER opportunities such as solar, batteries and EV's. Our customers told us that they have an increasing desire to be able to freely exercise choice about their CER investments, as well as saving on their bills and contributing to a reduction in carbon emissions.

'This is a real turning point in the pathway – so many decisions made now will impact future generations by either closing down or opening up options … distribution is such a key part of the net zero puzzle'

Customer quote from Voice of Community Panel 2024-29 regulatory reset engagement

AEMO forecasts that 50% of customers will use some form of CER such as rooftop solar or electric vehicles by 2030. Customers without CER are telling us that they aspire to have CER one day. AEMO forecasts that 50% of customers will use some form of CER such as rooftop solar or electric vehicles by 2030. Customers without CER are telling us that they aspire to have CER one day. Figure 2 below outlines Ausgrid's forecasts on CER penetration for all customers including commercial and industrial, based on the AEMO step change scenario.



	Current	Slow	Progressive	Step	Electrification
PV	10%	19%	21%	22%	29%
Battery Storage	0.40%	2%	4%	7%	6%
EVs	0.50%	4%	19%	21%	27%
Off Peak Hot Water	27%	19%	21%	24%	21%
Electrification of Residential Gas	0	0.3%	0.3%	5%	5%

Figure 2: Translation of AEMO forecast scenarios into Ausgrid service area penetration for all customers[4]

It is expected that technology changes, government policy, regulatory change and customer behaviour will continue to accelerate CER uptake over the next 5-10 years in Ausgrid's service area.

This timeframe is driving the need for Ausgrid to realise the potential of the network as a platform that supports customer choices, and the complex power flows which can result from that. It is expected that to reach the NSW government 2050 net zero target, DNSPs have a critical role to play in enabling load flexibility and collaborating with AEMO on system security. This includes supporting the Hunter-Central Coast Renewable Energy Zone (**REZ**), which will form a key part of supply with the retirement of coal generation.[5]

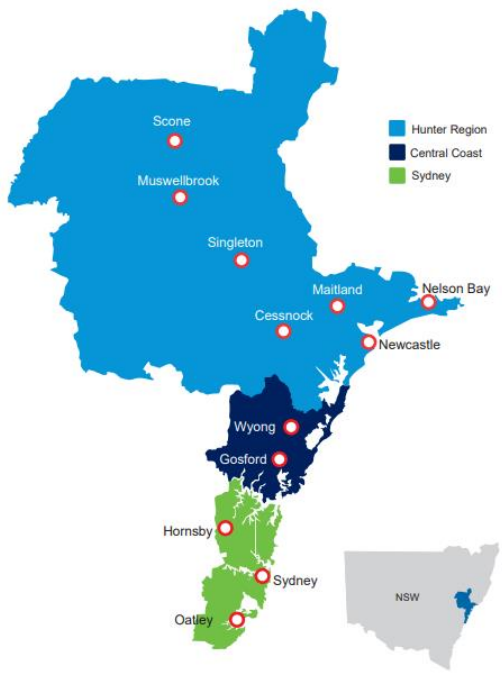


Figure 3: Ausgrid's supply area

As shown in **Figure 2**, various demographic and environmental factors mean customers are not adopting CER evenly across the network. This results in load and generation not being efficiently co-located, with a reliance on the distribution system to balance energy supply and demand across suburbs and regions. 38% of Ausgrid's customers live in apartment blocks with limited access to useable rooftop space for adoption of rooftop solar, while Sydney and Newcastle urban centres will be the drivers for electrification of transport. Suburban homes will see increasing rooftop solar and charge EVs in garages. With 2 million EVs forecast to be connected by 2039 and with batteries around 5 times larger than the typical solar installation, ineffective coordination will drive new peak load events. Ausgrid will seek to utilise tariffs and connection agreements as the primary mechanism to manage network capacity and guide customer decisions about charging times. More direct methods of control, such as curtailment or voltage management, will also be explored (with appropriate incentives) to manage emergencies and minimise inefficient investment. Hot water loads will continue to be optimised as a controlled load as the capability is retired over time.

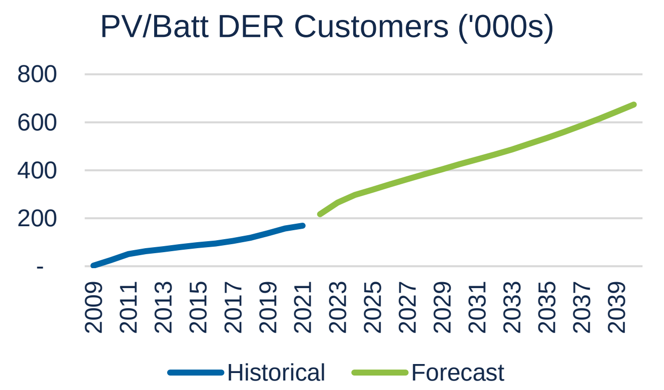
[4] Ausgrid selected AEMO's Strong Electrification sensitivity modelling as the alternative Scenario to AEMO's Hydrogen Super Power Scenario. This is due to how the Strong Electrification Scenario impacts the low voltage network relative to the Hydrogen Super Power Scenario. See, AEMO (2022), [2022 Integrated System Plan (ISP)](), p. 92.
[5] We did not include the Hunter-Central Coast REZ in our 2024-29 period forecasts as we understand that it will be managed through a separate regulatory determination process.

Table 2 below, outlines Ausgrid's understanding of the expectations and forecast behaviour of customers and stakeholders by CER driver. It also gives an overview of the network impacts of this, which provides an initial insight into the reasons why successful CER integration is so important. This is discussed further in successive sections of this paper.

Table 2 – CER drivers and network impacts

<table>
<tr><th>CER driver</th><th>Network impact</th></tr>
<tr><td>Rooftop Solar and (small scale) batteries

Rooftop solar uptake has consistently outstripped AEMO forecasts in Australia. Solar uptake has been significant in Ausgrid's network relative to historic uptake and this is forecast to continue. As 38% of Ausgrid's customers reside in high-density apartments, the opportunities for rooftop solar remain limited. And so, Ausgrid expects rooftop solar growth to be concentrated in suburban and rural areas of our network. We expect home battery systems to grow by more than 1GWh between now and 2029. They are typically paired with rooftop solar installations.



*Based on AEMO 'Step Change' Scenario</td><td>Distribution networks have been designed to maintain voltage levels within a desired range based on traditional customer demand patterns, i.e. one-way flows and not two-way flows of energy.

Rooftop solar exports cause network voltages to rise. When they rise sufficiently the inverters in customers' rooftop solar systems limit their output (newer systems) or 'trip off' (older systems) and stop generating for both in-home consumption and for exports. This keeps grid voltage levels within acceptable levels. This is known as CER 'curtailment'.

This curtailment does not meet customer expectations and the NSW net zero 2050 objective where rooftop solar significantly contributes to the zero-emissions generation mix.

Ausgrid forecasts 11% of CER installed by the end of 2029 will experience curtailment.</td></tr>
<tr><td>Electric Vehicles (Electrification of Transport)

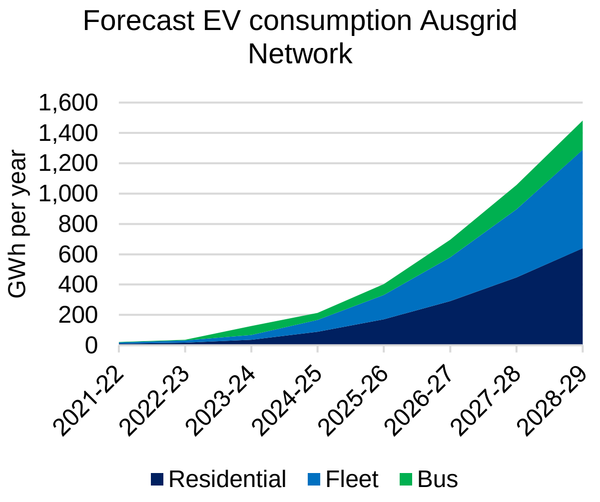
Our customers, and Federal and NSW Governments view electrification of activities currently using fossil fuels as a key driver of achieving net zero.

Electrification of the transport sector is one of the major elements of this transition, along with electrification of heating (see driver below).

AEMO's Step Change Scenario forecasts private EV ownership to grow due to price reductions, product offerings and government policies and incentives. Government and business fleets are also changing due to net zero targets and evolving business models.

In addition, vehicle-to-grid (V2G) technology has the potential to change the way people utilise their cars and could even displace stand-alone batteries over time. Several vehicles are proposed to have this capability by the end of 2022.</td><td>Ausgrid's existing network can be leveraged to enable electrification of the transport sector. Load is forecast to increase through the EV uptake. Due to Ausgrid's lower rooftop solar penetration compared to other DNSPs, there is less opportunity to offset EV charging with solar generation in urban Sydney and Newcastle.

If we do not effectively integrate EVs, then they have the potential to increase load at traditional peak times or create new peak loads in part of the network (such as at city car parks). This will drive increased network augmentation and present a cost burden passed on to all customers. We need to consider, and find the right balance based on our customers' preferences, for the following 3 elements for EVs:
1. Unconstrained (convenience); or
2. Incentivised (by tariffs); or
3. Orchestrated EV charging.</td></tr>
</table>

CER driver	Network impact
	
Electrification of built environment heating The nature of the impact of electrification of heating the built environment is different from EV's in practice but is driven by the same objective of phasing out fossil fuels to achieve net zero. Electrification of built environment heating involves changing heating loads from gas to electricity. It includes: • Converting **hot water service**s, • **Space heating,** and • **Cooking**.	Heating the build environment is a weather driven load likely to coincide with existing peak times in the network, particularly in winter peaking regions. Like EV's, unconstrained heating loads would have a more significant network impact than incentivised or managed loads. Flexibility of heating times (and heat storage) will be key to managing the network impact. Electrification of heating is an emerging area of focus.
Utility-scale batteries Larger 'utility-scale' battery installations are typically installed on the high voltage (**HV**) network or above i.e. 11kV+. They are solely focused on providing services to the electricity system. Utility-scale batteries are key to supporting variable renewable generation in energy markets but can also improve hosting capacity to enable more customer CER and improve system security through ancillary services to the grid.	Utility-scale batteries will play an active role in the Hunter-Central Coast Renewable Energy Zones in supporting the retirement of coal fired generation. Utility-scale batteries are more likely to connect in strong parts of the network with sufficient available capacity, allowing reliable market access but less scope for network support services. Low voltage (**LV**) connected community batteries are more likely to experience constraints in operation but have greater scope to provide network support, depending on location. Specific tariffs are being proposed for the 2024-29 period for storage only customers. This recognises the importance of these resources in the transition and the benefits that they can bring to the local network.

Electrification will increase electricity demand and is also expected to coincide with a reduction in traditional centralised 'base load' electricity supply, requiring increased quantities of distributed generation and storage to meet increasing demand.

The value of load flexibility is a common theme throughout the above CER elements and can make a material contribution to achieving a reduced overall energy cost for customers. Flexibility to align energy consumption with abundant renewable energy generation is a key enabler for replacing fossil fuels and achieving the community's net zero targets. Flexible loads also allow for better network utilisation and reduce the need for augmentation, when some loads can be moved away from peak times into periods when the network is more lightly loaded.

Regulators and market bodies are continually refining their understanding of customers and stakeholder wants and needs. They are adjusting and aligning the regulatory and compliance framework to enable market participants and national electricity market (**NEM**) entities to reflect those wants and needs in a cost-effective way. Ausgrid is already seeing market changes and expects this to continue into the 2024-29 period as the collective understanding of CER continues to evolve. Anticipated changes include introducing dynamic operating envelopes (**DOEs**), updating of CER technical standards in the National Electricity Rules (**NER**) and developing two-sided markets by AEMO to unlock load flexibility in the face of increased intermittent renewables. These changes mean Ausgrid will need to adapt its services to better suit customers' needs, wants and address additional compliance requirements

2.3 The need for successful CER integration

'Innovation is the best key to resiliency, net zero and balanced investments for the greater good for all'

Customer quote from Voice of Community Panel 2024-29 regulatory reset engagement

Ausgrid's customers support a proactive approach that enables their ability to invest in CER and directly access and share its benefits with all customers. Successful CER integration has the potential for multiple customer benefits including decarbonising the energy sector, increasing system resilience to weather events, facilitating growing CER capacity and improved customer experience.

From an economic point of view, successful CER Integration can be said to occur when:

- Maximising how much CER customer can use for the lowest costs;
- Optimising the investment in and use of CER on our network in a way that reflects the costs of the CER owner and Ausgrid; and
- Creating an environment that encourages innovation and investment in CER on our network that continuously improves the benefits of CER.

From a customer's point of view, CER Integration is successful when CER, two-way power flows and network risk are all managed in a way which means overall bills are lower and customers are not unnecessarily restricted in their choices about using or exporting power, while being enabled to contribute to the path to net zero.

Network risk arises when the network exceeds its design limits or 'hosting capacity' due to growing levels of CER. This drives a cost burden to customers through network augmentation or the opportunity lost for customers by curtailing their CER at an increasing rate. Curtailment means customers who can invest in their own CER are restricted from exporting some of that energy to the grid and customers without their own CER cannot access the shared benefits of a cheaper, renewable generation mix and greater network efficiency.

Successful CER integration enables our customers' net zero ambitions by improving 'hosting capacity' of generation and leveraging network capacity to support electrification. In other words, successful CER Integration provides headroom in Ausgrid's network to accept greater volumes and utilisation of zero-emissions CER. Greater electrification is enabled through higher network utilisation, increasing the scalable benefits of CER. The figure below explains this concept and its benefits to all customers of successful CER integration. It explains that customers with direct access to CER get higher value out of their CER investments and those without direct access can get benefits when CER is coordinated to improve the overall utilisation of the network.

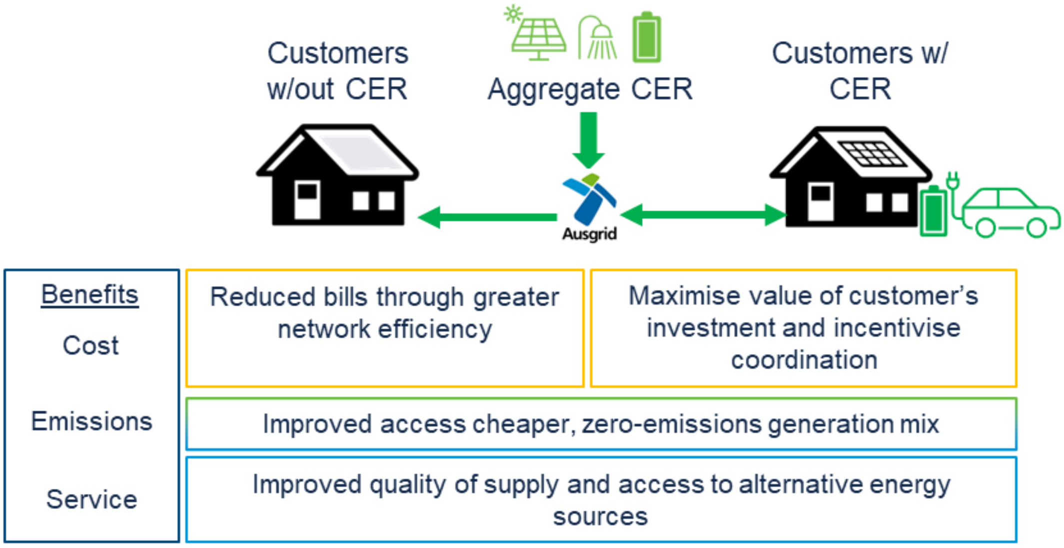


Figure 4: Successfully integrated CER delivers benefits to all customers

2.4 CER investment principles and Ausgrid's 2039 roadmap

The focus of this strategy is to accelerate development of our people, processes and systems aligned to our customers' needs. It builds on a strong history of innovation, and deliberate steps we have taken to make smarter network decisions in place of traditional network investment to overcome problems.

We have applied the following principles in forming the CER integration program:

1. Understand our customers' needs, including their role in investing in and accessing cheaper, zero-emissions generation;
2. Explore tariffs, price signals and information enabled by greater network visibility before considering traditional network investment;
3. Avoid unintended curtailment and resolve issues that will materially slow decarbonisation efforts.
4. Use the Ausgrid network's unique attributes as a platform to safely and cost-effectively accelerate net-zero; and
5. Share the benefits of low-cost, zero emissions CER with all customers.

The focus of this strategy is setting out a roadmap for establishing the key capabilities to deliver on our customers' needs through investments in the FY2024-29 period. This builds on innovation program investments from 2019-24 and is the foundational step of our 2039 CER roadmap outlined below. Key priorities for this 2024-29 period are improving network visibility to understand two-way power flows and developing systems to offer new innovative services to reduce the cost burden of reactive upgrades for all customers. This investment delivers on our customers' net zero ambitions by lifting the cap on how customers can use CER and sharing benefits.

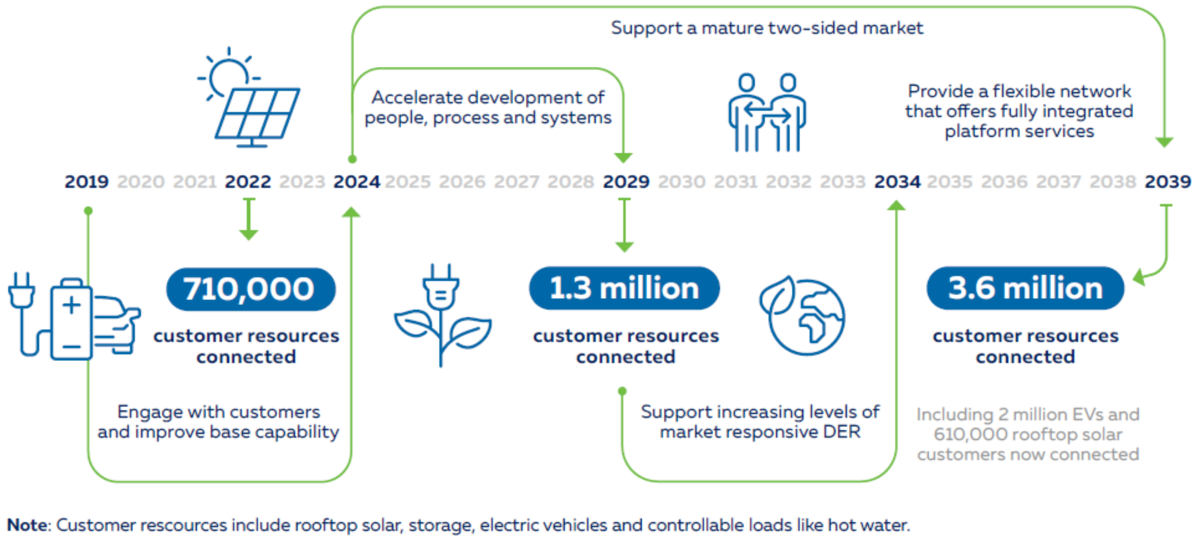


Figure 5: Ausgrid's 2039 CER roadmap outlines the capability steps in needed enable customers' forecast needs

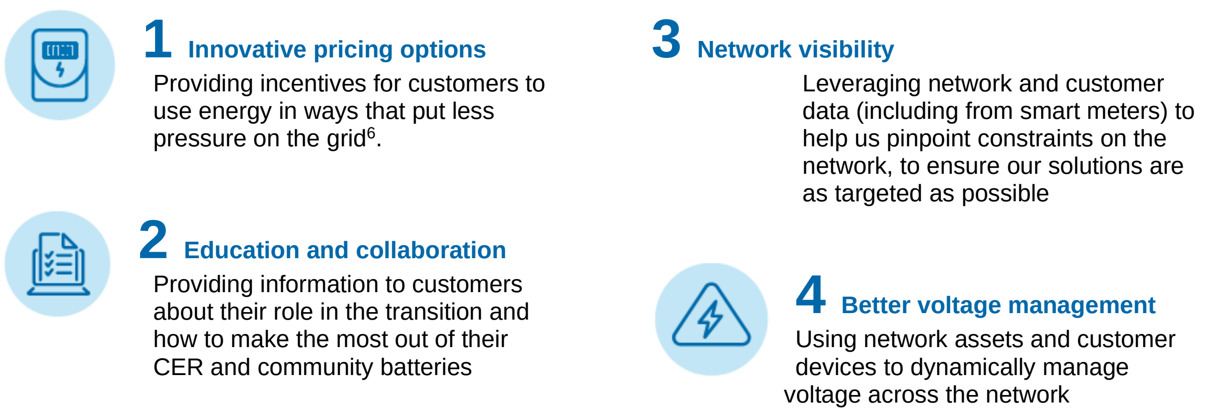
See Annexure C for a detailed version of the roadmap.

2.5 Ensuring Ausgrid produces the best result for customers

2.5.1 Cost Benefit Analysis (**CBA**) approach to determining alleviation profile

> **"Smarter use of what we have; pricing incentives will probably be effective and fair as long as people have the knowledge and tools to make the changes they want/need"**
>
> **Customer quote from Voice of Community Panel 2024-29 regulatory reset engagement**

Aligned to the AER's CER guidance notice, Ausgrid's CBA approach analyses costs over the 2024-29 period, and assesses the benefits arising from those investments over a 20-year period. All aspects of the investment program are analysed, including ICT, operational and capital investments to form a prioritised portfolio of investments that produce the highest economic benefit for customers. In assembling the CER Integration investment portfolio, Ausgrid employs a hierarchy of steps (see Figure 6 below) to determine the solution with the highest economic benefits and to align with the CER integration program investment principles (Section 2.4 above).



[6] Section 4.3 below outlines the reforms Ausgrid is considering. Further detail is provided in Ausgrid's **TSS Explanatory Statement.**

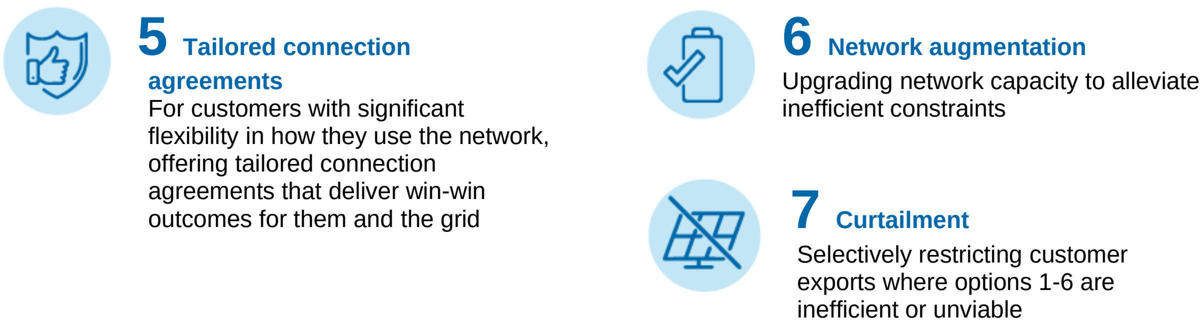


Figure 6: Hierarchy of steps to assess economic benefit

This hierarchy is applied across the three investment options tested and used to identify the lowest economic cost to customers and the highest economic benefits aligned to customer expectations.

The recommended Option 3 ‘proactive investment’ contains the following elements (total costs in $real, FY24):

1. **Foundational investments in ICT process and systems** of approximately $33.2 million in the 2024-29 period. This prepares us to coordinate market-responsive CER to integrate CER and new services with providers such as aggregators, improving the value of customer CER. This capability reduces the need for future network augmentation thereby decreasing potential future cost burdens to all customers;
2. **Improved network visibility** through a $24.9 million in the 2024-29 period as part of a continued smart meter data acquisition investment. Foundational ICT investments when paired with improved network visibility support more effective investment decisions, allow us to more accurately identify issues related to two-way power flows and understand the effectiveness of our services such as dynamic pricing;
3. **Network augmentation** makes up $47.1 million of the overall investment. Aligned to our customers’ feedback we are exploring a mixed approach to augmentation solutions that supports the use of innovative technologies such as STATCOMs ($10 million) and community batteries ($9.8 million). The remaining $27.3 million includes traditional network augmentation solutions including distribution tap changes, LV phase balancing and LV distributor augmentation;
4. **The Network Innovation Program** contains $20.9 million of CER-driven expenditure addressing problems and opportunities driven by increased customer CER uptake on Ausgrid’s network. This expenditure is not included in the **CER Integration Program Brief** (**Appendix A**) but within the scope of the CER integration program to provide visibility across all areas of CER related expenditure; and
5. **Curtailment** is used to manage remaining customer CER where augmentation is not a justified solution.

2.6 CER uptake and impact

Modelling CER impacts on the network are foundational to determining Ausgrid’s CER Strategy and Business case presented to the AER. There are many variables to account for including a significant diversity of potential CER uptake drivers and local variations in network hosting capacity.

Ausgrid approaches CER integration planning as a parallel process to traditional LV and HV network planning that cater for ‘BAU’ demand growth. In these processes network risks are identified, possible remediation options identified and investigated. The process for CER modelling is summarised in Figure 6 below.

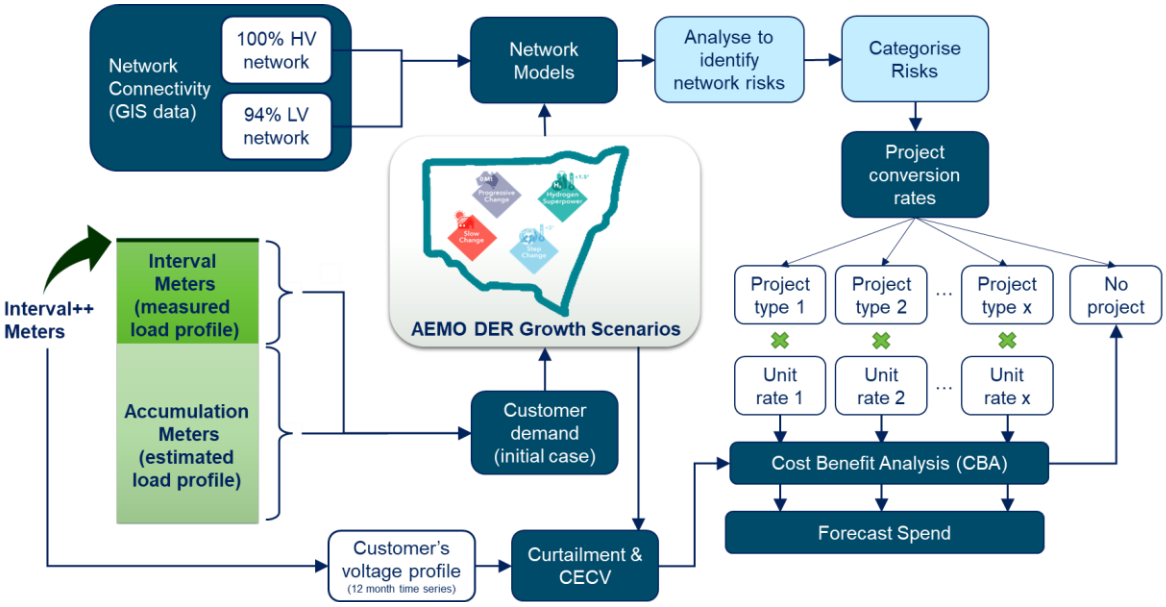


Figure 7: CER integration modelling process

2.6.1 Characteristics of CER integration modelling

CER integration modelling is quarantined from other investments

The CER integration planning process is designed to clearly discriminate between issues arising from CER uptake and issues arising from traditional customer demand growth. This is possible because a CER integration model identifies risks by directly simulating the network's electrical response to the uptake of one or more technologies. In a CER integration model:

1. The Load Information System (**LIS**) provides a 'snapshot' of current connected loads, defining the 'baseline' for the purposes of the model. At the start of a model run, all connections are assigned these baseline loads; and
2. Throughout a model run a subset of connections are selected at random and their loads are modified to mimic those of a technology adopter. Other connections retain their baseline loads.

CER integration planning is aligned to AEMOs forecast scenarios

AEMO's 2022 Integrated System Plan (**ISP**) describes four pathways to 2050:

1. **Slow Change** – slow CER uptake and insufficient energy transformation to meet the objectives of Australia's Emissions Reduction Plan;
2. **Progressive Change** – a progressive build-up of momentum leading to deep cuts in emissions across the economy from the 2040s;
3. **Step Change** – a rapid transition from fossil fuel to renewable energy with significant increase in the pace of electrification starting immediately; and
4. **Strong Electrification**[7] – rapid transition to renewable energy and electrification, with adoption of hydrogen technology.

The CER models considered these scenarios, and used the same data as the AEMO projections, supplemented with inputs from internal and commissioned studies to translate these to locational differences within the Ausgrid service area. Inputs to the CER model factor in forecasts for rooftop solar and battery technology and electric vehicles using the above scenarios. Predicted responsiveness to extension of the off-peak period proposed in the TSS Explanatory Statement is also included in the model. Existing solar installations are treated as fixed – that is

[7] AEMO has modelled a Strong Electrification case as an alternative to a Hydrogen Export scenario. Strong Electrification assumes the same emission reduction objectives, but with limited hydrogen uptake. Stronger and faster electrification of transport and heavy industry is therefore needed to achieve the economy-wide emission reductions contained in both scenarios.

assumed to not be replaced or expanded over the life of the model. Figure 8 below summarises the modelling assumptions.

CER	Fixed	Randomised
	kW / panel by customer type, generation profile	Location of new solar
	EV charger capacity by customer type	3 x charger sizes, EV charging location & charge profile (tariff effectiveness)
	kWh storage by customer type, self-consumption strategy	Location of new batteries and tariff response
	Existing customer numbers	% solar soak volume to reflect tariff changes

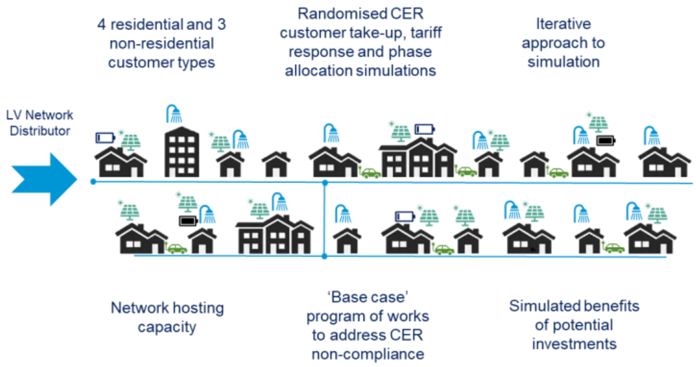


Figure 8: Applying CER forecasts at the customer level

The details of input forecast assumptions are included in Appendix B.

CER integration modelling depends on data and computational resources

CER models are possible because the network's electrical behaviour can be predicted once the loads on all connections are sufficiently forecasted.

The core of the methodology is to describe two aspects of a technology:

- How rapidly customers will adopt the technology (the uptake model); and
- How a customer who has adopted the technology will load the network (the load model).

The model then selects random samples of existing connections as technology adopters and examine the effects of their loads on the network. Multiple simulations are conducted with different NMI allocations to understand the possible range of variation.

This customer-based approach to network modelling is pioneering, and is only possible due to a previously developed stack of IT systems, in particular:

- Geographic Information Systems (**GIS**) and schematic network databases that make possible the electrical simulations; and
- The LIS, which can impute a continuous load profile for almost any connection by extrapolating from the real interval load data that is currently available.

In the CER model runs, the network was simulated only at times of maximum and minimum load, to reveal the likely range of future behaviour. This is sufficient to identify infrastructure that is at risk of overloading, and LV distributors on which the voltage will vary too widely and lead to export curtailment.

CER integration modelling allows us to quantify the impact of tariffs on customer behaviour

Historically, off-peak tariffs have been used to encourage energy use at night-time when loads are low. Using tariffs to change the timing of loads could be a cost-effective way to enhance the network's ability to support CER, by:

- Encouraging energy use at times when rooftop solar generated energy is abundant (the middle of the day) and;
- Discouraging the synchronisation of loads.

Where loads can be kept relatively uniform by 'behind the meter' behaviour changes it may be possible to avoid more costly infrastructure upgrades. The CER integration modelling methodology is based on translating models of customer behaviour into models of network electrical response. It allows the effects of tariff changes to be examined in the same framework as the effects of infrastructure upgrades.

The CER integration models compared 'solar soak' tariffs, which encourage energy consumption during daylight, to existing time-of-use-tariffs in the context of hot water heating, domestic battery charging and EV charging.

2.6.2 CER integration modelling outcomes

Future CER adoption is forecast to create network constraints by causing network voltages to rise outside of the safe design range or exceed network capacity. These affect not only customers who adopt CER technologies, but also other customers on the local network.

Figure 9 below indicates the number of customers experiencing curtailment of their rooftop solar system under each AEMO scenario if we do not proceed with our proposed CER integration investments.

The 'Step Change' scenario presents significant levels of curtailment due to the strong uptake of rooftop solar without a compensating increase in daytime loads that would follow from widespread electrification.

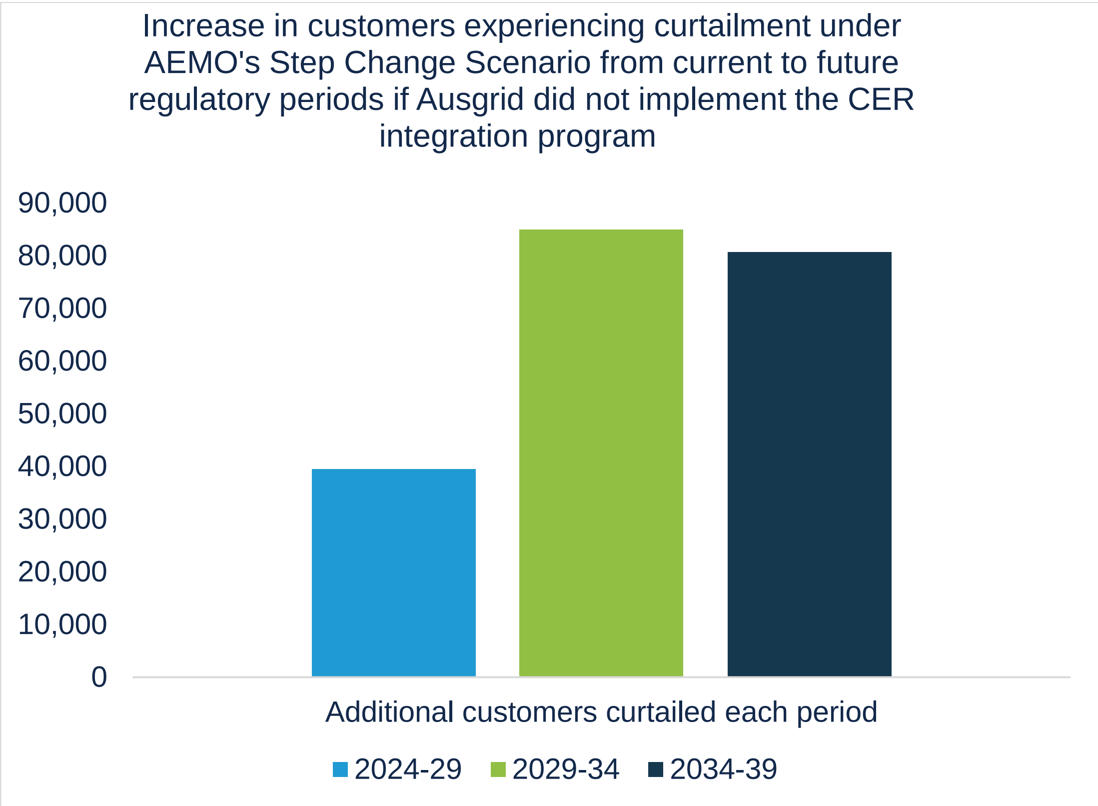


Figure 9: Increase in customers experiencing a form of curtailment under AEMO's Step Change Scenario for future regulatory periods if Ausgrid did not implement the CER integration program

Figure 10 below the number of *LV distributors* that have at least one customer experiencing curtailment. Under the Step Change scenario the number of constrained customers increases more rapidly than the number of affected LV distributors, supporting the view that the network is not homogenous. i.e. there are strong sections that can either accommodate high penetrations of CER or that have a high load density relative to the potential for CER, and relatively weaker sections that are subject to wider voltage ranges and thus higher levels of curtailment due to length, line impedance and higher penetrations of rooftop solar to load density.

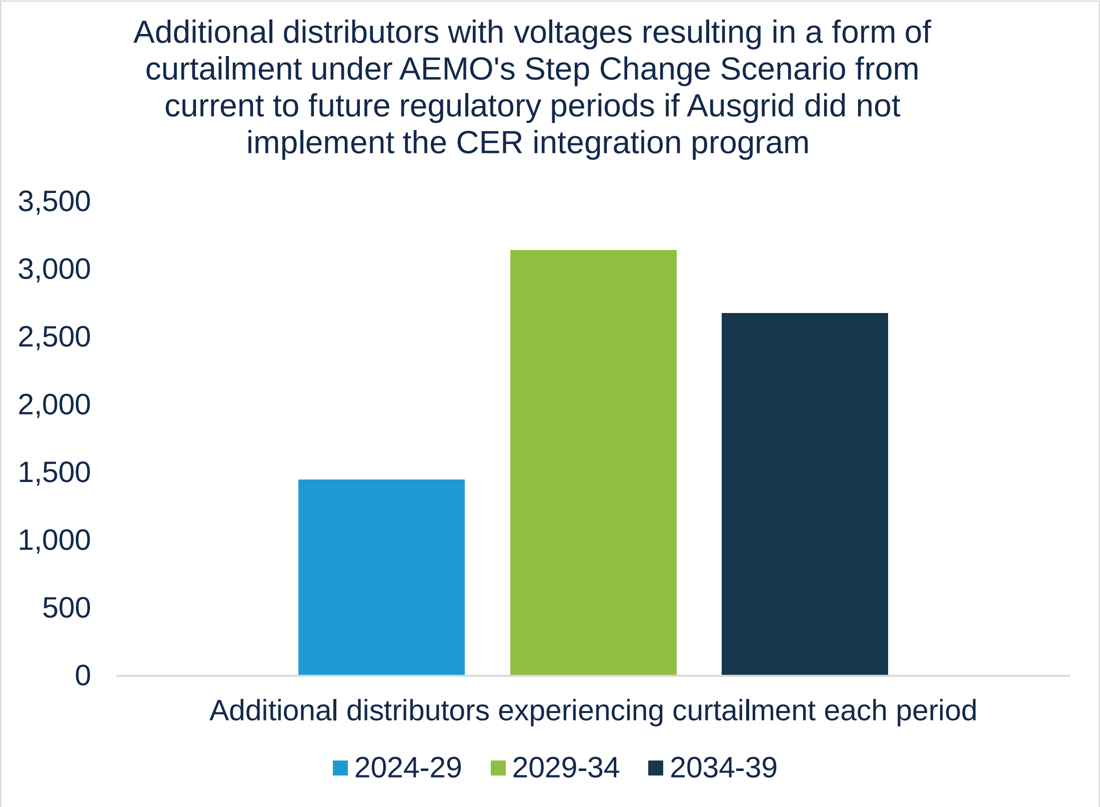


Figure 10: Additional LV distributors with voltages resulting in a form of curtailment under AEMO's Step Change Scenario for future regulatory periods if Ausgrid did not implement the CER integration program

The following table provides estimates of the annual value of curtailed energy for each scenario, the volume of curtailed energy, and the implied value per unit of the curtailed energy.

Customer curtailment export value (FY24 real $m)	2024	2029	2034	2039
Slow	3.2	2.0	1.2	0.9
Progressive	2.8	2.0	1.1	0.9
Step	3.7	2.9	2.4	2.4
Strong electrification	3.1	2.6	1.4	1.1

The CER integration modelling isolated the impacts from EV charging. The impacts relate to *LV distributor* capacity constraints which result in EV charging limitations and reduced reliability for customers. Figure 11 below indicates the number of customers supplied by LV distributors with capacity constraints initially and as a result of EV charging if we did not proceed with our proposed CER integration investments.

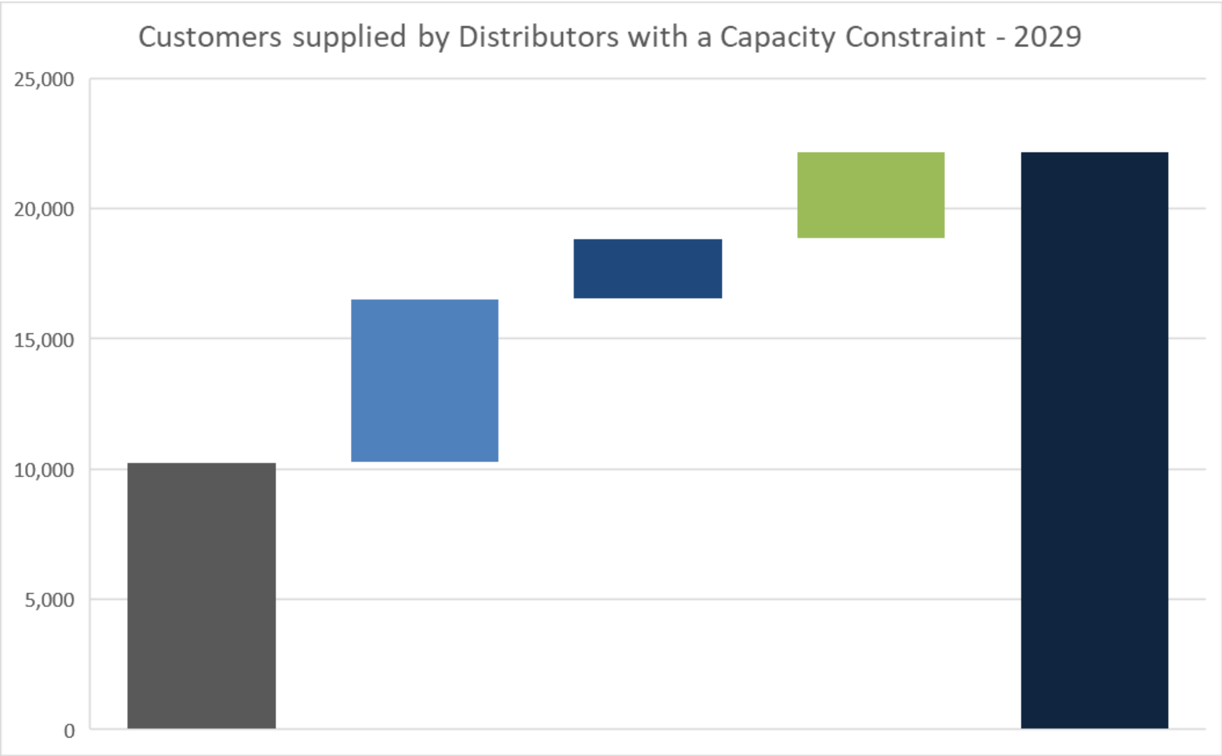


Figure 11: Number of customers impacted by constrained LV distributors by 2029

	Existing customers
	EV customers charging out of peak times
	EV customers convenience charging
	Non-EV customers impacted by EV loads
	Total customers

2.7 Ensuring no overlap between our programs

Ausgrid has implemented the necessary governance to ensure CER integration investment does not overlap or duplicate other areas of proposed expenditure. Ausgrid is proposing a CER integration program to support our net zero objective alongside climate resilience and the Network Innovation Program. The CER integration program and **CER Integration Program Brief** (**Appendix A**) outline visibility between programs. Projects driven by CER within the Network Innovation Program and Climate Resilience are not included as CER integration expenditure.

Table 3 below explains the delineation between the programs based on investment drivers, under the recommended Option 3: Proactive Investment.

The following programs are related to CER expenditure;

- **ICT:** Investment that improves capability in Ausgrid's IT systems that allows us to offer innovative services such as new connections, tariffs and better understand the impact of dynamic flows on our network;
- **Innovation:** Program investment with low maturity in understanding and experiencing benefits and challenges of a potential technology. Includes trials, pilots, research, and development; and
- **CER integration:** Program investment driven by the challenges and opportunity of CER aligned to the AER's DER Guidance Notice.

Table 3: Investment drivers and delineation between programs

Area of investment under Option 3		Included initiatives
CER and ICT **Included in CER expenditure**	• Dynamic network modelling uplift • CER connections process uplift • Network connections compliance • Closed loop voltage optimisation • DOE/Virtual Power Plant (**VPP**) integration • APIs for aggregators • Dynamic pricing	• **Improve Ausgrid's systems capability to manage complex two-way power flows and improve customer choice to incentivise and reward changes in behavior to maximise network utilisation.**
CER and Innovation **Not included in CER expenditure – See Network Innovation Program[8]**	• Feeder level load shedding capabilities • Community batteries • Grid batteries • Advanced load information system • Closed loop voltage control trials • Digital Substations • Advanced smart meter services (inc. flexible controlled load • Network state estimator • Dynamic ratings calculation system • Phasor Measurement Unit (PMU) Trials)	• **Enhancing the benefits of improved network visibility gained through CER program's smart meter data investment** • **Exploring innovative partnering and co-funding models which can make community batteries a cost-effective alternative to traditional solution in a greater proportion of cases** • **Exploring benefits of grid-scale storage aligned to those explored through community batteries** • **Modernising protection and control systems to have the flexibility to support the more dynamic behaviour of a network with a high penetration of CER** • **Network state estimator and complimentary systems which provide a near real-time view of network state, performance, and capacity, including the low voltage network – allowing topology to be optimised to improve performance under both planned and unplanned operating conditions**

LV/HV augmentation, reinforcements, tap changes and load surveys form part of 11kV and LV augmentation program, with a specific capacity driver for investment. 'HV and LV augmentation' Section 1.2 above outlines governance within these programs to ensure incidental investment that improves CER access is not included in the scope of the CER program.

ICT investment forms a foundational component of the CER integration program. We have been careful to not duplicate ICT expenditure, for either existing or proposed capabilities over the 2024-29 period. Project Edith is primarily an ICT based demonstration of dynamic network services including dynamic pricing and DOEs on a pilot scale. The pilot is limited to demonstrate the benefits of dynamic network services with DMIA funding used to simulate incentives to our aggregator partner (Reposit). Ausgrid will use results from Edith to shape the CER integration program and have used insights from in field testing to inform production system requirements.

Independently of the CER Integration program, Ausgrid is proposing an uplift of $20.2 million in network connections capability between 2024-29 as outlined in the Customer information systems (**CIS**) program brief[9]. This program targets an uplift in the core connections management process in parallel to our CER related connections investment. It includes self-service portals and information channels including SMS services. This

[8] Attachment 5.8.a Network innovation program
[9] Attachment 5.9.d Customer information systems program brief

will provide a range of improvements to Ausgrid's general connection processes which are complimentary to the CER integration initiative.

The CER integration program connection process uplift does not overlap scope with the CIS uplift as it only targets CER related connection applications, the costs, and benefits of which are delineated by separate system requirements within the Better Connect platform. While CIS upgrades will increase the level of digitalisation and user experience of CER connections, the CER program puts in place the automated network analysis and incremental improvements to support the type and volume of automated CER connections.

3. Addressing customer needs

3.1 Customer and stakeholder needs

Ausgrid has been actively engaging with customers to understand their needs in relation to the energy transition, the future ways they expect to use our network and its services. Customers have provided feedback that they are supportive of Ausgrid investing in people, process, and systems to enhance CER integration. Customers recognise the overall benefits CER offers and expect Ausgrid to offer a platform that facilitates the transition to a decentralised and low carbon economy that delivers on their net zero ambitions. Customers also recognise the transformation of the role of a network operator from transporting energy in one direction to facilitating CER integration and new market opportunities.

We have heard through customer engagement that customers have consistently been looking for:

- Improved access to the benefits of CER for customers, which include;
    - A greater choice of lower cost energy options that reduce bills, and
    - Zero emissions renewables to realise their net-zero emissions ambitions.
- A greater understanding of their role in the energy transition and opportunities to engage with Ausgrid around the choices available to them; and
- Rewards for supporting lower network costs and clean energy investments.

Our stakeholders have similar expectations.

The AER released its final DER Guidance Notice in June 2022, which outlines advice on preparing business cases to prepare for increased CER penetration. The guideline accompanies other advice from the AER, including quantification of risk-opportunity benefits reduced to customers in the event of curtailment. Curtailment takes many forms, but is a reduction in customers' use of CER, typically as a response by the customers' inverter to scale back exports. It is a response to minimise risk to all customers when the customers' CER is exceeding network design limitations including voltage or capacity. Curtailment represents a loss to society as decreased access to a lower-cost, zero emissions energy mix.

The NSW Government has set a target to cut emissions by 70% by 2035 and to achieve net zero carbon emissions by 2050 (based on 2005 levels)[10]. It expects that Ausgrid and other NSW DNSPs are prepared for increasing levels of electrification and decentralised generation.

3.2 Legislative and regulatory obligations

This CER integration program reflects the evolving regulatory and legislative obligations and requirements on Ausgrid as well as initiatives and activities led by market bodies and groups. These are detailed in the sections below.

3.6.1 National Electricity Objective

Under the National Electricity Law (**NEL**) framework, distributors are regulated to advance the National Electricity Objective (**NEO**); *'to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:*

- *price, quality, safety and reliability and security of supply of electricity*
- *the reliability, safety, and security of the national electricity system.'*

The current NEO variables of price, quality, safety, security, and reliability do not explicitly include managing CER integration. Instead, it is the impacts of managing CER on these variables that makes it relevant to advancing the NEO in the interests of customers.

[10] NSW government (2020), Net Zero Plan Stage 1: 2020-2030

In a clear statement of intent for federal and state electricity regulation Federal, state and territory energy ministers agreed to include emissions reductions in the NEO on 12 August 2022[11]. In December 2022, the Department of Climate Change, Energy, the Environment and Water released a consultation paper on the proposed legislative changes to incorporate an emissions reduction objective into the NEO.[12] Ausgrid will closely observe and participate in the process of developing the requirements to consider emissions and will adjust our CER integration program of required to align with this new NEO requirement.

3.6.2 *3.2.2 AEMC's Access and Pricing Rule Change*

On 12 August 2021, the AEMC made a final determination for the Access, pricing and incentive arrangements for distribution energy resources rule change which seeks to integrate CER such as small-scale solar and batteries more efficiently into the electricity grid[13]. The rule change places clear obligations on Ausgrid to support CER connecting to the grid including:

- Highlighting export services as a core service to be provided by DNSPs;
- Requiring that customers seeking an export connection be provided with a non-static zero export limit (unless exemptions apply);
- Requiring DNSPs to offer a basic export level in all tariffs without charge for 10 years;
- Introducing new customer safeguards to help the transition to export pricing[14];
- Plan for the provision of export services and explicitly explain the approach to CER integration; and
- Requiring Ausgrid to consult widely and test and trial options using Export Tariff Guidelines to be developed by the AER.

The rule change also requires the AER to develop and consult on a customer export curtailment value (CECV) methodology and publish CECVs annually.

3.6.3 *AER's* DER Integration Expenditure Guidance Note

On the 30 June 2022, the AER published the final guidance note for CER integration expenditure which outlines the AER's expectations for how DNSPs should develop business cases and quantify values associated with network investments for CER integration. The CER Guidance Note also complements the AER's CECV methodology and published values.

3.6.4 *ESB's Consumer Energy Resources CER Implementation Plan*

The Energy Security Board (**ESB)** has established a 3-year reform roadmap to unlock value for customers from the integration of CER and flexible demand into energy markets[15]. These reforms intend to leverage technology and data, improve access and efficiency, enhance market participation, and strengthen customer protections and engagement. Ausgrid has developed the CER integration program and in particular DSO capabilities roadmap to reflect the ESB's recommendations across various activities, taking into account reform programs such as dynamic operating envelopes (**DOEs**), flexible trading arrangements and two-sided markets.

3.6.5 *ICT Compliance Requirements*

There are additional compliance and regulatory obligations regarding Ausgrid's ICT, including those outlined in the following:

- *Security of Critical Infrastructure Act 2018 (Cth)*;

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[11] Energy Ministers' Meeting Communique, Friday 12 August 2022, https://www.energy.gov.au/sites/default/files/2022-08/Energy%20Ministers%20Meeting%20Communique%20-%2012%20August%202022.docx

[12] See: https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-energy-transformation-partnership/incorporating-emissions-reduction-objective-national-energy-objectives.

[13] See: https://www.aemc.gov.au/rule-changes/access-pricing-and-incentive-arrangements-distributed-energy-resources.

[14] Including requirements that existing solar customers cannot be put on export pricing arrangements until 1 July 2025 at the earliest (unless they elect to do so), Ausgrid to develop and have an approved export tariff transition strategy describing any plans to phase-in export pricing over time, and an increase to tariff trial thresholds to support Ausgrid to develop and trial new, innovative network tariffs.

[15] https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-electricity-market-reforms/post-2025-market-design/der-implementation-plan-design-and-implementation-process

- DNSP Licence Conditions;
- *Record Keeping in the State Records Act 1998 (NSW)*;
- *Privacy Act 1988 (Cth)*;
- NEL and NER; and
- Future market changes related to the introduction of DOEs, updating of CER technical standards and demand side participation.

These are further detailed in **Section 3.5** of the **CER Integration Program Brief (Appendix A)**.

4. Options, analysis and outcomes

This section outlines outcomes of Ausgrid's investment options analysis consistent with the AER's DER Guidance Note. A detailed analysis of evaluation methodology, explanation of each option including the base case is outlined in the **CER Integration Program Brief** (see **Appendix A**).

4.1 Proactive investment (Option 3) delivers the best results customers

Our customer engagement has signalled the need for a proactive investment approach which reduces barriers for impacted customers, including those without direct access to CER. Option 3 aligns with our vision to reduce future network investment by efficiently coordinating CER and sharing the benefits of CER across all customers. This includes customers that can invest in CER and those that cannot.

Option 3 will deliver the following benefits to customers;

- Enable customers to get the most value out of their investment in CER, with adoption expected to reach an additional 620,000 customer energy resources by 2029;
- Reduce customer curtailment by at least 85% for new and existing CER customers, maximising and sharing potential benefits with all customers by increasing a low-cost, low-carbon generation mix;
- Reduce the need for traditional network augmentation by 50% of our base case, Step Change scenario by implementing new technology solutions and dynamic services; and
- Enable our customers' net zero ambitions, including achieving a 50% reduction in our own Scope 1, 2 and 3 emissions by 2030 and net zero emissions by 2045.

Table 4 below summarises the **CER Integration Program Brief** and outlines how issues and opportunities identified in our customer engagement are addressed through corresponding Option 3 initiatives to deliver a range of benefits to customers. The **CER Integration Program Brief** outlines a more detailed analysis of forecast problems and opportunities.

Table 4: Problems, opportunities with corresponding benefits and enabling investment activities from Option 3

Problem and Opportunity	Customer benefits	Enabling investment initiative
The increased complexity of power flows on the distribution network challenges our ability to easily plan for changing customer	Improving overall visibility of power flows and changes in the way customers use the network, and our ability to respond to these.	**Smart meter data acquisition and Network Modelling Uplift.**
Ausgrid's network connection systems lack the capacity and adaptability to meet future CER connection requests. **There is evidence of low levels of compliance of Behind the Meter**	Increasing one customer's capability to invest in lower cost and lower carbon CER, so that another can have greater access to a lower cost generation mix and access the benefits of an inherently efficient grid (through improved utilisation). It will also reduce bill	**Connections uplift and compliance**

(BTM) CER to technical and network standards. **As further CER penetration grows in our network, monitoring of compliance against connection agreements will become increasingly important.**	impacts by reducing the need for additional network investment	
Current pricing and billing systems are not equipped to support the creation and implementation of more dynamic and complex network pricing structures and trialing innovative tariffs that benefit our customers. **Customers' resources are increasingly becoming aggregated into VPPs and responsive to market pricing signals. This coordinated responsiveness could exceed network capacity limits, and potentially network outages and/or the need for additional network augmentation.** **Price responsive devices within the distribution network make dynamic pricing a powerful tool for increasing network utilisation and reducing stress on the network during peak times.**	Establishing foundational technologies needed to enable new network access and pricing arrangements for active CER customers that reduce the need for traditional network investment	**Dynamic service capabilities**

Option 3's scope includes Option 2's scope, with reduced traditional network augmentation expenditure resulting from foundational ICT investments that defer network investment. These investments unlock the value of preparatory investments including improved network visibility. These investments are included in option 2 but are not realised without further investing in Ausgrid's capability to unlock the value of price responsive CER.

4.2 How customer feedback has shaped our investment proposal

'Just makes sense - allows Ausgrid to make changes if circumstances demand. They can also get ahead of the curve. It risks that there may be dead ends, but the benefits outweigh the downside'.

Customer quote from 2022 Voice of Community engagement

Customers are telling Ausgrid that they plan to invest more in CER and support a proactive approach to us enabling those investments. Ausgrid's forecasts are consistent with the AEMO scenarios, projecting almost double the current rooftop solar uptake and 320,000 additional distributed resources between 2022 and 2029. Stakeholders are responding to customers' desire for a net-zero future through policies such as the NSW Electricity Infrastructure Roadmap and 2050 Net Zero plan, to which our corporate net zero goal is aligned.

Section 2.6 outlines how uncoordinated CER can restrict customers' ability to invest in their own CER and prevent its benefits from being distributed to all customers – including deferring the need for costly, reactive network augmentation. Modelling analysis indicates 11% of customers with direct access to CER will experience curtailment before the end of 2029 if no action is taken.

'Proactive investment needs to happen, and Ausgrid is well-positioned to do it.'

Customer quote from 2022 Voice of Community engagement on investment approaches

We have heard through extensive customer engagement that customers support a $100-150 million investment to support CER adoption and reduce curtailment by 80-90% for impacted customers. This investment introduces a proactive and targeted mix of investments, with particular support for foundational ICT system investments that enable us to incentivise and reward customers to reduce the need for further network augmentation. This has shaped Ausgrid's investment strategy, directing us to prioritise analytical and pricing systems and network visibility investments above network augmentation in a prioritised investment stack. We capture our customers' identified need for a proactive approach in making these foundational investments to prepare us for increasing CER uptake.

'We need to get off coal sooner rather than later. If we are moving to net zero, we need to start here … without solar hosting, customers will not be able to choose solar power.'

Customer quote from 2022 Voice of Community engagement in relation to community batteries

Ausgrid's approach to network augmentation aligns with customer support for selective, strategic investment and is part of an optimised portfolio that delivers the greatest benefit out to 2044. The program includes a proportion of investment delivering our Community Batteries program, leveraging co-funding opportunities. Our customers support a proactive approach to community batteries and want to see more delivered. Customers see community batteries as an integral part of our CER integration business case, complementing drivers to reduce future network augmentation through new, innovative services.

4.3 Proposed pricing structures as an enabling capability

Tariffs have the potential to support the integration of CER whilst also reducing the need for network investment through managing demand and influencing customer behaviour. To increase utilisation in the network and improve cost efficiency, Ausgrid have developed a set of pricing reforms that respond to the changes and opportunities in the energy sector in the 2024-29 period, and feedback from customers and communities.

Ausgrid's proposed pricing structure will manage the demand for consumption and export services and make best use of existing network hosting capacity. It includes the following:

- **Introducing export pricing for residential and small business customers** to reflect the increasing costs that receiving CER customers' exports imposes on the network and to provide an incentive for CER customers to self-consume or time their exports to minimise these costs and maximise the benefits they receive.
- **Simplifying and updating the charging windows for demand, capacity and TOU tariffs** to make it easier for retailers to pass through Ausgrid's price signals to customers, and to ensure peak charges apply when demand on the Ausgrid network is highest.
- **Updating controlled load tariffs for residential and small business customers** to reflect changes in the times of day when demand on the network is lowest and to allow the 470,000 controlled load customers to operate their hot water systems during the day when solar energy production is highest.
- **Introducing tariffs for embedded network operators** that better reflect the costs that business customers impose on the network, so they make a fairer contribution to funding these costs.
- **Streamlining the existing tariff offerings and tariff assignment policies for customers** to make it easier for retailers to respond to or pass through Ausgrid's price signals to customers.

Further details on the current draft proposed reforms are summarised in Table 5 Proposed pricing reforms from 1 July 2024 below and discussed in detail in the Ausgrid's 2024-29 TSS.

Table 5: Proposed pricing reforms from 1 July 2024

Proposed Reform	What	Why
Export pricing transition strategy	Introduce opt-in export pricing for small customers in July 2024 and make it the default assignment for new and existing small customers on TOU and demand network tariffs from July 2025. Our proposed structure has a charge and a reward component. The proposed level of the charge is low, and we expect it to have minimal bill impacts in 2024-29.	**To create a framework that allows people, communities, and households to extract additional value out of the network. It will manage growth in these energy exports by:** • **Encouraging exports during the 4pm to 9pm periods; and** • **Empowering customers to optimise future CER investments and maximise the value they get from self-generation, improving pricing flexibility, and facilitating the transition to net zero.**
Tariff streamlining	Withdraw up to 10 network tariffs that are very similar to other tariffs or have few or no customers assigned to them.	**To simplify our tariff offerings, making it easier for retailers to understand them and pass on the price signals they send in their retail prices, improving pricing efficiency.**
Embedded network pricing	Introduce 3 tariffs for embedded networks (ENs) with medium or large annual energy usage and make them the default tariffs for new and existing ENs connected to our network from 1 July 2024.	**To better reflect the costs to serve ENs, and thus improve pricing efficiency and fairness.**
Utility scale storage tariffs	Introduce three new opt-in storage tariffs on 1 July 2024. The three tariffs differ by voltage level of connection.	**To enable large batteries and other energy storage facilities connect to our network and create a level playing field for projects located in the distribution network**
Capacity charges	Lift the lower usage threshold at which capacity charges apply from 40 MWh to 100 MWh.	**To align with the National Energy Retail Law (Adoption) Regulation 2020 (NSW)[16] definition of a small customer and improve available options in our tariff assignment process.**
Controlled load	Change the switching times for controlled load devices to allow customers to use these devices during the daytime, when solar customers are exporting to the grid.	**To help mitigate the impact of solar exports on our low voltage network during the day, improve network utilisation, and potentially reduce greenhouse gas emissions, improving pricing efficiency and supporting the transition to net zero.**
Charging windows	Move our peak period window to later in the day for customers on TOU and demand/capacity network tariffs and extend it to weekends for residential customers.	**To ensure our peak charges accurately signal the periods when these customers' energy use imposes highest**

[16] See: https://legislation.nsw.gov.au/view/whole/html/2020-08-28/sl-2020-0511#sec.4.

		costs on the network, improving pricing efficiency and fairness.

4.4 Investment option overview

This section provides an overview of investment options which could credibly deliver CER integration. Option 3, proactive investment, is the recommended option as it produces the greatest economic benefits to our customers while delivering on customers' needs to access low-cost, zero emissions energy solutions. It is supported by our customers as a proactive and efficient approach to alleviate CER curtailment for our customers to 2039. This includes $10 million in community batteries which customers support as part of a balanced program. To balance cost and service, some network constraints (where a solution is either not practical or not economically justified) remain unaddressed and will lead to customer curtailment.

Our proactive approach to CER integration, as proposed by this strategy and supported by our customers, will deliver the following customer outcomes:

- Enable customers to get the most value out of their investment in CER, with adoption expected to reach an additional 620,000 customer energy resources by 2029[17].
- Reduce costs for all customers by improving network utilisation.
- Support connection of additional rooftop solar, achieving a low-cost, low-carbon generation mix by reducing the curtailment of customer's solar output by at least 85% for new and existing CER customers.
- Reduce the cost of connecting CER by 50% compared to our base case, by implementing new technology solutions and dynamic services rather than relying solely on traditional augmentation.
- Enable our customers' and communities net zero ambitions, as well as a 50% reduction in our own scope 1, 2 and 3 emissions by 2030 and net zero emissions by 2045.

All investment options include the 2024-29 proposed pricing structure outlined in Section 4.3.

Ausgrid's CER strategies consider the investments and benefits over a period to 2039. For the purposes of informing the 2024-29 regulatory proposal, costs in the 2024-29 period have been considered in the table below, along with only the benefits resulting from those investments, consistent with the AER's DER Guidance Note.

Table 6: Investment options overview

Option	Description	CAPEX	OPEX	NPV
			(FY24 real $m)	
Option 1: Base case	• Address CER with our current capabilities and static network settings. • Most investment is through traditional network augmentation.	47.3	3.0	**-2.9**
Option 2: Preparatory investment	• Improved network visibility to manage complex power flows through better understanding of the network and optimising network investment. • Digital tools that improve the experience of connecting CER and network information available. • Customer education resources to improve customer literacy about technology, services and benefits. • Primarily traditional network augmentation where economically justified.	95.0	30.1	**48.8**

[17] In line with AEMO's ISP step change scenario.

Option 3: Proactive investment	• **Providing incentives to customers through innovative connection and pricing options to use their energy in ways that puts less pressure on the grid.** • **Improved network visibility to manage complex power flows through better understanding of the network and optimising network investment.** • **Customer education resources to improve customer literacy about technology, services and benefits.** • **Deploying a mix of traditional augmentation and flexible network solutions. This includes distribution substation tap changes, phase balancing, LV distributor augmentation, STATCOMs and community batteries.**	**89.9**	**36.2**	**169.4**

4.5 Incorporating Ausgrid's historic approach to enabling CER into investment options, including the base case

Ausgrid's CER strategy builds on a historical commitment to innovation. In the 2019-24 period Ausgrid made a modest investment in our ability to integrate CER, which was primarily driven by traditional business needs rather than focused on CER itself. In this period investment is primarily driven from the innovation program, including establishing a base level of network visibility, greater operational capability, and flexibility via an Advanced Distribution Management System (**ADMS**).

Ausgrid has been developing core capabilities through its Network Innovation Programs, delivering real changes to the way we operate the network. Table 7 outlines investment in CER enablement between 2019-2024, milestones Ausgrid has achieved, and outcomes delivered to customers. This includes detail of customer outcomes from historical investment in network visibility, dynamic pricing that will be built on during the 2024-29 period.

Table 7: Ausgrid's historical investment in CER including planned and delivered milestones up to FY24

Area of investment	Planned and delivered milestones	Customer outcomes
Customer technology integration	• VPP trials • CER Register • CoolSaver program • Enhancing our controlled load system through smart meter integration • One of the first trials in Australia of aggregator linked DOEs through Project Evolve	These programs will help reduce customer energy costs and improve the value and utility they receive from investment in their own energy resources like solar and batteries.
Network visibility	• Capability such as deployment of distribution monitoring & control (**DM&C**) devices and remotely viewable Earth Fault Indication (**EFIs**) at most kiosk substations • Acquisition of smart meter data to profile our low voltage network performance and improve our Load Information System (**LIS**) used to synthesise individual customer, LV distributor and substation load estimates	These programs will improve Ausgrid's understanding of the grid's capacity and performance, allowing us to operate more efficiently, safely and reliably. This will reduce costs for customers over the long term.

Area of investment	Planned and delivered milestones	Customer outcomes
	• Deploying IEC61850-ready zone substations to facilitate future dynamic and advanced control functionality	
Network management and control enhancement	• Advanced Distribution Management System (**ADMS**) • Trials of distribution automation schemes • New devices for voltage management such as STATCOMs and community batteries • The digitisation of our network assets to improve asset data quality and completeness	Improved network control and management capability will reduce costs for customers over the long term by improving the utilisation of existing assets, improve reliability by reducing the frequency and duration of outages, and increase our ability to host CER.
DSO capabilities - Project Edith	• Demonstration and testing of dynamic network pricing, including 5-min variable, location-dependent prices • Demonstration and testing of a subscription model for minimum DOEs for import and export levels • Demonstration and testing of a pricing and DOE engine through technology service provider, including network model, operational forecasting and constraint analysis • Development of an IEEE 2030.5 / Common Smart Inverter Profile for Australia utility server to communicate between Ausgrid, CER aggregators and the technology service provider's pricing and DOE engine.	Greater value from CER investments through greater trading opportunity. Improved choice of network access and associated tariffs Greater network access (via DOEs) compared with the static limits expected to be applied in coming years.

Ausgrid has an established Power Quality Compliance capital program which addresses compliance to AS61000.3.100 and Network Standard 238 – Supply quality. These programs are reactive programs rather than proactive and primarily address compliance where customers have initiated a complaint process with Ausgrid, and we have determined the network to be out of compliance. In recent years most of these reactive investments have targeted addressing overvoltage complaints and as such are aligned to CER integration. Although a proactive CER integration program will arrest the growth of the Power Quality Compliance capital program, it is anticipated that some reactive spend will remain efficient.

Table 8: Historic CER expenditure

	Historic CER spend components FY2018 - 22 ($'000s)				
Capex component	**2018**	**2019**	**2020**	**2021**	**2022**
DC and LV distributor augmentation and upgrades	361	456	171	369	969
DC tap change $	286	675	510	443	413
VR tap change $	75	125	150	150	200
DC + VR	361	800	660	593	613
Total CER	**722**	**1256**	**831**	**962**	**1,582**

4.6 Assessment option results

Option 3, assessed using AEMO's 'Step Change' forecast, is our recommended option as it produces the greatest economic benefits to Ausgrid's customers while delivering on customers' desire to access low-cost, zero emissions energy solutions. It is supported by customers as an efficient method to alleviate CER curtailment for customer CER export and usage out to 2044, including $9.7 million allocated to community batteries.

Table 9 below outlines the investment options outlined in 4.4 and their Net Present Value (**NPV**) over 20 years.

Table 9: Investment options overview

<table>
<tr><th colspan="4">Investment Options (FY24 real $M)</th></tr>
<tr><th>Capability</th><th>Option 1 Base Case</th><th>Option 2 Preparatory investment</th><th>Option 3 Proactive investment</th></tr>
<tr><td>Network visibility and modelling uplift</td><td>-</td><td>29.7</td><td>32.1</td></tr>
<tr><td>Dynamic service capabilities</td><td>-</td><td>-</td><td>12.1</td></tr>
<tr><td>Connections and compliance</td><td rowspan="2">3.0</td><td rowspan="2">13.9</td><td rowspan="2">13.9</td></tr>
<tr><td>Education</td></tr>
<tr><td>DER innovation projects^</td><td>-</td><td>20.9</td><td>20.9</td></tr>
<tr><td>Traditional network augmentation</td><td>47.3</td><td>60.6</td><td>27.3</td></tr>
<tr><td>Flexible technology augmentation</td><td></td><td></td><td>19.8</td></tr>
<tr><td>Total</td><td>50.3</td><td>125.0</td><td>126.1</td></tr>
<tr><td>Net Present Value</td><td>-2.9</td><td>48.8</td><td>169.4</td></tr>
</table>

Costs include all costs from FY25 to FY29, **Benefits** look at all benefits out to 2044 *from investments made out to 2029,* **NPV** = Net Present Value of Benefits minus Costs out to 2039, with costs only modelled to 2029.
^ Included in the CER integration program for visibility but expenditure allocated in the Network Innovation Program (**NIP**).

4.7 Testing sensitivities

The impact of each investment item and their ability to unlock benefits to customers is dependent on key factors that have been developed based on the best available data and information. A sensitivity analysis was performed to pressure test and further understand the risks and uncertainties associated with the inputs and assumptions underpinning the recommended option.

The rate of CER adoption was determined as a prominent input that would affect the materiality of the benefits. The analysis of costs and benefits were assessed across the various CER adoption forecasts which align to AEMO's forecast scenarios as outlined in Section 2.6.1. The costs and net present value of the investment portfolio across the CER adoption forecasts are shown in Table 10 where a decrease in CER adoption corresponds results in a decrease in both costs and net present value. Curtailment is shown to be significantly impacted by the level of CER adoption as shown in Section 2.6.2, with an increasing CER adoption rate primarily allowing for greater levels of alleviated customer curtailment and network utilisation. As such, the 'Step Change' scenario that is used in our core assessment of options is shown with the greatest economic benefit as a result of the strong uptake of rooftop solar without a compensating increase in daytime loads from electrification.

Despite the varying CER adoption rates, the net present values for the recommended option across all assessed CER adoption forecasts remain beneficial to customers. This suggests that there is minimal risk in unlocking benefits to customers if the CER adoption rates as forecasted do not eventuate.

Table 10: CER adoption forecast overview

Option 3 Proactive Investment		
CER Forecast	**Total Cost (FY24 real $m)**	**Net Present Value (FY24 $m)**
Step Change	126.1	169.4
Slow Change	107.9	114.1
Progressive Change	116.6	132.3
Strong Electrification	132.9	159.6

5. Deployment and implementation

5.1 Proposed approach

The table below outlines Ausgrid's implementation timing for ICT CER enablement under the recommended option 3. Option 3 proposes an initial investment in Ausgrid's capability to calculate and bill dynamic pricing and trial tariffs. A system scale implementation overhauling the existing billing system is forecast to occur between FY25-27. An initial investment building dynamic service capability prepares us for a larger scale implementation through the ERP and continue testing DSO services in parallel going forward.

	FY24	FY25	FY26	FY27	FY28	FY29
Network visibility and modelling uplift						
Smart meter data acquisition						
Network visibility and modelling uplift						
Connections compliance and education						
Connections process improvements and education						
Connections performance and compliance						
Dynamic service capabilities						
Dynamic pricing and DOEs[1]						
Billing engine and basic DNP						
ERP Metering Data Management and Billing (MDM/B)						

1. Includes DOEs, pricing engine and standards-based interface (aggregator APIs)

APPENDIX A:
CER Integration Program Brief

Table of Contents

1. DOCUMENT GOVERNANCE

1.1. Purpose of this document

The purpose of this document is to outline the business case and justification for the Customer Energy Resources (**CER**) Integration program that forms part of Ausgrid's 2024-29 regulatory proposal.

1.2. Compliance with AER DER integration expenditure guidance note

This document addresses the following requirements set out in the AER Distributed Energy Resources (DER) integration guidance note, within the overall context of Ausgrid's CER integration program.

Section 3 outlines the problems with integrating CER

Section 4.3 describes Ausgrid's value framework for measuring the economic benefits of CER, including identification of where the AER's CECV quantification has been applied

Section 4.5 to 4.7 sets out the base case, credible options considered, and overall costs/benefits of each credible option to identify the solution which maximises the net economic benefit across the NEM.

1.3. Related documents

Document	Author
CER integration program	**Ausgrid**
Technology Plan	**Ausgrid**
Network Innovation Program	**Ausgrid**

2. EXECUTIVE SUMMARY

Ausgrid's Customer Energy Resources (**CER**)[18] Integration Program Brief details our approach to CER integration, consistent with the Australian Energy Regulator's (**AER**) Distributed Energy Resources (**DER**) Integration Expenditure Guidance Note (**CER guidance note)**[19]. It outlines how Ausgrid has identified problems and assessed and quantified opportunities aligned with our customers' needs relating to increased forecast adoption of CER. This document evaluates 3 investment options and determines the best approach to improve access to CER and share its benefits with all customers, aligned with Ausgrid's CER integration program.

Forecast adoption of CER is expected to accelerate over the period and beyond under the Australian Energy Market Operator's (**AEMO**) 'Step Change' scenario, with 50% of customers nationwide using a form of CER by 2030. In Ausgrid's service area we are anticipating that pockets of communities will rapidly reach or pass these levels, while others will develop more slowly (due to factors like roof space and home ownership), but still achieve considerable growth over time.

Increasing volumes of CER and the changing needs of customers will lead to our network being used in more complex ways. Supporting the energy transition will require fundamental changes to how we manage our network, interact with customers, and support the stability of the end-to-end system. Ausgrid must therefore de-risk the increasing complexity and support the transformation of energy services that customers desire, while continuing to provide essential network services such as connecting customers and responding to incidents and complaints.

Ausgrid's network does not currently have sufficient hosting capacity to meet forecast levels of CER and our processes and systems are not yet set up to deal with the projected influx. Effective CER integration involves unlocking the flexibility of load and generation and moving it away from periods of high network usage and towards lower usage periods (such as the middle of the day).

This CER Integration Program Brief assesses issues, opportunities relating to CER integration on Ausgrid's network and how we can respond to provide the best outcomes for customers. The document outlines how we have identified issues specific to our network and how increasing risk impacts our customers depending on their needs, which we have understood through an extensive engagement process. We explain how we have assessed the potential benefits of de-risking the network and enabling greater access to the benefits of CER for all customers.

This document uses this methodology to evaluate 3 options to accelerate development of Ausgrid's people, processes, and systems to increase overall network utilisation and reduce curtailment. Our assessment of these three options is consistent with the AER's CER Guidance Note and the key principles of Ausgrid's CER integration program (see **Section 2.4** of the **CER integration program**) to deliver new services aligned with customer needs and wants. Each option applies a consistent method to determine costs and benefits aligned with the expectation that Ausgrid would integrate accelerating CER adoption, while balancing the costs of continuing to provide essential network services.

Table 11: Investment option assessment overview

[18] Previous public discussion of this area has used the term Distributed Energy Resources (**DER**). More recently this has evolved to Customer Energy Resources (CER).

[19] AER 2022, DER integration expenditure guidance notice

Investment option	Outline of scope (see Section 4.0 for details)	CAPEX*	OPEX*	NPV#
		(Real $m, FY24)		
Option 1: Base Case	• Integrate CER using our current business settings, including a set of assumptions around existing and proposed tariffs; • Applies traditional network augmentation as the primary means to alleviate CER curtailment. Investment activities are economically justified based on the value of alleviated forecast customer curtailment.	47.3	3.0	-2.9
Option 2: Preparatory investment	• Improves capability to manage complex power flows through visibility and understanding of the network; • Includes an uplift in digital capabilities to improve customer compliance to CER standards (this improves cost effectiveness of planning decisions in relation to CER by improving accuracy); • Includes scope for a connections uplift to improve Ausgrid's capability to connect increasing volumes and types of CER above current capability; • Does not include Dynamic Pricing or large-scale Dynamic Operating Envelopes (**DOEs**).	95.0	30.1	48.8
Option 3: Proactive investment (preferred)	• Builds on the scope of ICT improvements in Option 2 and leverages Option 2's stack of preparatory investments to deliver the highest benefit to customers by increasing utilisation of the existing grid, incentivising and rewarding coordinated CER; • Introduces dynamic service capability platform allowing Ausgrid to deliver dynamic pricing and DOEs. • Leverages Option 2's scope for improved network visibility improving the accuracy and effectiveness of dynamic services. This unlocks value not available between these initiatives on their own. • Uses dynamic services and a mixed approach to augmentation including community batteries and STATic COMpensators (**STATCOMs**) to defer a greater volume of traditional network augmentation than Option 2.	89.9	36.3	169.4

*__Costs__ include all costs from FY25 to FY29

#**Net Present Value** is calculated out to 2044

We are proposing Option 3 because:

- We understand through extensive engagement with our customers that they support a proactive approach to integrating CER (Option 3). A proactive approach to CER integration, as proposed by this strategy and supported by our customers, will deliver the best outcomes compared to Options 1 and 2. Option 3 includes a higher proportion of investment into our foundational capability to manage CER through a platform that offers new dynamic services such including DOEs and dynamic pricing;
- These capabilities align with our DSO vision and what customers have told us in offering incentives and flexible generation and load in place of traditional network augmentation. Option 3 produces less than half of the traditional augmentation of Option 2 and delivers a wider variety of flexible technology options including STATCOMs and community batteries to intelligently manage CER. In addition to enabling new and greater value areas through dynamic services, Option 3 builds on the ICT scope of Option 2 to deliver synergistic benefits not available through Option 2, such as improved visibility alone.
- While Option 2 offers some of the foundational capabilities to help Ausgrid manage and enable CER, a proactive approach to enabling dynamic service capabilities captures customer value in preparation for the influx of CER and the rapidly changing market conditions outlined in 3.1.

- It is an efficient approach that enables customers to get the most out of their CER, reduce the cost of connections by 50% compared to the case, enabling out customers' net zero ambitions and importantly, sharing these benefits with all customers including those who cannot access CER directly.

3. THE PROBLEMS WITH INTEGRATING CER

3.1. Problems with CER

The way that society produces and uses energy is rapidly changing as a response to environmental factors, increasing energy costs and the availability of new technologies. AEMO predicts that 50% of customers nationwide will use a form of CER by 2030, with further increases expected beyond then. In Ausgrid's service area, pockets of communities will rapidly reach these levels, while others will develop more slowly (due to factors like space and home ownership), but still achieve considerable growth over time.

Electrification of transport is one of the major drivers of our customer's, and the federal and NSW governments goals of achieving net zero by 2050, with urban Sydney being a key focus.[20] Load is forecast to increase with increasing electric vehicle (**EV**) uptake, and – with Ausgrid's relatively lower rooftop solar penetration compared to other DNSPs – there is less opportunity in urban Sydney and Newcastle to offset EV charging with solar generation.

These changes in energy production and usage are increasing the complexity of power flows and the operation of electrical networks. This creates challenges in both managing our network on a day-to-day basis and in forecasting future usage. Ausgrid's network does not currently have sufficient hosting capacity to meet forecast levels of CER and our processes and systems are not yet set up to deal with this influx. Network risk arises when the network exceeds its design limits or 'hosting capacity' due to growing levels of CER. This drives a cost burden for customers through network augmentation or the opportunity lost for customers by curtailing their CER at an increasing rate. Curtailment means customers who can invest in their own CER are restricted from exporting some of that energy to the grid. Customers without their own CER cannot access the shared benefits of a cheaper, renewable generation mix and greater network efficiency

Supporting the transition will require fundamental changes to how we manage our network, interact with customers, and support the stability of the end-to-end system. Without significant network investment, Ausgrid's customers will miss out on 3.7 MWh of zero emissions, lower cost energy between 2024-44 under AEMO's 'Step Change' scenario, to the value of $38.7 million (NPV). Under the 'Step Change' scenario 460,000 customers will experience a form of curtailment, 20% of whom will experience a form of curtailment for more than 50% of the year by 2039. More than 5% of all customers will experience curtailment by 2029 including a proportion who are not EV owners but will otherwise be impacted by EV customers.

[20] The NSW Government, a major shareholder in Ausgrid and the jurisdictional regulator for NSW, has set a target to cut emissions by 70% by 2035 and a goal of to achieve net zero carbon emissions by 2050 (based on 2005 levels). It expects that Ausgrid and other NSW DNSPs are prepared for increasing levels of electrification and decentralised generation.

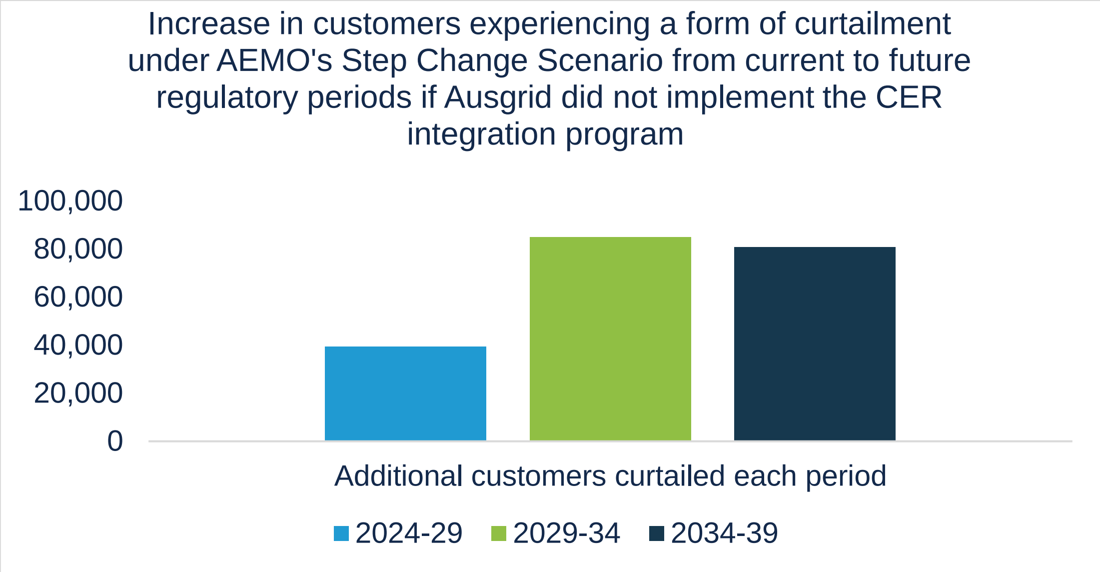


Figure 12: Increase in customers experiencing a form of curtailment under AEMO's Step Change Scenario for future regulatory periods if Ausgrid did not implement the CER integration program

Ausgrid has a non-homogeneous network topography, geography and customer base that influences both the value of CER/DER (**VaDER**) and the rate at which our customers adopt CER. This requires Ausgrid to implement a variety of responses to enable CER integration.

3.2. Background to Ausgrid's CER Integration Program

Section 1.2 of Ausgrid's CER integration program outlines various external changes related to CER penetration across our network occurring during and after the 2024-29 period. These include:

- Forecast growth in customer investment in CER (including rooftop solar, batteries and electric vehicles);
- Increased electrification of loads previously supplied by fossil fuels; and
- Development of two-sided markets by AEMO to unlock load flexibility to compliment increased intermittent renewables.

Ausgrid plans to help our customers adopt and utilise CER as they choose, while offering the best balance of cost, safety, and reliability for all customers so that CER's benefits can be shared by all. In support of this we are aligning our CER related ambitions and plans with our customers' wants including:

- Improved access to the benefits of CER for customers, such as;
  - A greater choice of lower cost energy options that reduce bills; and
  - Zero emissions renewables to realise customers' net-zero emissions ambitions.
- A greater understanding of their role in the energy transition and opportunities to engage with Ausgrid around the choices available to them; and
- Rewards for supporting lower network costs and clean energy investments.

Ausgrid's network has a non-homogeneous topography, geography and customer base that will drive different responses to CER uptake dependent on location. This includes approximately 40% of our customers living in apartments. Two significant areas of difference identified in our network over the next regulatory control period are:

- The Sydney Basin and the Hunter regions. This is because Sydney is expected to have increasing load through CER; and
- The Hunter region is likely to become a net exporter of renewable energy due to the Hunter-Central Coast Renewable Energy Zone (**REZ**).

We have recognised that it is no longer adequate for us to only offer our current network services if we are to address these changes across our network. Our CER related modelling has identified that multiple responses to

CER integration will be required to address these changes. We understand that we will need to be an active participant in the energy transformation of New South Wales, by transitioning our services and supporting various forms of CER across the network to make the market viable.

3.3. Ausgrid's CER integration program

The CER integration program outlines Ausgrid's CER vision to ***'Utilise Ausgrid's network as a platform to safely, efficiently and equitably enable CER to meet the needs of customers and stakeholders'*** to facilitate a net zero future. The strategy focuses on the accelerated development of our people, processes and systems aligned to our customers' needs.

This program brief aligns with the following principles outlined in the main strategy document.

1. Understand our customers' needs, including their role in investing in and accessing cheaper, zero-emissions generation;
2. Explore tariffs, other price signals and information enabled by greater network visibility before considering traditional network investment;
3. Reduce curtailment and resolve issues that will materially slow decarbonisation efforts;
4. Use Ausgrid's network's unique attributes as a platform to safely and cost-effectively accelerate net-zero; and
5. Share the benefits of low-cost, zero emissions CER with all customers.

Under the proposed CER Program, Ausgrid is aiming to reduce – by FY29 – future network investment by efficiently coordinating CER and sharing the benefits of CER across all customers. This objective seeks to give lasting value to those that can invest directly in CER as well as to those who cannot.

3.4. Outcomes customers want

Ausgrid's Corporate Strategy has identified key objectives that support the vision for communities to have the power in a resilient, affordable, net zero future to allow us to best consider holistic solutions across a range of customer and stakeholder needs.

Ausgrid's Voice of Community engagement for our 2024-29 regulatory reset confirmed that customers have a strong awareness of CER opportunities such as solar, batteries and EV's. Our customers told us that they have an increasing desire to be able to freely exercise choice about their CER investments, as well as saving on their bills and contributing to a reduction in carbon emissions. A key finding from our customer engagement has been that customers want improved access to these benefits for those with the means to directly access CER, but also to ensure value is unlocked for those without direct access.

3.5. Compliance requirements to be addressed by the CER program

Increased adoption of CER, the way customers use technology, and our services are driving challenges and opportunities in our cyber security and market obligations. While maintaining compliance with some of these obligations are within the scope of our current business settings, others require targeted actions. The tables below outline how different components of the CER integration expenditure program support our broader compliance and regulatory obligations.

Table 12 - Compliance Requirements with corresponding responses from the CER integration program

	Description of changes and requirements	What customers expect from us	How we are responding
CER technology changes	▪ As CER adoption accelerates the ways customers use the network and the services they expect will also change	▪ Customers support ICT capabilities that enable CER integration and promote efficient investment in the network	▪ **Proactively investing in our foundational ICT capabilities to incentivise efficient use of the network and decrease the need for traditional network augmentation**

	Description of changes and requirements	What customers expect from us	How we are responding
CER market changes	▪ Expected introduction of rules for new CER to comply with DOEs and the publication of DOEs ▪ CER technical standards expected to be updated to establish mandatory compliance for new CER (including EV charging standards) ▪ Enable a two-sided market through flexible trading arrangements, structured procurement of CER network services and publication of network visibility to improve planning decisions	▪ Customers support access to innovative approaches to managing load to increase network utilisation ▪ Affordability remains a priority for customers, and customers support more efficient use of CER and network assets	▪ Developing ICT capability to calculate and publish DOEs where most efficient and required ▪ Increasing network visibility that supports better, more accurate decisions ▪ The capability to validate CER connections compliance accurately
Security of Critical Infrastructure	▪ As we move towards an increasingly decentralised network model, the network will increasingly rely on remote network operation. ▪ Aligned to market trends offering services such as DOEs there is increasing volume and complexity of customer data stored and used in OT and ICT systems	▪ Enhanced obligations for operating critical infrastructure assets that provide critical services ▪ Strong controls, protection of personal data and the right level of data availability to support better decision making	▪ Keeping our ICT CER integration systems up to date, supported and secured

4. POTENTIAL SOLUTIONS

Three alternative options have been considered as potential solutions to address problems created by increasing CER penetration on our network. The options are outlined below and are described in further detail in the following sections.

The **Option 1** outlines Ausgrid's base case scenario, explaining how we integrate CER using our current business settings, including a set of assumptions around existing and proposed tariffs. **Options 2 and 3** assess the economic benefits to customers of direct investment in ICT capabilities and additional network visibility.

ICT enablement scope includes an improved connections process. Ausgrid's current connection systems and processes are unable to deal with the forecast influx of CER connection volumes and connection types outside of rooftop solar. Improving connection systems reduces an operational cost burden to connecting customers through automation and makes more information available to reduce the costs of connecting.

Improved network visibility improves the accuracy of planning decisions, which reduces the risk of over or under investing in the network to meet customer needs, reducing costs for all customers.

Option 3 introduces new, dynamic service capabilities including dynamic pricing and DOEs that defer the greatest volume of traditional network investment by incentivising and rewarding coordination of flexible generation and demand. Option 3 builds on the ICT scope of Option 2, leveraging improved visibility and understanding of the network to improve the effectiveness of these dynamic services. This creates additional value not available from visibility or dynamic services on their own.

Option 3 also includes a mixed approach to augmentation, including flexible technology solutions such as STATCOMs and community batteries. During our extensive engagement with our customers we heard that they want innovative approaches to enabling CER in place of traditional network augmentation. Solutions like community batteries improve hosting capacity, which allows a higher penetration of CER onto the network as well as distributing the benefits of zero emissions, cheaper solar for customers without direct access.

Options 2 and 3 include CER related scope from the Network Innovation Program. These initiatives are included in the CER Integration Expenditure Program Brief and the CER Integration Strategy for visibility. Costs are not included in proposed capital expenditure (**capex**) and operating expenditure (**opex**) of the CER program.

4.1. Defining Ausgrid's base case scenario

Ausgrid's base case scenario models how we would address customer curtailment using the current settings of our business. **Section 4.5** of the CER Integration Program outlines our historic approach to enabling CER and how this is incorporated into our investment options, including the base case. The base case includes the impact of tariffs including a solar soaking tariff based on Ausgrid's FY22 trial and forecast electrification including EV charging behaviour based on the 'Charge Together' project with Evenergi[21]. A detailed explanation of base case model assumptions is outlined in Appendix B, Section 1 of the CER integration program.

Under the base case Ausgrid would invest $47.3m in traditional network solutions. While this approach would increase network hosting capacity, enabling customer CER. It forgoes the opportunity to manage CER in a more cost effective, dynamic way that increases utilisation of our existing assets.

4.2. Overview of options

4.2.1. Option 1 – application of base case scenario

Option 1 applies and assesses the base case explained in section 4.1 above. It applies traditional network augmentation and activities as the primary means to alleviate CER curtailment, with investment activities prioritised based on the greatest economic benefit. Investment activities are economically justified based on the value of alleviation of forecast customer curtailment.

Under Option 1 Ausgrid would not progress any direct investment in ICT capabilities during the 2024-29 period to directly address problems and opportunities related to increased CER penetration in the network. This option considers alternate and manual workarounds to respond to these impacts as they occur, and to attempt to support compliance with market changes as detailed in Section 3.5.

Remaining network impacts are addressed primarily through the customer's inverter curtailing their CER's ability to export. As with all investment options, this option incorporates Ausgrid's 2024-29 pricing proposal using current limited ICT capability. Due to limited current ICT capability dynamic pricing would not be possible.

4.2.2. Option 2 – preparatory investment

This option improves capability to manage complex power flows through better understanding of the network and optimised network investment. Option 2 also includes scope for a connections and compliance uplift in CER capability. Ausgrid seeks to improve its digital capabilities to improve compliance to CER standards. More accurate identification of noncompliance is enabled by improved network visibility.

This option includes an upgrade to the connections system that can accept different types of CER applications (in addition to rooftop solar) and efficiently manage an increased volume of CER connections above current capability. This option continues the cost reflective tariff reform proposed in Ausgrid's **Pricing Directions Paper**, using limited pricing and billing system capability.

This option includes a reduced portfolio of traditional network augmentation based on deferred augmentation. Deferred augmentation is achieved through increased investment accuracy and constraint identification enabled by improved network visibility.

4.2.3. Option 3 – proactive investment

This option proposes investment in a dedicated ICT CER Program during the 2024-29 period to proactively address the impacts of CER penetration on Ausgrid's network and unlock all system value. Option 3 builds on the scope of ICT improvements in Option 2 and leverages Option 2's stack of preparatory investments to deliver the highest benefit to customers. Specifically, Option 3 utilises improved network visibility to materially improve the

[21] Arena (2021). Evenergi Charge Together Phase 2

effectiveness of dynamic pricing in managing price responsive CER and unlocks additional hosting capacity through DOEs.

These investments defer a greater volume of traditional network augmentation than Option 2 and form part of a mixed approach to augmentation including community batteries and STATCOMs. Community batteries and STATCOMs have been included consistently with the outcomes of Ausgrid's extensive customer engagement, where customers support a mixed investment approach as part of a proactive investment strategy to enabling and distributing the benefits of CER to all customers.

4.3. Assessing the benefits to CER customers

Investments within the CER enablement program are prioritised to produce the greatest benefits for customers. Ausgrid quantifies benefits using a variety of quantified risk assessment (QRA) methods that monetise benefits, so the value of an investment can be understood in the context of cost and benefits to all customers. Ausgrid's Cost-Benefit-Analysis (CBA) approach aligns to the AER's DER integration expenditure guidance note and the Ausgrid value framework[22].

Table 13 below outlines the benefit types and value streams used in our CBA modelling. The table's framework includes the Customer Export Curtailment Value (CECV), aligning to the AER's 'Final CECV methodology' guidance note released in June 2022.

In developing the CBA modelling dispatch values sourced from the AER's CER integration expenditure guidance notice has been used. These dispatch values form only part of the overall CECV value stack.

In undertaking our CBA modelling Ausgrid has included potential additional emissions reduction benefits, which is a value stream we consider to be likely capable of quantification in the 2024-29 regulatory period, following the implementation of reforms to the National Electricity Objective (**NEO**) currently under consultation.[23]. Emissions are valued using emissions intensity published in the National Greenhouse and Energy Reporting (Measurement) Determination 2008[24] by the Clean Energy Regulator and valued at $30/tCO2 aligned with industry standards.

Table 13 – Benefit types and value streams used in CER CBA modelling

Benefit type	Value stream	Estimation method
Wholesale market	Avoided marginal generator short run marginal cost (**SRMC**)	CECV methodology outlined in CER guidance note
	Avoided investment in generation capacity	Market efficiency benefits estimated based on results of the 'Economic benefits of distribution system operator investments' [25]
	Essential System Services (**ESS**) including (**FCAS**)	Calculated by Ausgrid consistent with CECV methodology outlined in DER integration note[26]
	Reduced wholesale electricity costs	Market efficiency benefits estimated based on results of the 'Economic benefits of distribution system operator investments'
Network sector	Avoided or deferred investment in transmission/distribution augmentation	Based on improved hosting capacity against the modelled base case outlined in Section 4.1.

[22] Ausgrid Value Framework is a common set of dimensions and metrics supported by our customers to inform our decisions
[23] See: https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-energy-transformation-partnership/incorporating-emissions-reduction-objective-national-energy-objectives. The Department of Climate Change, Energy, the Environment and Water's *Consultation Paper* suggests the amending Act may commence as early as 2023 (see p 3).

[24] https://www.cleanenergyregulator.gov.au/NGER/Legislation/Measurement-Determination

[25] Housten Kemp (2022), Economic benefits of distribution system operator investments
[26] AER DER integration expenditure Guidance Note, June 2022

	Avoided replacement/asset derating	No material benefit estimated
	Avoided transmission/distribution losses	CECV methodology outlined in CER guidance note
	Distribution network reliability	Estimated consistent with the value of customer reliability (**VCR**) outlined in the Ausgrid value framework.
	Public and worker safety	Estimated consistent with the value of statistical life and approach outlined in the Ausgrid value framework.
	Avoided OPEX and productivity	Estimated consistent with the method for calculating avoided opex outlined in the Ausgrid value framework.
Environment	Avoided greenhouse gas emissions	Calculated by Ausgrid, consistent with CECV methodology outlined in CER Guidance Note. Adjustment may be needed following amendment to the NEO
Customer	Customer experience	Estimated consistent with the method for calculating customer experience consistent with the Customer Information Systems Program Brief.

4.4. Approach to costing

Ausgrid has used revealed costs, market testing and peer review to ensure that costs for each option are efficient. A bottom-up methodology is used to estimate the costs for each option. Expenditure is assessed using unit rates where applicable. Unit rates are based on historical project data combined with forecast cost inputs. Typical delivery team resource requirements are estimated and where applicable, delivery partner costs and license/subscription fees.

To ensure activities specific to ICT components of the CER strategy produce the lowest cost for highest benefits, we have tested costs against industry peers directly, coordinated with software vendors and through consultants' independent cost benchmarks to ensure activities represent value for money for customers. Costs have also been benchmarked internally against the current Customer Information System (CIS) program, using actual costs from historic projects to maintain a consistent approach with the most accurate information available.

4.5. OPTION 1: Base case – Address CER with current capabilities

4.5.1. Option 1 program initiatives overview

Option one focuses on traditional network augmentation and the need for manual workarounds in place of system investment to meet our customers' future requirements.

Table 14 - Option 1 Program initiatives overview

Investment activity	Description	(FY24 Real $m)			Customer benefits
		CAPEX	OPEX	NPV	
Traditional network augmentation	Alleviate customer curtailment through the current capabilities of the business. Distribution substation tap changes, LV phase balancing, LV DC, LV distributor augmentation, upgrades, HV feeder augmentation and voltage regulation changes of a variety of scale as justified	47.3	3.0	-2.9	• Support further connection of customer CER while maintaining service levels and potentially reduces costs for all customers by increasing access to a lower-cost generation mix.

Costs include all costs from FY25 to FY29, Net present value is calculated out to 2044

4.5.2. Option 1 inputs and assumptions

The base case is aligned to the CER integration program, which explains assumptions that form inputs into CER network modelling outlined in **Annexure C** of the **CER integration program**. Assumptions and inputs include.

- Implementation of Ausgrid's 2024-29 TSS, specifically opt-in export pricing tariffs for small customers, changes to switching times for controlled load devices and peak charging windows as outlined Ausgrid's 2024-29 TSS compliance paper.
- Timings are based on the years that related market changes are forecast to occur (changes to these may require a new baseline of initiative timings for this program).
- Historical costing accurately informs investment types and volumes specific to network constraints identified because of network modelling; and
- All investments will occur in the 2024-29 period.

4.5.3. Option 1 costs

Targeted network investment focused on traditional network augmentation and activities produces the costs for option 1 as outlined in Section 4.2.1 above. Costs are calculated as historical project data combined with forecast cost inputs on a historical basis. Opex costs have been modelled for Option 1. These costs represent an increase in resourcing required to accommodate increasing volumes and complexity of CER on the existing connections platform.

Table 15 - Option 1 capital and operational expenditure

Real, $ million FY24	FY25	FY26	FY27	FY28	FY29	Total
Total capex	9.5	9.5	9.5	9.5	9.5	**47.3**
Total opex	0.2	0.3	0.6	0.8	1.1	**3.0**
Total expenditure	**9.7**	**9.8**	**10.1**	**10.3**	**10.5**	**50.3**

Totals are different to subtotals due to rounding

4.6. OPTION 2: Preparatory investment

4.6.1. Option 2 program initiatives overview

Option two adds greater investment in network visibility to apply traditional network augmentation more effectively. This option also includes improvements to the CER connection process to improve the customer experience, efficiency of the process and give greater visibility of customer compliance with CER connection requirements designed to enhance the effectiveness of CER integration.

Table 16 - Option 2 Program initiatives overview

Investment activity	Description	(Real $m, FY24) CAPEX	OPEX	NPV	Customer benefits
Network visibility and modelling uplift	Increased smart meter data acquisition. Improved capability to manage two-way power flows via network visibility. Improved network modelling and leveraging visibility to identify and alleviate localised constraints/curtailment and manage network assets for controlling min and max loads more effectively.	3.1	26.5	2.6	• Reduced costs to all customers by deferring base case network augmentation • Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customers via more accurate visibility of network constraints and the effectiveness of solutions in

					addressing these constraints.
CER Connection process uplift and compliance	Develop connection systems to enable Dynamic Connection Agreements (DCAs) for larger customers, an automated self-serve CER connections approval platform. Includes a customer portal to improve connections experience through greater access to information. Uplift digital capabilities for monitoring of compliance to CER standards in network, such as compliance with dynamic connection agreements. This initiative includes a customer education component that seeks to raise awareness of the services available to customers and potential benefits.	11.2	2.7	1.9	• Automated addition to solar connection to support new ways in which customers can use the network. • Support a greater volume of CER connection requests and improve customer experience through decreased wait times. • Improve customer connection experience, support more cost-effective connection solutions through greater access to information and resources. • Ensure value is extracted for all customers from new connection arrangements with flexible resources. • Reduced manual effort to monitor compliance with dynamic connection
Traditional network augmentation	Alleviate customer curtailment through the current capabilities of the business, which includes distribution level network augmentation and replacements. Distribution substations tap changes, LV phase balancing, LV DC, LV distributor augmentation, upgrades, HV feeder augmentation and voltage regulation changes of a variety of scale as justified	60.6	0	37.0	• Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customers by increasing access to a lower-cost generation mix.

Costs include all costs from FY25 to FY29, Net present value is calculated out to 2044

Innovation projects which support the CER integration program are set out below. CER innovation projects form part of the larger Network Innovation Program but are also accounted for in the costs and benefits of the proposed CER program.

Table 17 - Related CER Innovation Program projects

Investment activity	Description	(FY24 Real $M)			Customer benefits
		CAPEX	OPEX	NPV	
CER and Net Zero (Network Innovation Program[27])	This workstream is focused on the trialling of new, untested technology that helps integrate and support more distributed energy resources to connect to the Ausgrid network – enabling customers to	7.4	0.3	10.1	• Reduce customer energy costs and improve the value and utility they receive from investment in their own energy resources like rooftop solar and batteries. • Help achieve customers' net zero ambitions by trialling low-emission intensity devices.

[27] Attachment 5.8.a Network Innovation Program

	extract more value from their asset				
Intelligent devices (Network Innovation Program)	This workstream is focused on developing and testing new field assets that deliver safe, reliable, and sustainable energy for our customers	3.7	0.1	6.5	• Reduce costs for customers over the long term by improving the utilisation of existing assets; • Improve reliability by reducing the frequency and duration of outages; and • Increase our ability to host CER.
Intelligent systems (Network Innovation Program)	Developing technology and capability in Ausgrid to better plan, maintain and operate the network. This includes an uplift in capability to use the increasing amounts of data available to us through customer and network devices	9.0	0.4	9.8	• Reduce customer energy costs over the long term by improving Ausgrid's understanding of the grid's capacity and performance, allowing us to operate more efficiently, safely and reliably

Costs include all costs from FY25 to FY29, Net present value is calculated out to 2044

4.6.2. Option 2 inputs and assumptions

Inputs and assumptions are the same as Option 1 with the addition to the following.

- ICT investments will leverage our Big Insights Platform data and analytics, as well as integration capabilities to drive economies of scale and re-use.

4.6.3. Option 2 costs

Table 18 - Option 2 capital expenditure

Real $ million FY24	FY25	FY26	FY27	FY28	FY29	Total
Total capex	25.8	20.3	14.6	16.4	17.9	**95.0**
Total opex	4.6	6.1	6.1	6.4	6.8	**30.0**
Total expenditure	**30.4**	**26.4**	**20.7**	**22.8**	**24.7**	**125.0**

4.7. OPTION 3: Proactive investment

4.7.1. Option 3 program initiatives overview

Option three adds to Option two in terms of introduction of dynamic pricing capability via the use of DOEs, and in terms of further investment in tools to take advantage of the greater network visibility.

Customers support the implementation of community batteries as a solution to improving access to cheaper, zero-emissions renewables. This program proposes $9.8m in community batteries within the CER integration program under the supervision of the Network Innovation Advisory Council (NIAC). A NIAC supported implementation of community batteries aligns with customer expectations, facilitates policy implementation and navigates uncertainty around sources of funding. Community batteries are part of Ausgrid's mixed funding approach to community batteries, utilising a mixture of external and internal funding to deploy community storage beyond our 2019-24 trials.

Innovation projects which support the CER integration program are set out below. CER innovation projects form part of the larger Network Innovation Program but are also accounted for in the costs and benefits of the proposed CER program. The related CER Innovation Program projects for Option 3 are the same as those discussed in Table 17 above.

Key investments for 2024-29 include the following:

Table 19 - Option 3 program initiatives overview

Investment activity	Description	(FY24 Real $m) CAPEX	OPEX	NPV	Customer benefits
Network visibility and modelling uplift including multi-horizon forecasting	**From Option 2:** Increased smart meter data acquisition. Improved capability to manage two-way power flows through increased network visibility. Leveraging improved forecasting accuracy and network visibility to alleviate localised constraints/curtailment and inform asset management decisions. **Additional to Option 2:** Improved network modelling and increased capability to perform multi-horizon forecasting.	4.7	27.4	2.5	• Reduced costs to all customers by deferring base case network augmentation • Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customer through a more accurate understanding of network constraints and the effectiveness of different solutions in addressing these.
CER connection process uplift and compliance	Develop connection systems to enable DCAs for larger customers, an automated self-serve CER connections approval platform. Includes a customer portal to improve connections experience through greater access to information. Uplift digital capabilities for monitoring of compliance to CER standards in network, such as compliance with dynamic connection agreements. This initiative includes a customer education component that seeks to raise awareness of the services available to customers and potential benefits.	11.2	2.7	1.9	• Automated approach in addition to solar connection to support new ways in which customers can use the network. • Support a greater volume of CER connection requests and improve customer experience through decreased wait times. • Improve customer connection experience, support more accurate and cost-effective connection solutions through greater access to information and connection resources. • Ensure value is extracted for all customers from new connection arrangements with flexible resources. • Reduced manual intervention to monitor compliance with dynamic connection
Dynamic service capabilities Prior to Enterprise Resources Planning (ERP) platform Metering Data Management and Billing improvements	**Additional to Option 2:** Enable dynamic pricing capability to be added to our billing system to unlock the value of price responsive CER in our network. Upgrades to the billing system are within the scope of this initiative, beginning from FY23. These upgrades support tariff demonstrations, dynamic pricing capability to bill retailers for these innovative tariff	6.7	5.4	119.1	• Improve unit cost of energy through increasing network utilisation and managing peaks. • Allow behind the meter optimisation of CER in lieu of direct market intervention (i.e., setting export levels at the connection point rather than directly turning off solar). • Maintaining network reliability in an increasing complex and two-way system

<table>
<tr><th rowspan="2">Investment activity</th><th rowspan="2">Description</th><th colspan="3">(FY24 Real $m)</th><th rowspan="2">Customer benefits</th></tr>
<tr><th>CAPEX</th><th>OPEX</th><th>NPV</th></tr>
<tr><td>(benefits of billing upgrade not considered within this period)</td><td>structures prior to Ausgrid's 2024-29 ERP upgrade.
Develops VPP/DOE platforms and integrates these with ADMS to support control systems to dynamically manage the network.
Enables standardised and interoperable APIs for Dynamic Operating Envelopes (DOEs) and streamlining coordination with aggregators.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Traditional network augmentation and STATic COMpensators (STATCOMs)</td><td>Distribution substation tap changes, LV phase balancing, LV DC, LV distributor augmentation, upgrades, HV feeder augmentation and voltage regulation changes of a variety of scale as justified.

Additional to Option 2:
STATCOMs as part of a mixed approach to augmentation following successful STATCOM trials between FY19-24.</td><td>37.3</td><td>0</td><td rowspan="2">44.6</td><td>• Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customers by increasing access to a lower-cost generation mix.
• Maintains service levels and potentially reduces costs for all customers by increasing access to a lower-cost generation mix.</td></tr>
<tr><td>Community batteries</td><td>Additional to Option 2:
Following FY19-24 trials install community batteries to improve hosting capacity and deliver community benefit. Locations prioritised based on locations with highest benefit.</td><td>9.8</td><td>0</td><td>• Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customers by increasing access to a lower-cost generation mix.
• Enable improved customer access to energy storage, solar soaking capability and related tariffs outlined in the Ausgrid Pricing Directions Paper</td></tr>
</table>

Costs include all costs from FY25 to FY29, Net present value is calculated out to 2044

Further information on investment timings is detailed in Section 8.

4.7.2. Option 3 inputs and assumptions

Inputs and assumptions include the following in addition to Option 2:

- The Billing and Pricing initiative will occur in alignment and considering delivery risk and interdependencies with the Meter Data Management and Billing (**MDM/B**) program; and
- Timings are based on the years that related market changes are forecast to occur (changes to these may require a new baseline of initiative timings for this program).

4.7.3. Option 3 costs

Table 20 - Option 3 capital expenditure

Real $ million FY24	FY25	FY26	FY27	FY28	FY29	Total
Total CAPEX	26.3	19.8	13.2	14.8	15.7	**89.9**
Total OPEX	5.0	7.2	7.7	7.9	8.4	**36.2**
Total expenditure	**31.3**	**27.0**	**20.9**	**22.8**	**24.1**	**126.1**

4.8. Options overview and value comparison

Table 21 - Overview of investment options including NPV comparisons

Option	Description	CAPEX (FY24 real $m)	OPEX (FY24 real $m)	NPV (FY24 real $m)
Option 1: Base case Address CER with current capabilities	This option does not include any direct investment in ICT capabilities to address problems and opportunities related to increased CER penetration in the network during the 2024-29 period. Traditional network augmentation is the primary response to CER impacts. This option leverages existing investment in CER capability outlined in the CER integration program Section 4.5. This include Ausgrid's proposed pricing structure, which reflects price reflective tariff reform within the limitations of existing billing and pricing capability.	47.3	3.0	**-2.9**
Option 2: Preparatory investment CER enablement through improved network visibility and connections experience	Improve capability to manage complex power flows through better understanding of the network and optimising network investment. Improve connections process to cater for a higher volume, greater variety of CER and improve information shared to support customer connections. Continue cost reflective tariff reform using limited existing pricing and billing system capability. Remaining investment is through traditional network augmentation. Key initiatives for 2024-29 include: • Improved network visibility through increased smart meter data acquisition • Operational network modelling • Connections process improvements, connections performance and compliance • Customer education resources. • Traditional network augmentation activities including distribution substation tap changes, LV phase balancing, LV DC and LV distributor augmentation and upgrades and HV feeder augmentation & voltage regulation changes of a variety of scale as justified. Activities are prioritised based on greatest quantified alleviation benefit.	95.0	30.1	**48.8**
Option 3: Proactive investment (Preferred) Deferred network investment through improved visibility and dynamic pricing capability	**This option proposes investment in a dedicated ICT CER Integration Program during the 2024-29 regulatory control period to proactively unlock all system value. Option 3 includes ICT improvements outlined in Option 2 with additional investment in capability to manage complex power flows through DOEs and incentives as aligned the CER integration program.** **This enables us to remain compliant with current and upcoming CER-related market changes, offer new incentive based services aligned to our customers' needs and in doing so reduce the need for traditional network investment.**	**89.9**	**36.2**	**169.4**

Option	Description	CAPEX (FY24 real $m)	OPEX	NPV
	Key initiatives for 2024-29 include: • **Dynamic service capabilities in addition to our existing service offering, including dynamic pricing and DOE capabilities.** • **Improved network visibility through increased smart meter data acquisition** • **Operational network modelling and an uplift in multi-horizon forecasting capability** • **Connections process improvements, connections performance and compliance** • **Customer education resources.** • **A mixed investment approach to network augmentation including community batteries and STATCOMs; and** • **Traditional network augmentation activities including distribution substation tap changes, LV phase balancing, LV DC and LV distributor augmentation and upgrades and HV feeder augmentation & voltage regulation changes of a variety of scale as justified.**			

5. RECOMMENDATION

5.1. Recommended solution

Option 3: Proactive investment is the preferred option.

- Option 3 has the strongest NPV benefits relative to investment (See Table 21).
- Option 3 is consistent with the requirements of the NEO and is supported by customers as an outcome of extensive customer engagement. Customers have indicated support for a proactive approach to CER investment that reduces barriers to CER and its shared benefits with all customers.
- This includes support for a mixed approach to network investment that includes dynamic network technology, including a proportion of STATCOMs and Community batteries (Refer to Attachment 3.3.a).

Investment Options 1 and 2 are not recommended as they exhibit lower NPVs than Option 3 and do not align to customer engagement outcomes indicating support for a mixed approach to network augmentation (which includes community batteries).

5.2. Overview of preferred option – proactive investment

The investment options outlined in this section align with the CER Integration Program. We recommend Option 3 for the 2024-29 regulatory control period. This option aligns with our customer engagement, signalling the need for a proactive investment approach that reduces the barriers for impacted customers, including those without direct access to CER.

Option 3 produces the highest net economic benefit based on quantitative analysis. This is compared to Option 1 (Base case), which alleviates customer curtailment using the current business settings, relying on traditional augmentation.

Options 2 and 3 assess the economic benefits to customers of direct investment in ICT capabilities and improved network visibility. Option 3's ICT capability produces a higher NPV than Option 2. As outlined in Figure 13, Option 3 builds on the ICT scope of Option 2 but delivers a new value stream by building a dynamic service capability platform that includes dynamic pricing and DOEs. In addition to this new value stream, dynamic service capabilities produce synergistic benefits with improved visibility included in Option 2, unlocking the full value stack not available in option 2. Dynamic services and the introduction of flexible technology solutions such as STATCOMs and community batteries defer the greatest amount of traditional network augmentation between the options.

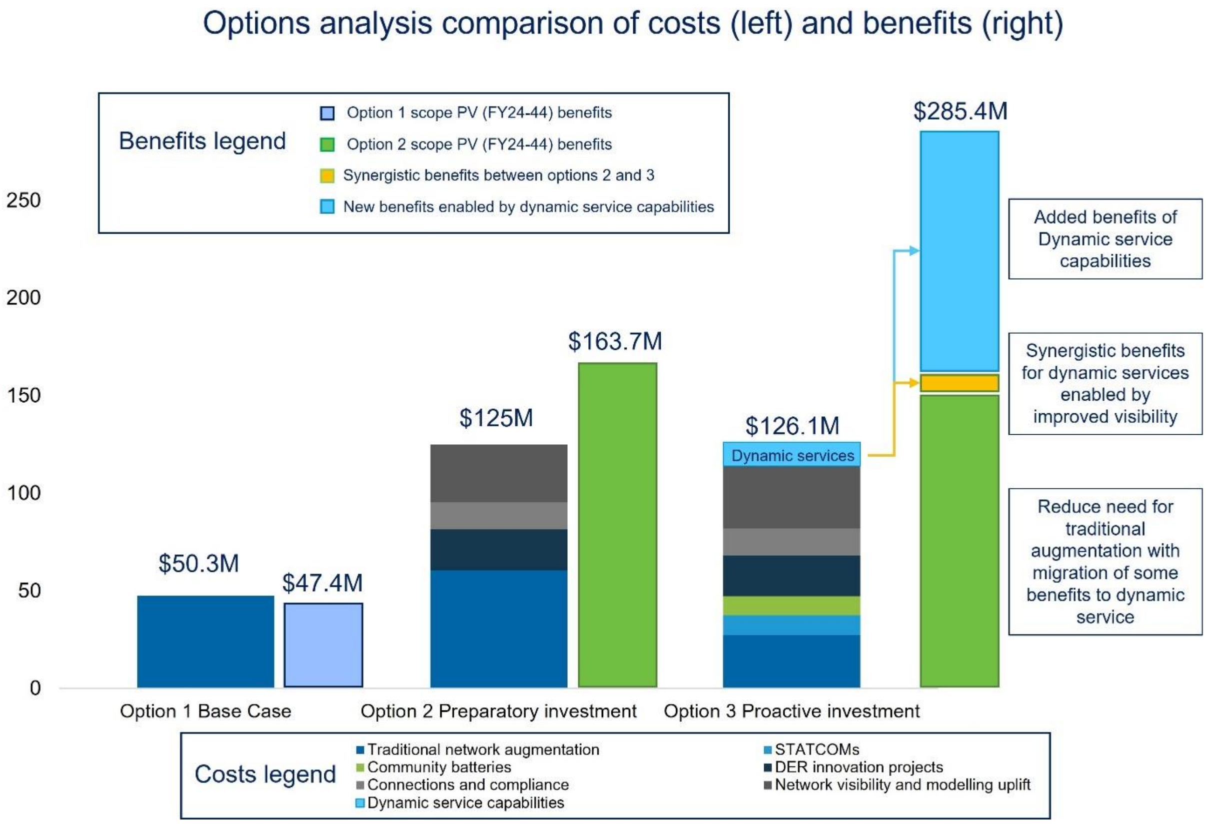


Figure 13: Option 3 costs and benefits

Without significant network investment, Ausgrid's customers will miss out on 3.7MWhs of zero emissions and lower cost energy to the value of $38.7m NPV Customer Export Curtailment Value (CECV[28]) between 2024-44 under the AEMO 'Step Change' scenario.

Option 3 produces system and process capabilities not featured in Options 1 and 2 that are required to reduce the likelihood of reactive, inaccurate network augmentation to improve network hosting capacity.

Option 3 seeks to address the following risks:

[28] AER (2022), Customer Export Curtailment Value methodology

- Increased labour costs associated with complying with market changes – because additional manual effort would be required to maintain or adjust existing business-as-usual processes to manage load control tariffs;
- Increased voltage complaints would occur as CER-related network events increase;
- Reliability may be impacted as VPPs become price responsive;
- Increased labour costs associated with manual effort in the absence of APIs with aggregators, needed to share data and communicate with aggregators;
- The inability to produce accurate dynamic pricing would still exist, as it is too complex for manual intervention; and
- There would be less targeted improvements on the augmentation of the network, forgoing opportunities could positively impact pricing for customers.

5.3. Overview of the problems and opportunities Option 3 addresses

The table below explains how Option 3's investment activities address forecast problems and opportunities in meeting our future customers' needs. For an assessment of benefits for each activity, refer between sections 4.5 and 4.7.

Table 22: Option 3 proposes a variety of investment activities to address problems and opportunities of increasing CER adoption.

Problem/Opportunity	Proposed Option 3 investment activity	Customer Benefits
Problem: Inadequate network visibility decreases our ability to accurately confirm and act on an identified constraint and identify new constraints and low levels of Behind the Meter (**BTM**) compliance. The increased complexity of power flows on the distribution network challenges the ability for us to easily plan for changing customer needs and in maintaining network reliability. These limit Ausgrid's ability to plan for and solve network solutions with flexible demand replacing or deferring network upgrades. More costly reactive, costly upgrades are needed, and CER curtailment is increased. **Opportunity:** Customers support improved ability to identify constraints and manage the network. Increased network visibility improves hosting capability and investment efficiency, with the ability to 'right size' network investments by increasing accuracy of inputs to network modelling and forecasting. More sophisticated and dynamic network modelling will release greater headroom for CER.	Increased smart meter data acquisition. Improved capability to manage two-way power flows through increased network visibility. Improved network modelling and increased capability to perform multi-horizon forecasting. Leveraging improved forecasting accuracy and network visibility to alleviate localised constraints/curtailment and inform asset management decisions.	Reduced costs to all customers by deferring base case network augmentation. Support further connection of customer CER while maintaining service levels and potentially reducing costs for all customer through a more accurate understanding of network constraints and the effectiveness of different solutions in addressing these.
Problem: Ausgrid's network connection systems lack the capacity and adaptability to meet future CER connection requests. The current system is limited to approx. 45,000 CER connections per annum without exponential operational investment and only able to manage solar and storage requests. Large customers in particular have very poor visibility of network hosting capacity and other information to assist their energy choices resulting in longer application times and increased costs. There is evidence of low levels of compliance of Behind the Meter (BTM) CER to technical and network standards. As further CER penetration grows in our network, monitoring of	Develop connection systems to enable DCAs for larger customers, an automated self-serve CER connections approval platform. Includes a customer portal to improve connections experience through greater access to information. Uplift digital capabilities for monitoring of compliance to CER standards in network, such as compliance with dynamic connection agreements. This initiative includes a customer education. It aims to improve customer	Automated approach in addition to solar connection to support new ways in which customers can use the network. Support a greater volume of CER connection requests and improve customer experience through decreased wait times. Improve customer connection experience, support more accurate and cost-effective

Problem/Opportunity	Proposed Option 3 investment activity	Customer Benefits
compliance against connection agreements will become increasingly important. Particularly once control is taken over by customer agents (e.g., hot water load control moving from ripple system to smart meter contact) and complexity of agreements increases (e.g., dynamic connections established with batteries). This will require more automated capture of this information to avoid manual intervention. Customer engagement indicates customers have different abilities to find, access and understand the impact of their energy choices and the solutions available to them. This limits customer access to CER, potential rewards, and incentives available to them. **Opportunity:** An automated and expanded customer experience with greater access to information improves customer experience and sets up a scalable process able to meet increasingly complex requirements. By making improvements in compliance and/or understanding the degree of non-compliance, significant hosting capacity can be unlocked without requiring additional network investment. This provides significant value to customers in the long term by reducing forecast network investment. Our customers support enhanced community engagement and communication. There is an opportunity to provide clear explanations of the factors that impact customer usage and cost.	literacy around energy customer choices, supporting choices that remove barriers to accessing the benefits of CER. Targets apartment residents, customers without direct access to CER, technology choices available, right-sizing investments and raising awareness around benefits including pricing options.	connection solutions through greater access to information and connection resources. Ensure value is extracted for all customers from new connection arrangements with flexible resources. Reduced manual intervention to monitor compliance with dynamic connection
Problem: Current pricing and billing systems are not equipped to support the creation and implementation of more dynamic and complex network pricing structures and trialing innovative tariffs that benefit our customers. Active CER on the distribution network introduces challenges for effectively managing power flows. This is expected to increase in complexity with higher penetration levels of active CER, and as these devices become responsive to price signals that increasingly reflect Time of Use (ToU). This could have both negative impacts on network reliability and add to overall network costs for customers, particularly for those who do not have CER. Customers' resources are increasingly becoming aggregated into VPPs and responsive to market pricing signals. This coordinated responsiveness could exceed network capacity	Enable dynamic pricing capability to be added to our billing system to unlock the value of price responsive CER in our network. Upgrades to the billing system are within the scope of this initiative, beginning from FY23. These upgrades support tariff demonstrations, dynamic pricing capability to bill retailers for these innovative tariff structures prior to Ausgrid's 2024-29 ERP upgrade. Develops VPP/DOE platforms and integrates these with ADMS to support	Improve unit cost of energy through increasing network utilisation and managing peaks. Allow behind the meter optimisation of CER in lieu of direct market intervention (i.e., setting export levels at the connection point rather than directly turning off solar).

Problem/Opportunity	Proposed Option 3 investment activity	Customer Benefits
limits, and potentially network outages and/or the need for additional network augmentation. **Opportunity:** High degrees of industry and policy alignment on the value of DOEs, and changing distribution network constraints in VPP operation, create an opportune time to increase our integration capabilities across DOE/VPP to help prepare for this future. Price responsive devices within the distribution network make dynamic pricing a powerful tool for increasing network utilisation and reducing stress on the network during peak times. Through signaling network constraints to operators of these VPPs in a standardised and easily digestible way, they can more easily operate customer resources with fewer issues.	control systems to dynamically manage the network. Enables standardised and interoperable APIs for DOEs and streamlining coordination with aggregators.	Maintaining network reliability in an increasing complex and two-way system
Problem: Solar exports cause network voltages to rise and when they rise sufficiently high, customers' solar inverters trip off and stop generating for both in-home consumption and for exports. Customers are limited in the size and type of CER they install, accepted on a first come first serve basis. There is a forecast increase in curtailment for those with CER installed. **Opportunity:** A proactive approach to alleviating customer curtailment reduces the risk of costly, reactive augmentation to address network constraints Customers support a proactive approach to enabling CER and reduce barriers of access to CER. Dynamic network devices including Community batteries offer solutions to network constraints and deliver additional community benefits over network augmentation. While all customers benefit from enabled CER by improving access to a cheaper, net-zero generation mix, many customers do not have the capability to directly invest in CER	Distribution substation tap changes, LV phase balancing, LV DC, distributor augmentation, upgrades, HV feeder augmentation and voltage regulation changes of a variety of scale as justified. STATCOMs and community batteries are part of a mixed approach to augmentation following successful STATCOM trials between FY19-24.	Support further connection of customer CER while maintaining service levels and potentially to reduce costs for all customers by increasing access to a lower-cost generation mix. Maintains service levels and potentially reduces costs for all customers by increasing access to a lower-cost generation mix.

6. RISKS AND ASSUMPTIONS

This section outlines risks and assumptions relating to the CER Integration Program. Risks are relating to delivery of benefits to customers, the program itself and what plans Ausgrid has put in place to mitigate the impacts of each risk,

6.1. Integration Program risks

Table 23 - Summary of program risks

#	Risk Category	Description	Inherent Risk Level	Mitigation Plan	Residual Risk level
01	Costs /Timing	Delays parallel ICT delivery including the MDM/B program and/or ADMS impacting dependent initiatives	Medium	Manage dependencies closely through steering committee and re-baseline alternate scheduling options to minimise resource and cost impacts should a delay in the dependent programs occur.	**Low**
02	Costs /Timing	Delays or early progression of dependent market changes may impact the timing of relevant initiatives in this program	Medium	Manage dependencies closely through steering committee and re-baseline alternate scheduling options to minimise resource and cost impacts should a delay in the dependent programs occur.	**Low**
03	Key resources	Due to the extensive use of flexible technologies and their application to the energy network environment skilled and capable resources may be difficult to obtain and/or retain.	Medium	Early engagement across a variety of projects with a range of lifecycle stages to ensure continuity of key resources and enable the establishment of longer-term skills within Ausgrid and relationships with key partners.	**Low**
04	Benefits realisation	Forecast adoption of the volume and types of CER does not align with AEMO forecasts analysed through modelling. Does not deliver on the opportunities that CER can deliver to customers and/or presents increased cost burden to customers through overinvestment.	Medium	Manage program governance to prioritise initiatives that provide the highest value to customers. Continue to refine forecasts as new information becomes available and re-assess solutions to deliver highest benefit.	**Low**
05	Benefits realisation	Customers and their representatives do not respond to incentives and new service offerings as forecast in Ausgrid's CER integration models, not delivering forecast benefits of investment in new dynamic	Medium	Ensure we continue to test price responsive in the market and refine the effectiveness of incentives. Customer education to inform them of the types of services available to them and their benefits.	**Low**

#	Risk Category	Description	Inherent Risk Level	Mitigation Plan	Residual Risk level
		services including dynamic pricing.		Continue to test sensitivity in the CBA model to determine how to scale system-based capabilities in line with adoption.	
06	Benefits realisation	Network augmentation does not address forecast network constraints as intended.	Medium	Manage program governance to prioritise initiatives that provide the highest value to customers. Continue to refine forecasts as new information becomes available and re-assess solutions to deliver highest benefit.	**Low**
07	Costs	Project Costs are estimated based on unit rates, historical project costs and market analysis in FY23. Costs could increase due to a variety of internal and external factors.	Medium	Develop a Gate 3 Business Case prior to executing the program and revise costs with costs at the time of execution.	**Low**
08	Partner Selection	The selection of appropriate partners to provide a balance of agility and financial stability to avoid abandoned investments	Medium	Careful selection of partners that have sufficient customer base or commitments and/or short engagements to enable continuity of agile and skilled project delivery or advice despite a changing and competitive energy landscape.	**Low**

6.2. Program assumptions

Table 24 - Summary of program assumptions

#	Type	Description
01	Resourcing	Analytics and integration resources will be available as required during the CER Program and for ongoing operations.
02	Resourcing	Asset scoping, design and delivery resources will be available as required during the CER Program and for ongoing operations.
03	Prioritisation	Due to the impacts on customer choice and flexibility this program will be prioritised accordingly.
04	Scope	The scope of this program includes initiatives detailed in Section 4.
05	Timing	Timing of the program initiatives have been based on forecast CER penetration during 2024-29 period, known market changes and dependencies with other major ICT initiatives such as ADMS, and the MDM/B program which impacts the Pricing and Billing stream for this program.

6.3. Program dependencies

Table 25 - Summary of program dependencies

#	Type	Description
01	ERP	The Dynamic Pricing and Billing initiative is dependent on the timing and solution selected for the MDM/B program.
02	ICT Infrastructure	The Develop ICT for VPP/DOE Integration initiative is dependent on integration with our new ADMS.
03	Market Changes	All initiatives in this program are dependent on market changes detailed in Section 3.5.
04	Planning Tools	Network analysis and issue of CER field projects will be dependent on development of analysis and planning tools.
05	Resource Strategy	Design and delivery of field equipment component of this program is dependent on the Delivery Plan and Resource Strategy

6.4. Business area impacts

Table 26 - Summary of business area impacts

#	Type	Description
01	All Ausgrid	Where possible the program initiatives will be managed with go-live dates that minimise the amount of (or any) disruption to business operations due to technology transition downtimes (e.g., planned out of hours etc.)
02	Specific Groups / Functions	Any ICT asset upgrade or change requires appropriate ICT Change Management processes to be followed. Impact to customer facing services or employees will be scheduled optimally to minimise impact and risk of unplanned outages.
03	Specific Groups / Functions	Any new field technology / devices to be installed requires appropriate Change Management processes to be followed. Impact to delivery groups will be prioritised and scheduled optimally to minimise impact and risk to delivery of overall capital and maintenance programs

7. GLOSSARY

Shortened Form	Extended Form
ADMS	Advanced Distribution Management System
Capex	Capital Expenditure
CER	Customer Energy Resources
DCA	Dynamic Connection Agreements
DER	Distributed Energy Resources
FY25-29	Financial Year 2025 to Financial Year 2029
GIS	Geographic Information Systems
ICT	Information and Communications Technology
MDM/B	Meter Data Management and Billing
NEO	National Electricity Objective
NER	National Electricity Rules
NPV	Net Present Value
Opex	Operating Expenditure
SaaS	Software-as-a-Service

8. OPTION 3 ICT INVESTMENT TIMING

The table below outlines Ausgrid's implementation timing for ICT CER enablement under the recommended option 3. Option 3 proposes an initial investment in Ausgrid's capability to calculate and bill dynamic pricing and trial tariffs. A system scale implementation overhauling the existing billing system is forecast to occur between FY25-27. An initial investment building dynamic service capability prepares us for a larger scale implementation through the ERP and continue testing DSO services in parallel going forward.

	FY24	FY25	FY26	FY27	FY28	FY29
Network visibility and modelling uplift						
Smart meter data acquisition						
Network visibility and modelling uplift						
Connections compliance and education						
Connections process improvements and education						
Connections performance and compliance						
Dynamic service capabilities						
Dynamic pricing and DOEs[1]						
Billing engine and basic DNP						
ERP Metering Data Management and Billing (MDM/B)						

2. Includes DOEs, pricing engine and standards-based interface (aggregator APIs)

Appendix B

Forecasting approach and modelling methodology

APPENDIX B - Forecasting approach and modelling methodology

1. CER integration models

To develop the uptake and load models for the CER technologies, each customer has been classified into seven strata based on their annual electricity consumption:

- Res apartment
- Res S
- Res M
- Res L
- Business S
- Business M
- Business L.

1.1 OPHW 'Solar soak' tariffs

This model investigates how a "behind the meter" change could be encouraged to transfer controlled loads for hot water heating from night-time to the middle of the day when solar generation is at its peak.

It is based on a 'solar soak' controlled load tariff, which is a modification of our existing OP1 tariff, based on trials undertaken in FY2022. The tariff reduces the price of electricity in the middle of the day. All customers with a smart meter (not just those with a rooftop solar installation) are eligible for this tariff.

It is assumed half of current OP1 customers would adopt the new tariff when introduced. Remaining customers will transition gradually as ripple and time clocks are replaced with smart meters, and retailers respond to the new opportunities.

	2024	2029	2034	2039
Slow change	50%	50%	75%	80%
Progressive change	50%	50%	65%	75%
Step change	50%	65%	85%	100%
Strong electrification	50%	75%	100%	100%

Proportion of electric hot-water customers who have adopted the solar soak tariff each model year under

The model assigns three standard hot water loads to each customer strata, representing summer, winter, and shoulder seasons.

1.2 Rooftop solar and batteries

These models examine the uptake of rooftop solar installations both with and without batteries. The effects of tariffs are considered against different models of customer charging behaviour. Under time of use tariffs, customers with their own rooftop solar combined with a battery storage system are incentivised to:

- Charge their battery from their solar systems (this is further incentivised by export tariffs) and overnight at cheaper rates,
- Ensure their batteries are fully charged just prior to the peak period
- Run their household loads off their solar and battery as much as possible to avoid paying for electricity from the grid at peak prices.

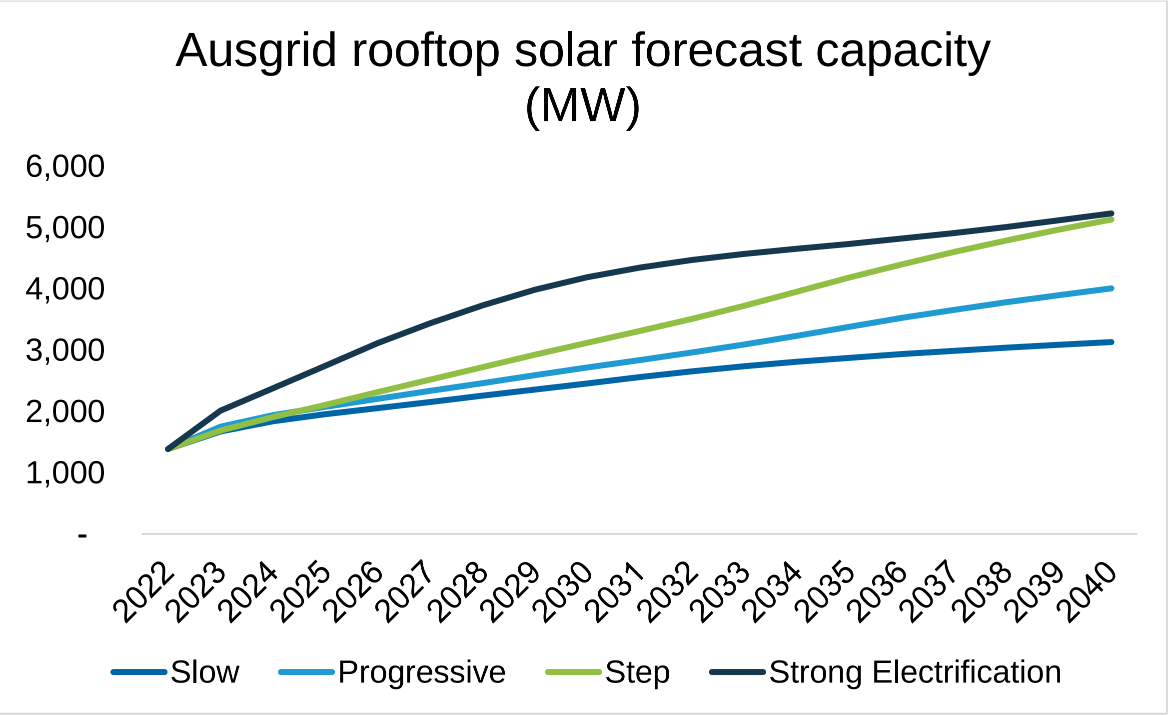
The number of current rooftop solar installations is established by counting customer accounts with feed-in tariffs. During the agent-based network simulations these customers are not eligible to be selected as technology adopters.

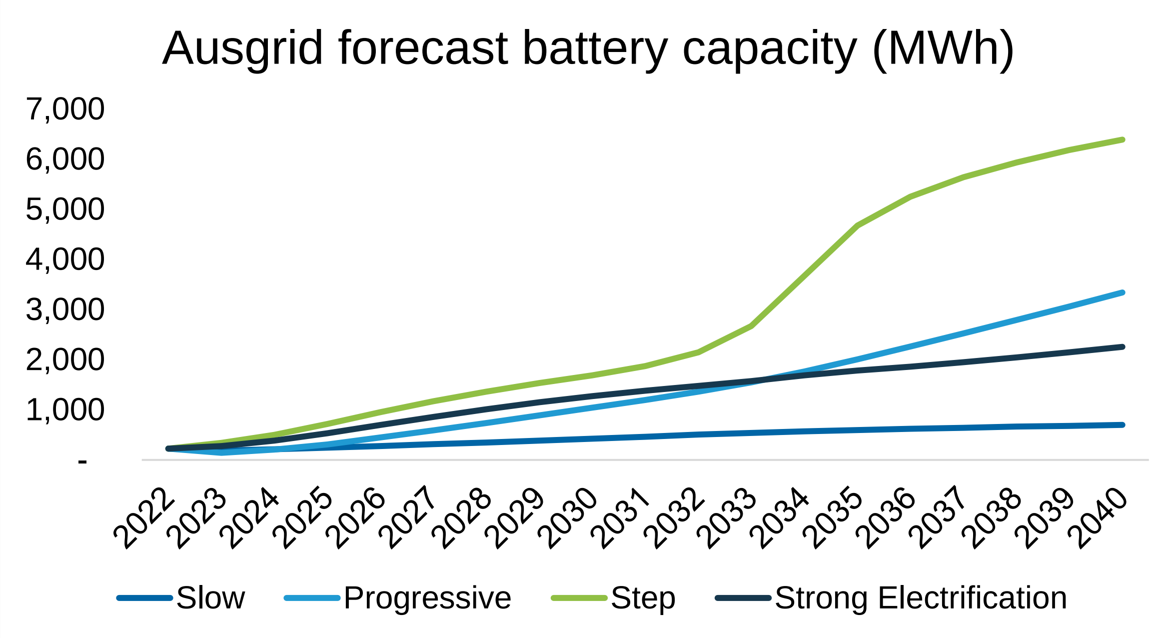
Load data from a random sample of 400 customers in each stratum is used to set typical generation and storage capacities for installations in each strata.

Customer strata	Rooftop solar (kW)	Battery (kWh)
Apartment	6.66	10
Res - S	6.66	10
Res - M	6.66	10
Res - L	6.66	10
Business - S	12	10
Business - M	36	30
Business - L	100	100

The predicted payback period for various combinations of rooftop solar and battery technology is calculated from the predicted future electricity price and installation costs, using the same data sources as AEMOs 2022 ISP. Models of the uptake rate in each stratum are developed based on the historical relationship with payback period.

For each of AEMO's scenarios (Net Zero, Progressive Change, Step Change, Strong Electrification) the payback model parameters are adjusted so that Ausgrid's overall rooftop solar generating capacity and battery storage capacity aligns with AEMOs projections for NSW (downscaled to Ausgrid's network, based on Ausgrid representing 32% of installed NSW capacity).





Projections of Ausgrid's total installed rooftop solar generating and battery storage capacity.

The model incorporates different technology subtypes to represent different modes of battery operation.

It is assumed that customers will become increasingly responsive to tariff signals and that more batteries will be synchronised into Virtual Power Plants (VPPs).

Battery management				
Year	**Battery behaviour**	**Share of new customers**	**Battery load at ZnMax**	**Battery load at ZnMinDay/ZnMin**
2024	VPP	15%	20%	5%
	Tariff_sensitive	0%	5%	5%
	Regular	85%	5%	2%
2029	VPP	20%	20%	10%
	Tariff_sensitive	15%	5%	5%
	Regular	65%	5%	2%
2034	VPP	50%	20%	15%
	Tariff_sensitive	45%	5%	5%
	Regular	5%	5%	2%
2039	VPP	50%	20%	20%
	Tariff_sensitive	50%	5%	5%
	Regular	0%	5%	2%

1.3 Electric Vehicles (EVs)

EV uptake for NSW is taken from the scenario projections in AEMOs 2022 ISP and disaggregated to Ausgrid based on Evenergi modelling:

- 2021-25: 70% of NSW
- 2026-30: 60% of NSW
- 2031-40: 46% of NSW

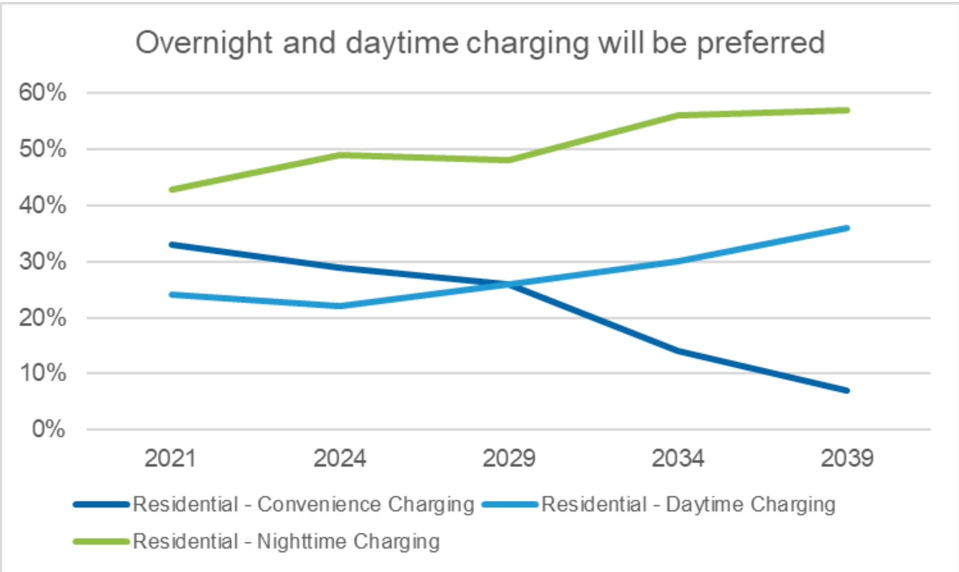
AEMO has projected the populations of ten classes of electric vehicles. The CER integration models do not consider busses. The proportional distribution of the remaining 9 types is set for each customer strata.

The models consider 3 charging patterns, associated with possible tariff settings:

- Unscheduled – charging takes place based on convenience and does not consider price signals,
- Daytime – charging during the daytime to take advantage “solar soak” tariffs, and
- Night-time – charging from the grid overnight to take advantage of cheaper off-peak electricity.

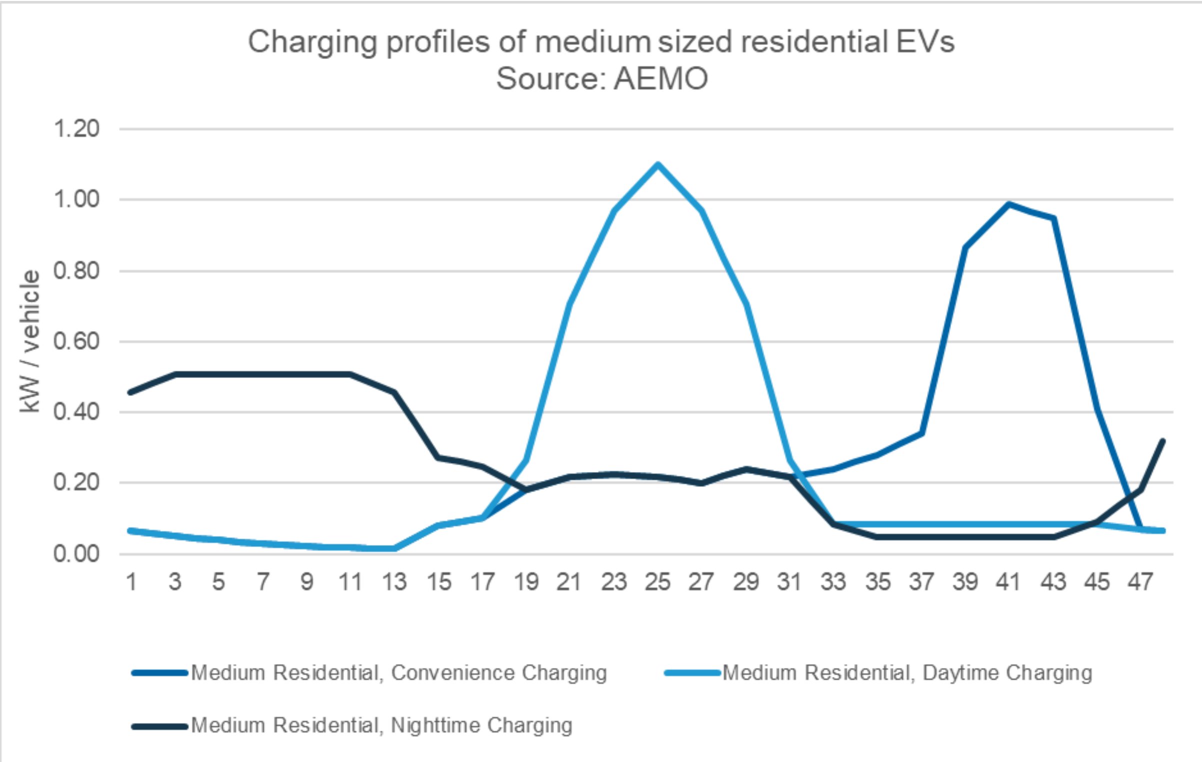
The initial mix of EV charging behaviour was informed by our collaboration project called ‘Charge Together’ with consultancy Evenergi and comprises of 33% unscheduled, 24% daytime and 43% overnight. Over time, the proportion of unscheduled charging declines steadily reaching around 7% by 2039 and over the same period night-time charging becomes the predominant charging behaviour reaching 56% followed by daytime charging reaching 36%. This means that most EV charging will gradually evolve towards either a charging overnight behaviour or charging during the day behaviour, following a time of use and solar-soak pricing signals, respectively.

For at home charging, it is expected that convenience charging will be gradually phased out in favour of night-time and daytime charging taking advantage of existing and future tariff structures.



The load impact of EVs is based on the following factors:

- The location where EVs charge, which can be either at home (house), at an apartment carpark, at a depot or at a public charger. Different locations are associated with different charger capacities.
- The load timing applied,
- Standard charging profiles per vehicle type taken from AEMO



Example EV charging profile used in EV modelling for CER integration

1.4 Electrification

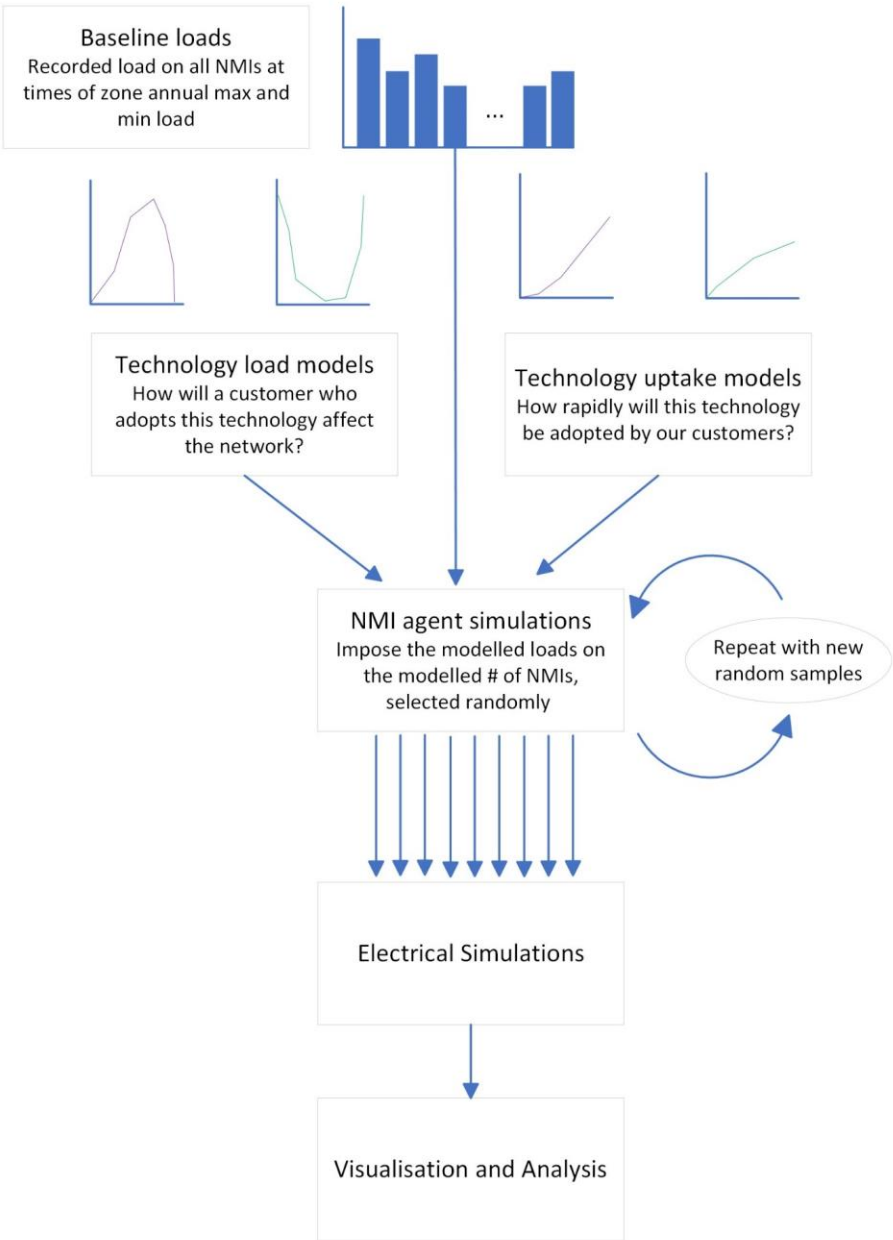
The electrification model considers the simultaneous effects of rooftop solar, batteries, EV and the introduction of new loads due to the transition from gas to electricity for heating and cooking.

2. CER hosting capacity modelling methodology

"Hosting capacity" refers to the ability of the network to support connection of CER without unacceptable loss of power quality or reduced reliability.

2.1 Structure of a CER hosting capacity model

CER hosting capacity models identify the network response to the adoption of CER technologies by considering the incremental effect from each connection and simulating the network for various load and CER uptake scenarios.



The structure of a CER hosting capacity model

2.1.1 Electrical models

CER hosting capacity models incorporate the same network electrical models used for BAU planning purposes. The models include both the HV and LV networks for each zone substation.

2.1.2 Model scenarios

A scenario specifies a particular load and CER technology uptake.

2.1.3 Model resolution

It is computationally intensive to simulate the network. To derive a picture of network response to CER over the next 20 years, simulations are performed for the years 2024, 2029, 2034 and 2039.

The purpose of a CER hosting capacity model is to derive the probable maxima and minima network conditions. The zone is simulated at loads likely to capture these extremes. Historical data is used to identify the three times of the year when the zone substation experienced its annual maximum load, minimum load, and minimum daytime load. At these times connections in the zone experience their lowest and highest voltages. The zone network is simulated at the corresponding times each model year.

The picture of zone evolution throughout the model period under a particular scenario is given by these 12 snapshots (three simulations in each of the four model years). A model that includes 4 scenarios performs 48 simulations of each zone. Each replication of a model run involves running 48 simulations per zone.

2.1.4 Baseline year

A recent 12–month period for which there is good interval load data coverage (*) provides the baseline against which change due to CER adoption is identified. Examination of the baseline year gives:

- The times each zone substation experienced its annual load extremes. These are used as the times of zone maximum and minimum load in all future model years.
- A snapshot of the loads on all NMIs in the zone at these three times. This defines the baseline extremes of the loads throughout the zone at these times.
- The classification of each NMI into one of seven customer strata based on its account type (domestic or business) and its annual electricity consumption over the baseline year.

(*) Ausgrid's Load Information System (LIS) provides historical load profiles for all NMIs (connections) that are interval metered and imputes a load profile for other NMIs by averaging real interval data from similar NMIs.

2.1.5 Customer models

Customers are stratified into seven classes based on their annual electricity consumption during the baseline year: Domestic Apartment, Small, Medium, Large; Business Small, Medium, and Large). This has proven over time to be a useful classification for load forecasting.

2.1.6 Technology models

A 'technology' considered by a model is specified by:

- A load model, which describes how a customer who has adopted the technology will use the network, this includes generation.
- An uptake model, which specifies how the technology will spread amongst customers.

This structure can describe both network technologies that connect to the network and non-network solutions: the response to a new tariff structure as well as the installation of an electric vehicle charger.

It is often necessary to divide a technology into subtypes with different load and uptake characteristics. For example, grid–connected batteries may be stand-alone or part of a synchronised VPP and the adopters of stand–alone batteries may have different sensitivities to tariff incentives. VPPs are also likely to have different uptake rates to stand–alone installations.

A CER scenario is defined by a particular mix of load and uptake models.

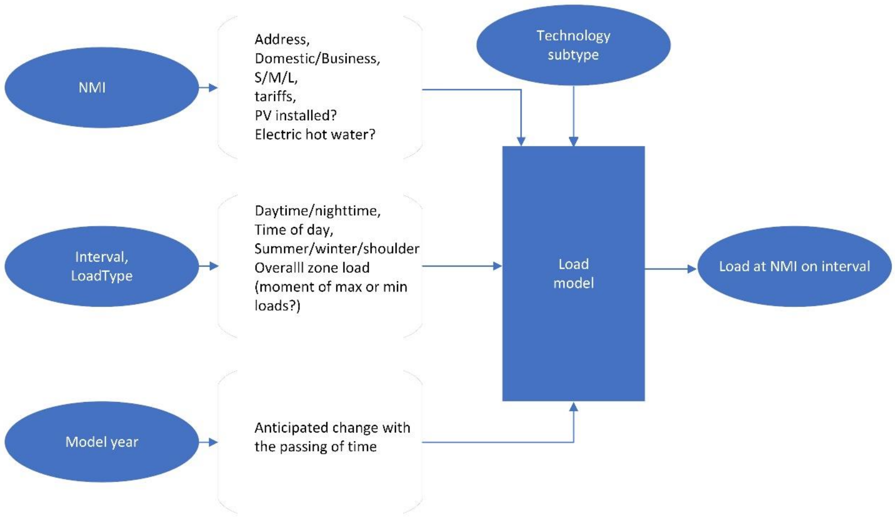
2.1.7 Load models

A customer who has adopted a technology will load the network in a characteristic way. In addition to the technology itself the load may depend on other factors such as the customer's tariff, the season, time of day etc.

During a CER model run NMIs are selected at random and assigned the behaviour described by the load model. This has two implications:

1. The load model must be general enough to capture zone substation load characteristics - zone substation min / max / day min loads at different times of the day for each zone substation; and

4 Any information the load model needs to specify a load must be derivable from the NMI, Interval, and model year.



A CER load model. During a model run NMIs are selected at random and allocated a load according to the model. The model can describe changes in the size and timing of loads.

2.1.8 Uptake models

An uptake model specifies the rate of adoption of a technology.

In each model year a random sample of NMIs from a zone is selected to represent technology adopters. The uptake model specifies how to derive the sample sizes.

The simplest possible uptake model for a CER model with four model years would specify the proportion of NMIs in the zone that have adopted the technology in each model year, for example:

Year	2024	2029	2034	2039
Uptake	10%	20%	60%	75%

Since the NMI count is different in each zone the proportions specified in an uptake model specify different sample sizes in different zones.

More detailed uptake models are often necessary.

2.1.9 Eligible NMIs

The simplest uptake models specify the proportion of NMIs in each zone (or each stratum in each zone) to select as technology agents. Sometimes it is necessary to restrict the NMIs that are eligible for selection, in which case the proportions are applied to the eligible NMIs only). For example:

- A customer can be allocated a single EV, but not a subsequent EV;
- Customers who already have rooftop solar cannot be selected as new rooftop solar adopters;
- Customers with a rooftop solar installation are eligible to be assigned a battery;
- Customers with an OP1 tariff are eligible to be assigned a solar soak tariff; and
- Customers who currently have gas heating are eligible for selection as electrification agents.

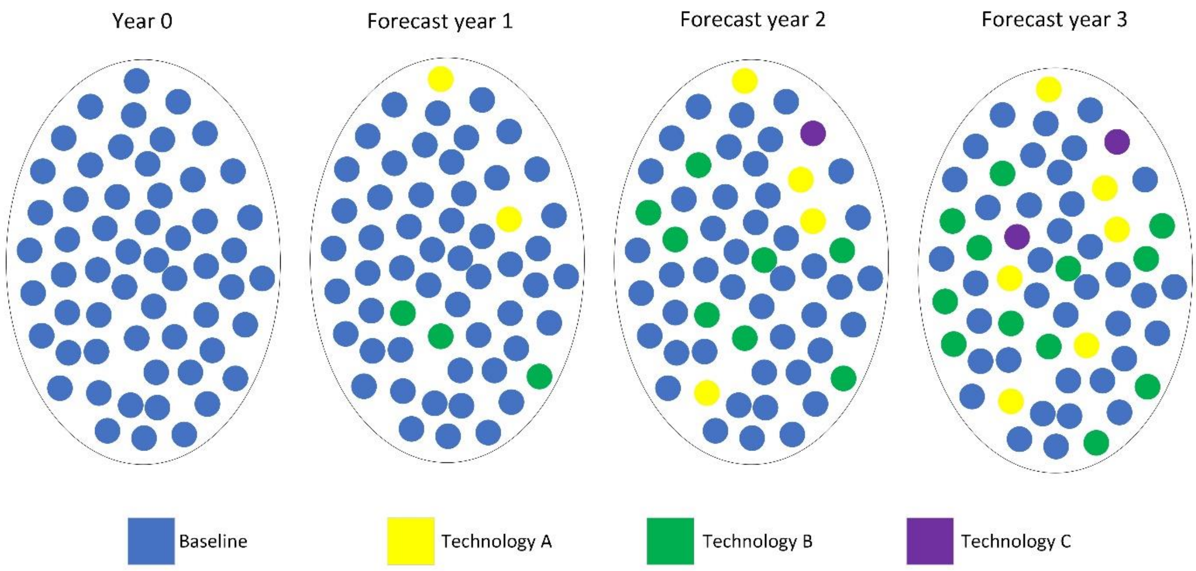
2.1.10 Different uptake rates for different customers/sub-technologies

Uptake models can specify a different uptake rate for each customer strata. The one-row table above would become a seven-row table, with each row showing the uptake of the technology in one stratum.

In full generality an uptake model might subdivide the technology being considered into subtypes, and provide for each subtype:

- Criteria for an NMI to be eligible to adopt the technology subtype.
- A seven-row table for each subtype defining the uptake rate in each customer strata.

2.1.11 NMI load agent model



A snapshot of the electrical behaviour of the network in a zone can be derived from the loads on all NMIs in the zone. The load agent model sets up the snapshots that will depict the evolution of the zone by creating lists of loads on every NMI as follows:

1. All NMIs are allocated the loads they had in the baseline year. NMIs that are not selected to represent technology adopters during the model run retain their baseline loads throughout.
2. Each model year a new sample is selected at random from eligible NMIs to represent technology-adopters. The sample size and definition of eligibility are as specified by the uptake model.
3. The load on each selected NMI is recalculated as specified by the load model.
4. The zone is simulated with the mix of baseline and changed loads.

The simulations may be repeated with different random seeds so that different NMIs are selected as technology adopters. The variance in results reveals how sensitive the response of the network in the zone is to the geographic distribution of CER adoption.

3. EV capacity evaluation methodology

The residential EV fleet is expected to grow more rapidly than the commercial EV fleet. If the history of domestic rooftop solar is a guide, uptake rates may exceed expectations.

LV distributor capacity ratings are the most likely bottleneck to residential EV uptake. A utilisation-based approach has identified those residential LV distributors most likely to require upgrade works to cope with EV charging loads at domestic premises in the short to medium term. A classification of distributors based on their length and physical characteristics leads to estimates of the investment required to render them robust.

Assumptions about the magnitude of EV charging loads are based on AEMO forecasts for the number of EVs and the average contribution of an EV to peak load. Base peak load (before applying EV loads) on a LV distributor is taken to be its maximum historically observed load.

The comparative modelling of AEMO scenarios thru 2040 considered the likely range of public and private charging options that will become available, and how EV load is likely to be distributed between them. In the short and medium term, public charging infrastructure will not be widely deployed and it is reasonable to use the simplifying assumption that each residential EV will be charged by a domestic charger where it is garaged.

3.1 EV clustering effects

AEMO forecasts the size of the residential EV fleet but does not say how the vehicles will be distributed. If it turns out that EVs are concentrated in only a few locations then there may be local bottlenecks to EV uptake even at low overall vehicle numbers.

Two possible clustering effects are examined.

3.2 Clustering due to household income

It is probable that EV uptake will be greater amongst high-income households.

ABS data has been used to estimate the household income of each NMI and calculate average household income along each LV distributor. Based on this a factor has been assigned to each LV distributor:

- If the average household weekly income is less than $1350 then the factor is 0. These households will most likely not be buying an EV; and
- For higher incomes the factor increases linearly. The slope is fit to the estimated number of residential EVs in each LGA in 2021.

EVs are preferentially allocated to LV distributors with higher factors.

3.3 Clustering due to 'neighbourhood' effects

It is possible that EV uptake will be greater in neighbourhoods that have also adopted other CER technologies. This is supported by a survey of EV customers that indicated a higher proportion of rooftop solar uptake among EV owners compared to the general customer base.

A factor has been assigned to each LV distributor based on the proportion of its NMIs that had rooftop solar installations in 2021. EVs are preferentially allocated to LV distributors with higher factors.

3.4 Outline of EV capacity evaluation

1. Forecast the peak load on each LV distributor due to EVs.

- Assume each LV distributor starts with its historical maximum load
- Posit the size of the residential EV fleet, using AEMO forecasts for a particular year and scenario
- Model the number of EVs on each LV distributor, taking into account possible clustering due to income and neighbourhood effects
- Use AEMO forecasts of the proportion of these EVs that will "convenience charge", i.e. charge at peak load
- Use AEMO forecasts to predict the load of each EV (on average)
- Estimate the load offset due to simultaneous PV or battery energy feed-in
- Apply a voltage factor to derive the currents arising from the loads
- Apply a phase-imbalance factor to account for the fact that EV chargers may not be connected equally across phases

2. Identify those LV distributors at risk of overload.

These are the LV distributors on which the forecast load exceeds the LV distributor's rating.

3. Forecast the amount of investment required for each at-risk LV distributor

- Use a classification of LV distributors based on physical properties (total length, length of overhead sections, number of NMIs, rating) to forecast the cost of uprating.
- Check that the LV distributor has not already been flagged by voltage studies for CER investment that is high enough to likely fix the issue
- Apply a risk-investment conversion factor to estimate the portion of forecast issues for which an investment will be required.

3.5 Key parameters

We use AEMO's estimates to calculate the proportion of EVs that will be "convenience charging" in 2029 under the Step Change scenario, as a reasonable proportion to use for any year under all scenarios.

We further use AEMOs estimate that the average load presented by an EV that is 'convenience charging' during peak load will be 1kW, and the average offsetting (negative) load of a rooftop solar installation exporting at the same time is 0.35 kW.

4. Curtailment quantification methodology

CER integration modelling contributes to ongoing efforts to quantify the amount of energy lost to curtailment.

The AER has published a high-resolution pricing model of curtailment which sets a price per kWh of curtailed energy for every 30-minute interval over the next 20 years (starting FY2022-23). The computational power and interval data needed to directly simulate connection voltages at this level of granularity do not exist yet. Quantitative forecasts of curtailed energy have been made for 4 full years over this period (2024, 2029, 2034 and 2039) using a combination of the results of CER modelling and interval meter voltage data as is available. Estimates of energy lost to curtailment in intervening years may be obtained by interpolation.

The purpose of this modelling is to direct investment where it is needed to ensure the network can support community uptake of rooftop solar generating capacity. Only curtailment losses of rooftop solar installations with capacity less than 100kW are estimated (this covers all domestic customers). Larger installations fund the necessary network augmentations as part of their connection arrangements.

4.1 Challenges of quantifying curtailment

Quantifying expected curtailment under a particular scenario of CER adoption requires estimating:

- The number of rooftop solar installations, their capacities and inverter parameters.
- The amount of energy an installation will generate at any interval of a day.
- The geographic distribution of the installations on the network. (Concentrations of generating capacity led to local over–voltages and hence curtailment that would not occur if the installations were more evenly spread out.)
- The connection voltage profile at each connection.

The uptake and load models developed for CER integration planning address the first 2 bullet points above. The 3rd bullet point is addressed by randomised agent-based network simulations and the 4th bullet point requires historical data on voltage profiles at connections, which is not yet widely available.

4.2 Inverter curtailment profiles

Australian standard AS4777 determines the proportion of generated energy that is curtailed at each connection voltage. The standard was released in 2015 and updated in 2020. The two editions specify different curtailment profiles. The curtailment models assume that all inverters installed before 2022 operate according to the 2015 standard, and all inverters installed thereafter operate according to the 2020 standard.

4.3 CER integration modelling of rooftop solar

The CER modelling methodology, described elsewhere in Appendix B, is based on simulating the network when a set of connections have been randomly selected as technology–adopter ‘agents’. The models define how many agents to select and how each will load the network.

CER integration models are intended to identify the probable extremes of network conditions, not the time spent in different subranges between these extremes. In a model run the network behaviour in each zone is simulated at three moments only each model year—the times the zone substation has historically experienced its annual maximum, minimum, and daytime minimum total load. These times are chosen as they are likely to be the times of maximum and minimum voltages on most connections in the zone.

Curtailment forecasting uses the output of the CER integration model to derive a scaling factor to apply to connection voltages over the model period.

The energy that could potentially be generated by a PV installation at an interval is modelled as:

$$(0.5 \times 6.6 \times f)\ \text{kWh}.$$

Where:

- 0.5 represents 30-minute long intervals;
- 6.6 kW is today’s average capacity of smaller rooftop solar installations;
- *f* is an environmental factor, depending on the interval, to represent the proportion of total capacity achievable given the time of day and the season;

Curtailed energy is however much of this total that cannot be exported due to high connection voltages.

4.4 Interval meter voltage data

Curtailment starts to occur when the connection voltage rises past a threshold and the proportion of energy curtailed increases with the voltage, as specified in AS4777. To quantify curtailment in a 30-minute interval it is necessary to know the average connection voltage during that interval. There are 153300 daytime intervals over the next 20 years, and a CER model directly simulates connection voltages at 12 of them. Higher resolution requires leveraging interval meter data.

In a curtailment model, the connection voltage profile at each rooftop solar installation in a zone is successively taken to be one of the measured profiles of a meter in the zone. There are around 1.8 million NMIs on Ausgrid’s network. A full year of interval meter voltage data exists for around 9000 of them. Every zone has at least one meter with voltage data.

4.5 Curtailment estimation

A curtailed energy profile, giving the energy curtailed on every interval in a year is calculated for each zone for the years 2024, 2029, 2034 and 2039. The curtailed energy profile for a zone is the sum of the curtailed energy profiles of each rooftop solar installation in the zone. The number of installations in the zone each model year is given by the CER model. The curtailed energy profile for a single installation is the average of *N* profiles, each one obtained assuming the connection voltage profile is a scaled version of one of the *N* historical voltage profiles available for interval meters in the zone. The scaling factor translates the historical profile up or down to account for how the overall zone voltages have changed in the intervening time, and is defined to be Vy/Vb, where Vb is the measured connection voltage at the moment of zone minimum daytime load during the baseline year, and Vy is the modelled connection voltage at the same moment in the model year.

Appendix C

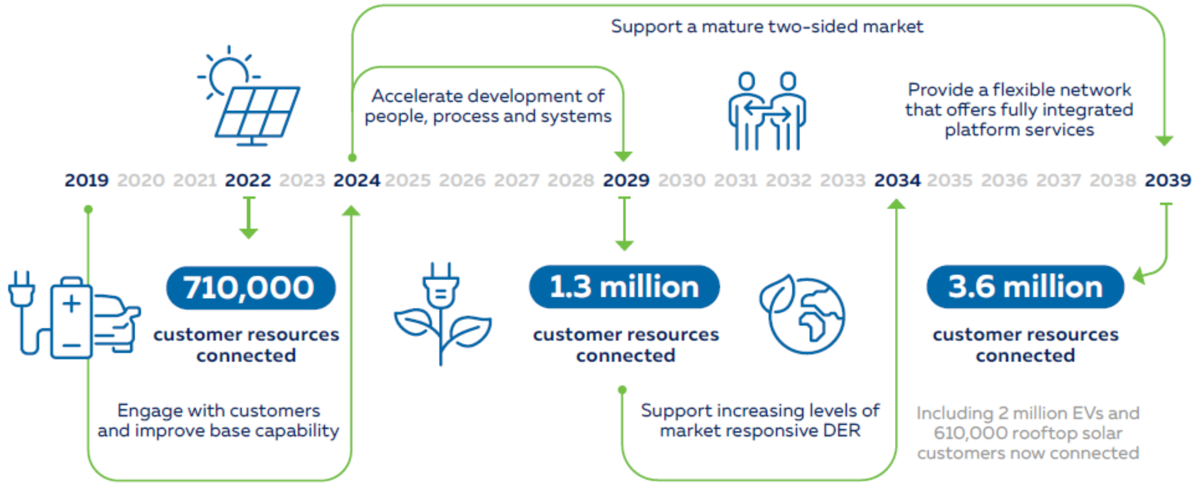
Additional information and supporting content

APPENDIX C - Additional information and supporting content

1. Delivery roadmap

Ausgrid's CER integration program is intended to facilitate decentralised renewable generation and increased electrification as the community transitions to net zero by offering innovative platform services and increasing the utilisation of the current network. Ausgrid plans to continue to progressively lift organisational capabilities, with the phases over the next regulatory periods being:

1. 2019 - 24 - Engage with customers, improve base capability and understanding of impacts.
2. 2024 - 29 - Accelerate development of people, process, and systems.
3. 2029 - 34 - Implement change to support increasing levels of market responsive CER.
4. 2034 - 39 - Support a mature two-sided market.



Note: Customer rescources include rooftop solar, storage, electric vehicles and controllable loads like hot water.

<u>Roadmap to CER Integration:</u>

1. 2019 - 24 - Engage with customers, trial solutions, improve base capabilities and further understand impacts and opportunities of CER on the network.

   a. 2022 – 24 – Ausgrid intends to build foundational capabilities by:
      - Completing or extending current key projects –implementation of an Advanced Distribution Management System (ADMS), advanced LV voltage regulation pilots, distribution automation pilots, VPP trials, community batteries, and distribution monitoring & control deployment.
      - Develop new concepts and approaches to integrating CER, collaborating with DNSPs and wider industry.
      - Understand the challenges and opportunities – clear definition of CER, improve modelling, listen to customers, translate forecasts into spatial forecasts, run scenarios, build business case for capability development.
      - Increase network visibility – expanding and acquiring existing and new sources of network and customer data, including smart meters, and ways to utilise the information to support network planning and operations.
      - Developing new innovating services – Tariff reform (including testing dynamic pricing), innovative network and non-network solutions, advance flexible load offerings and advocate for accelerated smart meter roll out.
2. 2024 - 29 - Accelerate development of people, process, and systems.

   a. 2024 – 26 – Ausgrid intends to Prepare the business for accelerated electrification by:
      - Visibility – continue to expand smart meter data acquisition in line with the market led roll-out of meters to increase real time visibility of LV energy flow and network capability and constraints.
      - Coordinate response – coordinated policy driven augmentation, accelerate tariff reform, influence smart meter roll out, reform connections process, lift capability across the business.

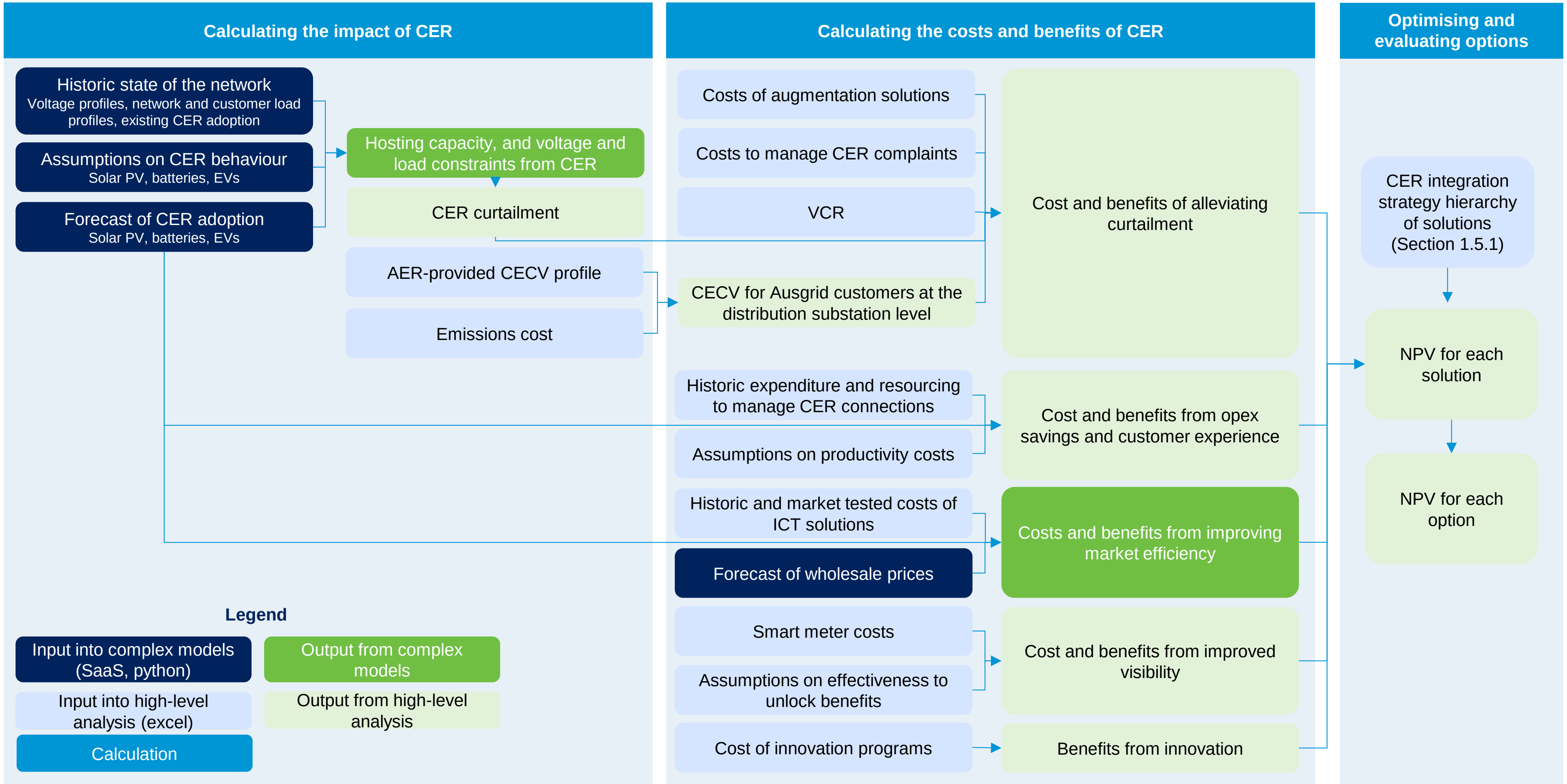
        - Predict – update models based on technology change and impact of new capability and visibility
        - Collaborate – create network transparency, continue to engage with our customers, DNSPs, industry, policy makers
    b. 2026 – 29 – Ausgrid intend to prepare for market responsive CER.
        - Continuing to understand evolving network and customer needs.
        - Systems – build the foundational IT and OT systems to integrate CER into the future, including integrating with new services providers (i.e., aggregators)
        - Forecasting…
        - Visibility increased through smart metering and installed monitoring, to an extent that near real time planning and managing of CER can begin.
        - Support flexible trading arrangements and other market reforms.
3. 2029 - 34 - Support increasing levels of market responsive CER.
    a. 2029 – 31 –
        - Continue to rapidly connect greater volumes of smart CER.
        - Mainstream offering of dynamic connection agreements and dynamic tariffs.
        - Increase network transparency and connection self-service options.
    b. 2031 – 34 -
4. 2034 - 39 - Support a mature two-sided market.

Appendix D

Overview of inputs and outputs of analysis and modelling

APPENDIX D – Overview of inputs and outputs of analysis and modelling

The below provides an overview of the flow of key inputs and assumptions between the suite of complex and high-level analysis and models used to derive the case for CER integration expenditure. The methodology to calculate costs and benefits is outlined in Section 4 of the CER integration program. Additional details on the methodology, inputs and assumptions for the forecasting and network modelling be found in Appendix B.



Flow diagram of inputs and outputs of the suite of analysis and modelling tools used