DER integration expenditure guidance note

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AUSTRALIAN ENERGY REGULATOR

Inquiries about this publication should be addressed to:

Australian Energy Regulator
GPO Box 520
Melbourne VIC 3001
Tel: 1300 585 165

AER reference: 65565

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Contents

1 Introduction

This document represents the AER's final distributed energy resources (DER) integration expenditure guidance note (the guidance note). DER include rooftop solar, batteries, electric vehicles and energy management systems. These resources are often located on the consumers' side of the electricity meter, rather than from a centralised generation source. DER are growing in Australia as consumers become more active in the power system.

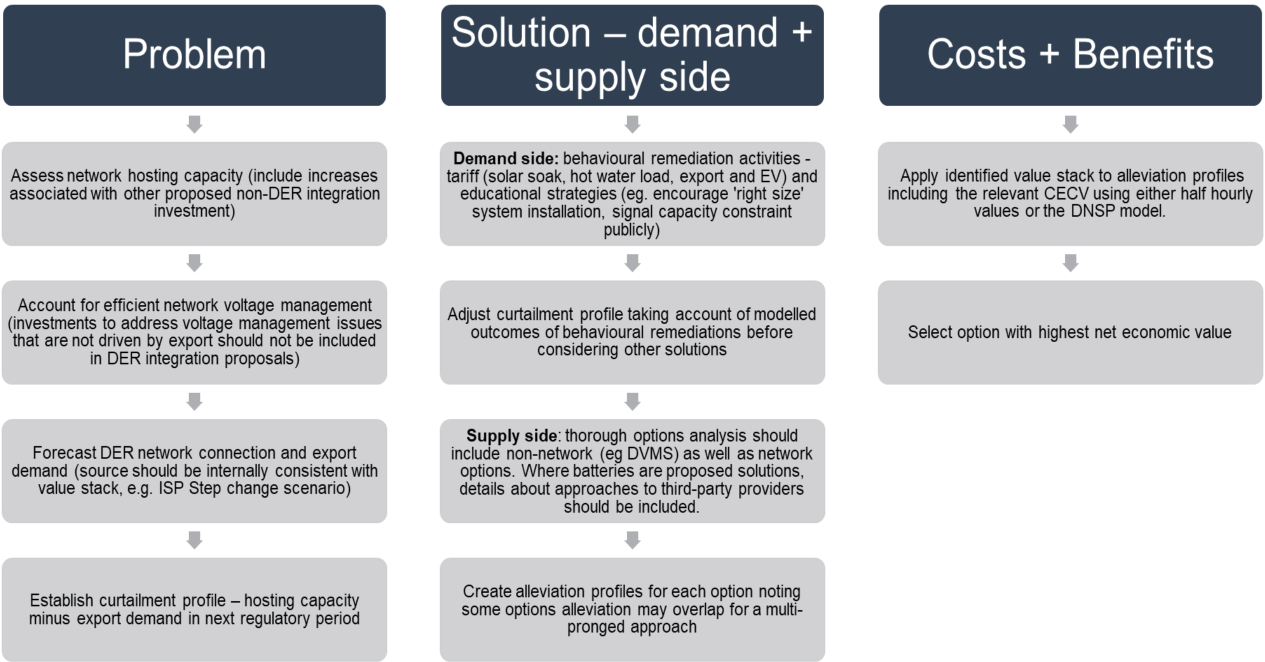
The uptake of DER is customer driven. The Australian Energy Market Operator (AEMO) anticipates rooftop solar capacity to double or even triple by 2040. As DER penetration levels increase and customer expectations with respect to DER use evolve, distribution network service providers (DNSPs) are responding by investing in projects aimed at increasing DER hosting capacity and supporting a broadening range of DER services. Justifying DER integration expenditure requires quantifying DER benefits, not just to the network in question, but to the broader electricity system, including the impact DER can have on the wholesale electricity market.

This guidance note outlines our expectations for how DNSPs should develop business cases and quantify values associated with network investments for DER integration (specifically, to increase hosting capacity). These values are partly estimated using our customer export curtailment value methodology, which we developed in consultation with stakeholders following the access, pricing and incentive arrangements for DER rule change.[1]

This guidance note will help DNSPs step through the process of developing DER integration plans and investment proposals with their customers and is summarised in Figure 1.1.

[1] AER, 'Final CECV methodology', June 2022.

Figure 1.1: Process for developing DER integration investment proposals



1.1 Consultation process

In July 2021 we published the draft guidance note and sought feedback from stakeholders.

In Table 1.1 we summarise the key issues raised by stakeholders and how we have responded to feedback on the draft guidance note.[2]

Table 1.1: Key issues and response to stakeholder submissions

Key issue	Treatment in draft guidance note and Stakeholder views	Treatment in final guidance note
Structure of guidance note	The draft guidance note contained sections focused on: • Presentation of the business case • Defining the base case scenario • Quantifying DER benefits	The final guidance note has been restructured to focus on the steps we expect DNSPs to take when proposing a solution for a DER integration challenge and justifying its expenditure. These are: 1. Identify a problem with integrating DER 2. Identify solution(s) 3. Assess the costs and benefits The first two steps are discussed in section 3 of the guidance note ("Justifying the case for DER integration expenditure"). The third step is discussed in section 4 of the guidance note ("Quantifying DER benefits").
Presentation of the business case	Stakeholders provided views on: • The DER integration strategy • Format of business case • Input assumptions, including the appropriate net present value analysis period	Guidance is provided in section 3. In response to stakeholder feedback we have: • Provided less prescriptive guidance re: the appropriate net present value analysis period

[2] Stakeholder submissions are available on the AER website.

Key issue	Treatment in draft guidance note and Stakeholder views	Treatment in final guidance note
	• Options analysis	• Noted that DNSPs should consider all credible options and selected the option that maximises the net economic benefit across the NEM
Defining the base case scenario	Stakeholders provided views on: • How DNSPs should assess hosting capacity on their networks • Defining the base case scenario, including	Guidance is provided in section 3. We have updated the guidance to clarify the types of data and information to provide when analysing hosting capacity. We have also provided examples of BAU activities to include under the base case scenario.
Quantifying DER benefits	Stakeholders provided views on: • The types of DER value streams that may be quantified in a cost benefit analysis • How DER value streams should be quantified.	Guidance is provided in section 4. In response to stakeholder feedback we have updated guidance on the quantification of other benefits of DER integration. The CECV methodology (separate to this guidance note) is used to quantify a subset of DER value streams associated with the wholesale electricity market.

1.2 Structure of this guidance note

This document is structured as follows:

- Section 2 – The AER's role. We provide context for the development of the guidance note and where it fits in the AER's expenditure assessment toolkit.
- Section 3 – Justifying the case for DER integration expenditure. We set out the key factors we expect DNSPs to consider when preparing an expenditure proposal, including:
  - identifying a problem with integrating DER (through an overarching DER integration strategy as well as an assessment of network hosting capacity), and
  - identifying solutions to solve the DER integration problem (and comparing them with a base case scenario).
- Section 4 – Quantifying DER benefits. We outline the different types of DER benefits (that may be applicable to a proposed investment) and how DNSPs should quantify them in a cost-benefit analysis.

2 The AER’s role

2.1 Background

The National Electricity Law (NEL) requires us to perform our economic regulatory functions in a manner that will, or is likely to, contribute to the achievement of the National Electricity Objective (NEO). The NEO is:[3]

> …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—
> (a) price, quality, safety, reliability and security of supply of electricity; and
> (b) the reliability, safety and security of the national electricity system.

The NEO places an overarching requirement on the AER to make distribution determinations that will deliver efficient outcomes to the benefit of electricity consumers in the long term. The revenue and pricing principles support the NEO and ensure a framework for efficient network investment exists.[4] We must take the revenue and pricing principles into account whenever we exercise discretion in making those parts of a regulatory determination relating to direct control network services.[5]

2.2 Capex objectives, criteria and factors

A distributor must include a total forecast capex that it considers is required to achieve the capital expenditure objectives, which involves:[6]

- meeting or managing the expected demand
- complying with applicable regulations
- maintaining: the reliability, quality and security of supply of standard control services; and the reliability, security and safety of the network.

The NER set out specific requirements to ensure we assess and determine expenditure proposals in accordance with the NEL, and hence give effect to the NEO. When we make a distribution determination, we must decide whether or not we are satisfied that a distributor's proposed total capex forecast reasonably reflects the capex criteria. These criteria are:[7]

i. the efficient costs of achieving the capital expenditure objectives
ii. the costs that a prudent operator would require to achieve the capital expenditure objectives
iii. a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives.

[3] NEL, s. 7.

[4] NEL, s. 7A.

[5] NEL, s. 16(2)(a)(i).

[6] NER, cl. 6.5.7(a).

[7] NER, cl. 6.5.7(c).

When considering whether the forecast reasonably reflects the expenditure criteria, we must have regard to the capex factors.[8]

2.3 The AER's expenditure assessment tools

Our expenditure forecast assessment guideline[9] describes the process, techniques and associated data requirements for our approach to setting efficient expenditure allowances for network businesses. It provides overarching guidance about how we assess a business's revenue proposal and how we determine a substitute forecast when required. For businesses to show their proposal is efficient and prudent, we generally expect the proposal to demonstrate the overall forecast expenditure will result in the lowest sustainable cost (in present value terms) to meet the legal obligations of the DNSP. Where businesses claim higher levels of investment are efficient relative to those required to meet their legal obligations, for example due to market benefits, the proposal should demonstrate the investment is the most net present value positive of the viable options.

For our assessment of augmentation capex, we typically consider a DNSP's demand forecasts, the proposed projects and programs to meet forecast demand and the associated forecast capex. Other triggers of such capex include voltage control issues, and net market benefits. Our assessment of such capex may also incorporate modelling of cost measures for such projects, and detailed engineering reviews.

DER integration expenditure is not explicitly addressed by our existing guidance. DNSP proposals for DER integration expenditure have varied in nature, with different approaches taken towards the types of DER benefits and the quantification of these benefits. This is partly due to differences in network topographies, network visibility and access to network data. Our assessment of these proposals has largely been in line with our RIT-D guidelines, however this guideline does not explicitly cater for investments intended to increase DER hosting capacity.

This guidance note improves our expenditure assessment toolkit by providing clarity and certainty to DNSPs and their customers about what we expect to see in DER integration investment proposals, and how we will assess these proposals. It does not replace any of our existing guidance, but ensures that we have the right tools to assess this emerging area of network expenditure. This is explained by Figure 2. 1

Rule reforms

On 12 August 2021, the AEMC made a final determination on updates to the National Electricity Rules (NER) and National Energy Retail Rules (NERR) to integrate distributed energy resources (DER) more efficiently into the electricity grid.[10] The final determination clarifies that export services are part of the core services to be provided by distribution businesses, and allows distribution businesses to develop export pricing options. The final determination also requires us to develop a CECV methodology to be used to calculate

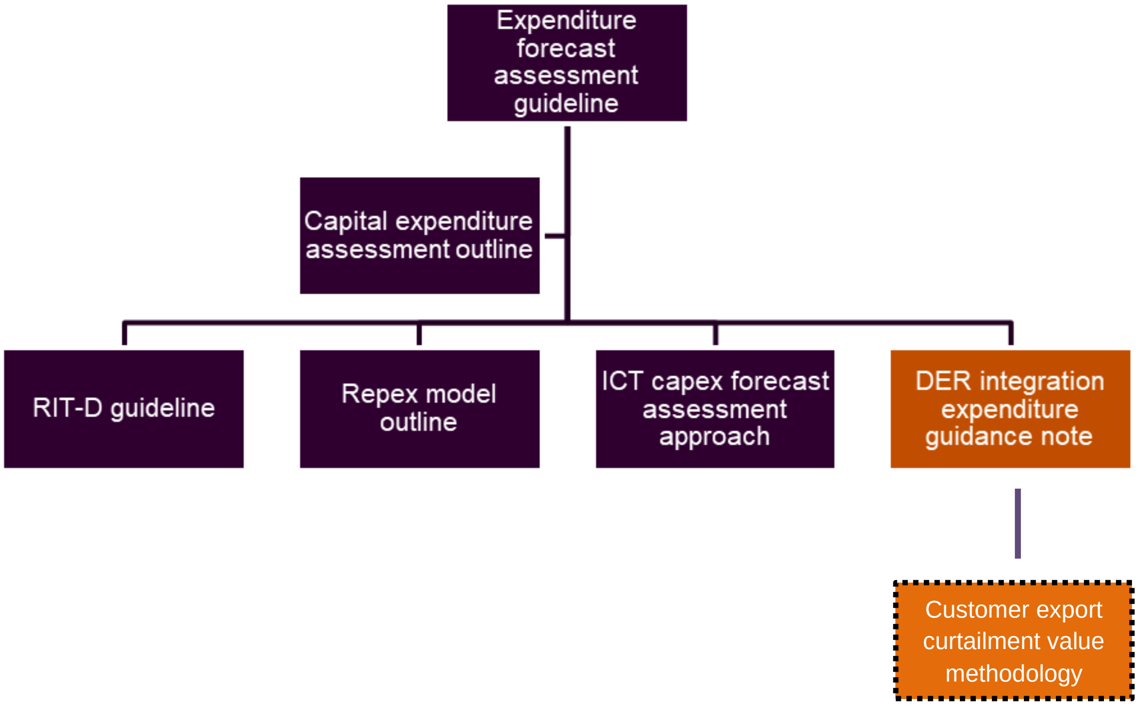
[8] NER, cl. 6.5.7(e).

[9] AER, 'Expenditure Forecast Assessment Guideline for Electricity Distribution', November 2013.

[10] AEMC, 'Access, pricing and incentive arrangements for distributed energy resources, Rule determination', 12 August 2021.

CECVs each year and publish values.[11] The CECV methodology is published alongside this guidance note, and is used to estimate a subset of DER value streams.[12]

Figure 2.1: AER distribution expenditure assessment toolkit



[11] NER rule 8.13.

[12] AER, 'Final Customer export curtailment value methodology', June 2022.

3 Justifying the case for DER integration expenditure

We expect that DNSPs will take the following steps when proposing a solution for a DER integration challenge and justifying its expenditure:

- Identify a problem with integrating DER
- Identify solution(s)
- Assess the costs and benefits

In this section we discuss each step and outline how DNSPs should demonstrate compliance with each step when proposing DER integration expenditure.

3.1 Identifying a problem with DER integration

While DER can provide benefits to customers, it can also present technical challenges for the operation of distribution networks. DNSPs should demonstrate foresight in planning for the continued uptake of DER and its impact on the operation of their networks, as evidenced by a DER integration strategy. In a technical sense, DNSPs should develop a detailed understanding of their network's ability to accommodate this uptake of DER, as evidenced by an assessment of network hosting capacity.

3.1.1 DER integration strategy

As part of the overview paper for its regulatory proposal, a DNSP will need to explain its proposed approach to export-related planning and investment against alternative options. It will also need to present information specifically relating to how DER integration is managed through the different elements of its regulatory proposal (i.e. connection services, pricing, expenditure) and discuss how its proposal is appropriate to meet expected consumer outcomes. The final rules require a DNSP to include the following additional information in its overview paper:

- an explanation of the approach to identifying demand for (and providing for) distribution services for supply from DER
- the trade-offs between different options the network considered and why the network has proposed the particular approach around DER integration and management
- a comparison of the DNSP's proposed capital expenditure to support the provision of export services against its actual or committed capital expenditure and an explanation of any material difference.[13]

DNSPs should supplement their DER integration strategy with the following practical information:

- network voltage analysis

[13] NER clauses 6.8.2(c1)(1) and (2).

- DER penetration forecasts for the electricity distribution network over the medium to long term (at least 10 years) and the expected forecast demand for export services on network
- Evidence of how DNSPs will structure their tariffs to meet the forecast increase in demand for export services (supported by consumer behaviour modelling). It is our expectation that the use of two way pricing, including incentive pricing like solar sponge, EV charging and hot water load, will go a long way in matching the demand for export services. DNSPs should demonstrate how their proposed pricing structures will manage the demand for consumption and export services and make best use of existing network hosting capacity
- A clear summary of the various elements of DER integration expenditure, in terms of augmentation, ICT capex and opex. Where the DNSP has identified deferred augmentation and/or replacement expenditure as a benefit associated with its proposed investment, it should demonstrate that its forecast of augmentation and/or replacement expenditure has been adjusted in a consistent manner
- Details of the DNSP's plan (if any) for the implementation of dynamic operating envelopes (DOEs),[14] which may include the timing of trials, methods for capacity allocation and consumer engagement[15]
- Details of activities undertaken and actual expenditure in the current regulatory period to manage DER integration
- Transparent references to expenditure items in the reset RIN.

AER position

DNSPs should explain how DER integration is managed through the different elements of their regulatory proposal, and also communicate the information and data listed above.

3.1.2 Assessment of network hosting capacity

More specifically, and at the project-level, the DER integration challenge facing DNSPs is likely to be a lack of available hosting capacity to support the connection of additional DER. Hosting capacity refers to the ability of a power system to accept DER generation without adversely impacting power quality such that the network continues to operate within defined

[14] A dynamic operating envelope is a principled allocation of the available hosting capacity to individual or aggregate DER or connection points within a segment of an electricity distribution network in each time interval. Dynamic operating envelopes vary import and export limits over time and location based on the available capacity of the local network or power system as a whole.

[15] As part of the Energy Security Board's DER Implementation Plan, the AER is currently developing an issues paper for stakeholder feedback as part of a broader work program to provide policy direction and advice to the ESB in relation to the implementation of DOEs in the National Electricity Market. The AER is developing an issues paper for release in early August 2022 for consultation, which will be followed by a directions paper towards the end of 2022 to outline what, if any, proposed changes should be considered to the frameworks around DOEs.

operational limits (without experiencing voltage or thermal violations). Hosting capacity varies by location and time due to changes in consumption and the level of DER penetration.

Our export tariff guidelines discuss the concept of “intrinsic hosting capacity” – a base level of DER hosting capacity that all networks currently provide because network assets constructed to provide the consumption service have capacity to support some reverse power flow without additional investment. In proposing an export tariff and basic export level we expect distributors to take into account the intrinsic hosting capacity of the network.[16]

DER and network voltages

DNSPs are required to maintain voltages at customer premises within an acceptable range in order to ensure safe, reliable and efficient operation of their appliances and equipment.[17] Voltage conditions are highly location-specific (impacted by local network configuration) and temporally varied (impacted by local PV generation and associated network demand at any given point in time).

When inverters[18] export real power into the distribution network this leads to an increase in network voltage. This can be further exacerbated when peak solar periods coincide with periods of low demand. To help manage the impact of rooftop solar on network voltage, inverter requirements known as ‘power quality response modes’ (PQRMs) have been developed. PQRMs which include tripping, volt-var and volt-watt response modes manage the reactive and active power exported by inverters to minimise the impact of rooftop solar on the distribution network. While PQRMs help to increase the solar hosting capacity of the distribution network and reduce the amount of inverter tripping, they can result in decreased generation from DER, otherwise referred to as curtailment.[19]

DER is not the sole driver of high voltages across the NEM. Even in the absence of rooftop PV, there are significant levels of high voltage, with networks also experiencing high voltages in the evenings, when solar is not generating and therefore can be contributing to high voltages.[20] Historically, the greatest voltage management challenge for DNSPs was managing peak demand conditions, driven in recent years by growth in air-conditioning, that reduces voltages. Therefore a key voltage management approach has been to increase

[16] AER, ‘Export tariff guidelines’, May 2022.

[17] In most parts of Australia the ‘standard nominal voltage’ is 230 volts. This is a requirement of Australian Standards AS 60038 and AS 61000.3.100 with which electricity distributors must comply under the Electricity Distribution Code of Practice (EDCoP). The EDCoP requires distributors to comply with overvoltage ‘soft limits’ 99% of the time, and undervoltage ‘soft limits’ 99% of the time, at each customers’ point of supply. The soft limit for undervoltage is set at 230 volts minus six per cent, which equates to approximately 216 volts. The soft limit for overvoltage is set at 230 volts plus 10 per cent, which equates to 253 volts. A higher percentage tolerance is allowed for overvoltage because Australian Standards previously required a standard nominal voltage of 240 volts.

[18] Also referred to as solar inverters or PV inverters.

[19] NER rule 8.13 defines customer export curtailment as reducing, tripping or otherwise limiting customer export.

[20] University of New South Wales, ‘Voltage Analysis of the LV Distribution Network in the Australian National Electricity Market’, May 2020.

network voltages towards the upper acceptable range. High voltages can also result in reduced line losses and better asset utilisation.

Analysis of hosting capacity can be deterministic or probabilistic and can be undertaken using a range of modelling and analysis methods. In considering whether DNSPs have demonstrated the best possible understanding of DER hosting capacity, we will consider the following criteria:

- **Relationship between hosting capacity and DER integration** – DNSPs should demonstrate the relationship between increasing levels of DER exports and the level of hosting capacity. For example, evidence of high network voltages during periods of solar PV generation would suggest that increasing hosting capacity may be necessary to accommodate addition DER. However, if high network voltages do not coincide with periods of solar PV (or other DER) generation, other voltage management solutions may be preferable.
- **Use of advanced metering infrastructure (AMI) data** – AMI data provides DNSPs with visibility of voltages experienced at customer supply points. DNSPs with access to AMI data should make use of this data in their assessment of DER hosting capacity, either using network models or econometric models. DNSPs without extensive access to AMI data may use a representative sample of data (capturing different types of network classes) to estimate DER hosting capacity.
- **DER penetration** – as an overarching principle, the level of hosting capacity analysis undertaken by DNSPs (and its complexity) should be commensurate to current and forecast levels of DER penetration on the distribution network, as well as the amount of hosting capacity to be unlocked by the proposed investment. That is, DNSPs with high levels of DER penetration (both currently and forecast over the next regulatory control period) should demonstrate a comprehensive understanding of DER hosting capacity. This is because a greater number of current and prospective DER owners are impacted by the DNSP's decision to invest or not invest in increasing DER hosting capacity.
- **Investment in network visibility** – DNSPs that have made investments to better understand the nature of their LV networks (in terms of voltage and thermal constraints) should demonstrate a thorough understanding of DER hosting capacity. DNSPs that have been previously funded for investments and activities of this nature should demonstrate value for money to their customers, and part of this value is the presentation of a suitable base case scenario to compare proposed investments against.
- **Dynamic operating envelopes –** the DNSP’s use or examination of the implementation of DOEs on its network is an advanced step in understanding and managing the efficient use of network hosting capacity. Typically, DNSPs have set static export limits very conservatively because they are generally set at the time of connection and must account for the potential state of the network at all times. DOEs accurately and dynamically determine the safe operating limits, or the safe upper and lower bounds for imports and exports. Flexible rather than fixed export limits could enable higher levels of energy exports from customers’ solar and battery systems by allowing higher export limits when there is more hosting capacity on the local network.

We anticipate that the results of hosting capacity analysis will be an important source of information for customers in understanding how their DNSP has determined and allocated hosting capacity for export services. This information is also likely to be especially useful for third-party providers in identifying market opportunities to provide non-network solutions to networks experiencing capacity constraints. As such, we expect that DNSPs will make results of their hosting capacity analysis and allocation publicly available and keep this information regularly updated, to the greatest extent possible.

AER position

DNSPs should clearly explain how they have assessed and allocated the level of hosting capacity on their networks and the extent to which DER exports are being curtailed due to a lack of hosting capacity.

3.2 Identify solution(s)

The methodology for determining the value of an increase in hosting capacity compares the total electricity system costs as a result of increasing hosting capacity with the total electricity system costs of not doing so. Broadly, the process of identifying the solution to the DER integration problem involves:

- framing an identified need for the investment in the upcoming regulatory period (driven by an increase in consumer and producer surplus). Section 4 of the guidance note outlines how benefits should be calculated. However, to calculate the value of increasing hosting capacity, DNSPs should also demonstrate how the proposed investment will allow additional DER exports via the alleviation curtailed DER exports (the alleviation profile);
- identifying a set of credible options to address the identified need; and
- characterising the base case against which to compare credible options.

3.2.1 Developing the alleviation profile

An alleviation profile provides the amount and timing of additional electricity that can be exported to the electricity grid because of the proposed solution to address forecast curtailment. This can be both demand side solutions (influencing customer behaviour) and supply side solutions (physical augmentations to the network).

DNSPs should not simply assume a single figure per annum (for example, the project will result in an additional 5,000 kWh of electricity exported to the grid). Instead, DNSPs should consider the conditions that will determine whether curtailment is occurring (or will occur in the future) under the base case scenario, and how the proposed solution will alleviate exports (and the timing of this alleviation).

Table 3.1 summarises the factors that DNSPs should consider when determining an alleviation profile for a proposed solution to address forecast curtailment.

Table 3.1: Factors likely to determine the alleviation profile

Factor	How it affects the proposed alleviation profile
Current and forecast DER penetration, sizes and potential (unconstrained) export (DER use cases)	Existing DER penetration will affect the existing level of headroom available within the network for the export of DER. The forecast penetration of additional DER (and the size of these systems) will likely be a key determinant of how quickly (and the specific times at which) any existing headroom will be used up, thereby influencing the amount and timing in which curtailment would be expected to be needed, absent any investment by the DNSP to increase hosting capacity. For example, the forecast number of behind the meter batteries (and how they are operated) will likely influence the amount of solar that, absent any network constraints, would be generated and available, net of the host facility's electricity needs, to be exported to the grid.
New and evolving tariffs and price signals	Solar sponge tariffs and/or two-way pricing or other price signals to be introduced over the analysis horizon could reduce the need to curtail energy by incentivising more internal consumption or less export during periods where curtailment may otherwise have been required. Such developments should be taken into account in the development of the expected alleviation profile.
Current network hosting capacity	The amount of export that can be accommodated in each specific part of the network will be limited by the capacity of the local network and available controls. That amount will vary over time based on the amount of electricity that is trying to be exported and other aspects of the electrical environment in the area, such as voltage levels and the location at which the export is seeking to access the network.
Curtailment profile	This is the amount and timing of the curtailment that would be expected to occur based on the current hosting capacity in the network and the export potential of existing and forecast DER systems.
Characteristics of the project being proposed to increase hosting capacity (investment case)	The nature of the project and operating practices being proposed by the DNSP will likely determine how much of the export that could be made available by existing and forecast DER systems will be able to be exported and how much may still have to be curtailed. For example, if the project results in the inherent export capacity of a part of the network increasing from 5kW to 7kW, curtailment may still be needed at those times when the average export available exceeds 7kW. The alleviation profile should consider situations in which the additional hosting capacity may not be sufficient to accommodate all available export.

AER position

DNSPs should explain how they have considered the above factors in developing alleviation profiles for their proposed DER integration investments.

3.2.2 Options analysis

DNSPs' proposals for DER integration expenditure should demonstrate that they have considered all credible options and selected the option that maximises the net economic benefit across the NEM. The options considered should explore different investment timing and staging scenarios, to demonstrate the potential impacts on net economic benefits.

As with all investment, the future operational environment is characterised by uncertainty. Greater levels of uncertainty require a greater focus on preserving optionality as some uncertainties may resolve over time, and with more time, a greater range of options may become available. Small scale actions taken now, or deferral, provide option value by reducing the potential for future regret from locking into a large-scale investment that later turns out not to have been needed or not well suited to future service level needs. The greater economic value to consumers that is realised through optionality should be recognised in comprehensive and robust options analysis.[21]

A credible option should be an option that addresses the identified need, is commercially and technically feasible and can be implemented in sufficient time to meet the identified need. For DER integration investments that include augmentation expenditure, DNSPs should demonstrate the consideration of opex or ICT capex options, such as dynamic voltage management systems to improve low-voltage network visibility and better utilise existing network hosting capacity. Where the selected investment option involves a combination of these types of expenditure, DNSPs should explicitly identify the benefits associated with each component of the investment option. Consistent with the capex objectives, if DNSPs are to consider network battery solutions, evidence demonstrating how the DNSP has considered and provided for efficient and prudent non-network options includes the provision of those services by potential third-party providers.

As with other types of network expenditure, it is important that DNSPs select credible input assumptions when considering investment options. In line with the RIT-D application guideline,[22] wherever possible, DNSPs should use:

- inputs based on market data where this is available and applicable
- assumptions and forecasts that are transparent and from a reputable and independent source (and consistent with other aspects of the regulatory proposal). In particular:
    - material that the Australian Energy Market Operator (AEMO) publishes in developing the National Transmission Network Development Plan (NTNDP), Integrated System Plan (ISP), or similar documents should be a starting point.
    - material that AEMO publishes in any up-to-date ISP or equivalent document, where that document has been adopted in the NER and/or NEL, should be used as a default.
- up-to-date relevant information. For instance, it might be appropriate to depart from information that AEMO has published where there is evidence and good reason to demonstrate that alternative sources of information are more up-to-date or more appropriate to the particular circumstances under consideration.

DNSPs should provide sufficient justification for the analysis period selected in their cost-benefit analysis.

AER position

DNSPs should demonstrate that they have considered all credible investment options, including non-network investment options.

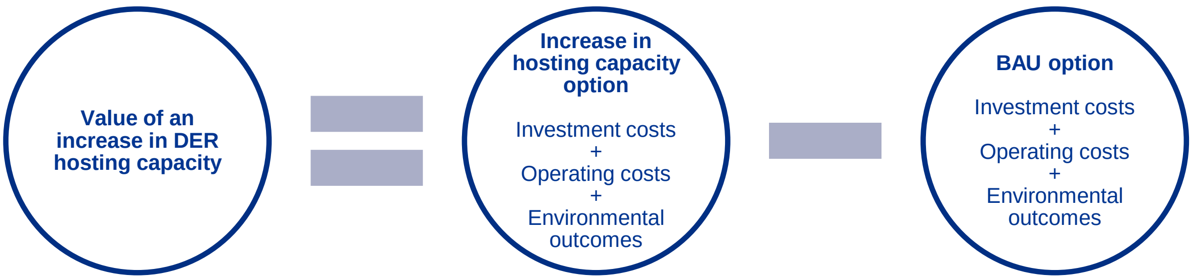
[21] AER, 'Industry practice application note – asset replacement planning', January 2019, p. 12.

[22] AER, 'Application guidelines: Regulatory investment test for distribution', December 2018.

3.2.3 Base case scenario

The methodology developed for determining the value of an increase in hosting capacity compares the total electricity system costs as a result of increasing hosting capacity with the total electricity system costs of not doing so.[23] Part of this equation (illustrated in figure 3.1) relies on quantifying investment costs, operating costs and environmental outcomes under the base case, or business-as-usual (BAU) scenario.[24]

Figure 3.1: Value of DER methodology



The RIT-D guidelines define the BAU base case as a standard base case where the RIT-D proponent does not implement a credible option to meet the identified need, but rather continues its BAU activities.[25] 'BAU activities' are ongoing, economically prudent activities that occur in absence of a credible option being implemented.

The base case scenario should comprise BAU operating expenditure associated with voltage management, which may include managing distribution transformer tap settings and rebalancing across phases. It could also include BAU expenditure associated with the operation of a dynamic voltage management system (DVMS), where these have been deployed by DNSPs.

As most networks have already mandated new rooftop PV and battery inverters connected be configured with the volt-var response modes defined in AS4777.2 inverter standards (discussed in section 3.1.2), the base case could allow inverter systems to "trip" at times where DER exports exceed hosting capacity.

DNSPs that employ more advanced techniques to understand network behaviours (such as a DVMS or dynamic operating envelopes) should demonstrate how these techniques have informed the export limit selected in the base case scenario.

[23] Koerner M, Graham P, Spak, B, Walton F, Kerin R (2020), 'Value of Distributed Energy Resources, Methodology Study: Final Report', CutlerMerz, CSIRO, Australia.

[24] Investment costs are expenditure on long-lived assets such as generation technologies, network infrastructure, and customer DER. Operating costs include fuel and maintenance costs and are impacted by changes in the timing of the operation of other participants in the sector (hence changes in behaviour are also relevant in this category of expenditure). Environmental outcomes focus primarily on changes in emissions of greenhouse gases and other pollutants.

[25] AER, 'Application guidelines: Regulatory investment test for distribution', December 2018.

When comparing credible investment options to increase hosting capacity against the base case, the preferred option is the option that maximises the net economic benefit across the NEM. If no credible option yields a net economic benefit, then the base case represents the best option.

The DNSP's connection offer in response to a connection application from a micro embedded generator must not specify a static zero export limit except where the connection applicant requests the static zero export limit or in circumstances permitted in the connection charge guidelines.[26] Consultation on amendments to the connection charge guidelines are ongoing at the time of drafting, however we expect that there will be limited circumstances in which zero static export limits will apply.[27] Therefore, the base case scenario should represent the allocated available hosting capacity – the status quo – and not a static *zero* export limit. Although DNSPs may assume a static export limit (above zero) in their base case scenario, they should demonstrate that this limit is not arbitrary. DNSPs could undertake sensitivity analysis to demonstrate that the investment case is preferable when compared to a range of BAU export limits. This may demonstrate that the assumed export limit is not selected arbitrarily.

DNSPs should provide a baseline forecast of DER adoption in terms of number, capacity and type of DER systems adopted over the investment life. In general, our assumption is that networks will invest to integrate forecast DER (subject to tariff mitigation strategies) and not actively recruit and grow DER adoption beyond projected adoption, however there may be some exceptions to this.

These exceptions may occur when it is assumed that the proposed investment will automatically permit additional DER exports. For example, a proposed investment to increase hosting capacity may enable an increase in default connection export limits and allow existing DER owners to export more electricity. Where DER adoption forecasts do not match those in the investment case, DNSPs should provide evidence of analysis to support their assumptions. This analysis should detail whether the assumed difference in DER adoption forecasts is due to customers purchasing DER, existing DER owners being provided additional capacity to export electricity, or both. We note in section 4.4 that where DER adoption forecasts are different, DNSPs may need to quantify the costs and benefits associated with changes in customer investment in DER.

AER position

The base case scenario should reflect the BAU operation of the network and consider the factors discussed in this section.

3.3 Assess the costs and benefits

The Value of DER (VaDER) methodology study identified DER value streams which describe the types of costs and benefits that may arise as a result of a network investment to increase

[26] NER cl. 5A.F.1(c).

[27] NER, cl.5A.E.3(b1).

DER hosting capacity.[28] DNSPs should compare the proposed expenditure (based on their cost estimates) against the sum of benefits under each value stream (where they are applicable). Some value streams are estimated under the CECV methodology and captured in our published CECVs. Other value streams may be estimated by DNSPs. Table 3.2 summarises the DER value streams according to the benefit type. Section 4 provides further detail on how each value stream is quantified.

Table 3.2: DER value streams provided by AER guidance

Benefit type	Value stream	Estimation method
Wholesale market	Avoided marginal generator short run marginal cost (SRMC)	Captured in CECVs published by AER.
	Avoided generation capacity investment	Estimated by DNSPs (see section 4.1.1).
	Essential System Services (ESS) (including FCAS)	Captured in CECVs published by AER (based on approximation).
Network sector	Avoided or deferred transmission/distribution augmentation	Estimated by DNSPs (see section 4.2.1).
	Avoided replacement/asset derating	Estimated by DNSPs (see section 4.2.2).
	Avoided transmission/distribution losses	Partly captured in CECVs published by the AER. Otherwise estimated by DNSPs (see section 4.2.3).
	Distribution network reliability	Estimated by DNSPs (see section 4.2.4).
Environment	Avoided greenhouse gas emissions	Parlty captured in CECVs published by the AER. Otherwise estimated by DNSPs (see section 4.3).
Customer	Change in DER investment	Estimated by DNSPs (see section 4.4).

[28] Koerner M, Graham P, Spak, B, Walton F, Kerin R (2020), 'Value of Distributed Energy Resources, Methodology Study: Final Report', CutlerMerz, CSIRO, Australia.

4 Quantifying DER benefits

The total electricity system is our assumed system boundary for considering the costs and benefits of DER integration investments. This means that the boundary extends beyond customers' electricity meters, and so we consider DER owners to be producers of electricity. However, the boundary does not extend to society as a whole, as this extends beyond our remit. As we noted in section 2, the NEO places an overarching requirement on the AER to make distribution determinations that will deliver efficient outcomes to the benefit of electricity consumers in the long term.

In this section we detail the approaches that DNSPs should follow when quantifying DER benefits. When 'stacking' benefits, DNSPs should explicitly identify the value of each benefit and ensure there is no double counting of values. DNSPs should ensure all identified benefits are real and realisable by electricity consumers.

4.1 Wholesale market benefits

DER integration can deliver the following wholesale market benefits:

- Avoided marginal generator SRMC – Increased DER generation substitutes for generation by marginal centralised generators, which may have higher short-run marginal costs, in the form of fuel and maintenance costs.
- Avoided generation capacity investment – Increased DER generation reduces the need for investment in new/replacement centralised generators.
- Essential System Services (including FCAS) – Increased DER capacity enables more DER participation in ESS markets, reducing investment in new/replacement centralised ESS suppliers.

Under the CECV methodology, CECVs capture the value of avoided marginal generator SRMC (including an approximation of the value of FCAS). DNSPs should use the published CECVs to quantify these benefits, if they are delivered by proposed network investment(s), in line with the approaches outlined in the CECV methodology.[29]

4.1.1 Estimating avoided generation capacity investment costs

DNSPs should use electricity market modelling to estimate avoided generation capacity investment costs. Quantifying changes in investment outcomes requires a "with/without" approach to modelling, whereby explicit assumptions about export curtailment alleviation profiles are made to represent the additional DER export.

The alleviation profile needs to assume the amount of additional DER export at different time slices corresponding to those used in the electricity market modelling. DNSPs should explain how they have considered the underlying DER technologies as well as the location of DER export curtailment in estimating the alleviation profile.

[29] AER, 'Customer export curtailment value methodology', June 2022.

In addition, DNSPs should provide empirical evidence to support the magnitude of its assumed alleviation profile and the change that it causes in the electricity generation investment mix. In general, the curtailment of rooftop PV exports occurs during sunny conditions and requires that household demand and solar irradiation are present in a specific range of proportions to one another (e.g. very low demand and high irradiation, or low to medium demand and very high irradiation). DNSPs should also consider how the application of dynamic operating envelopes as opposed to static limits will impact on the likelihood of export curtailment over time.

4.2 Network benefits

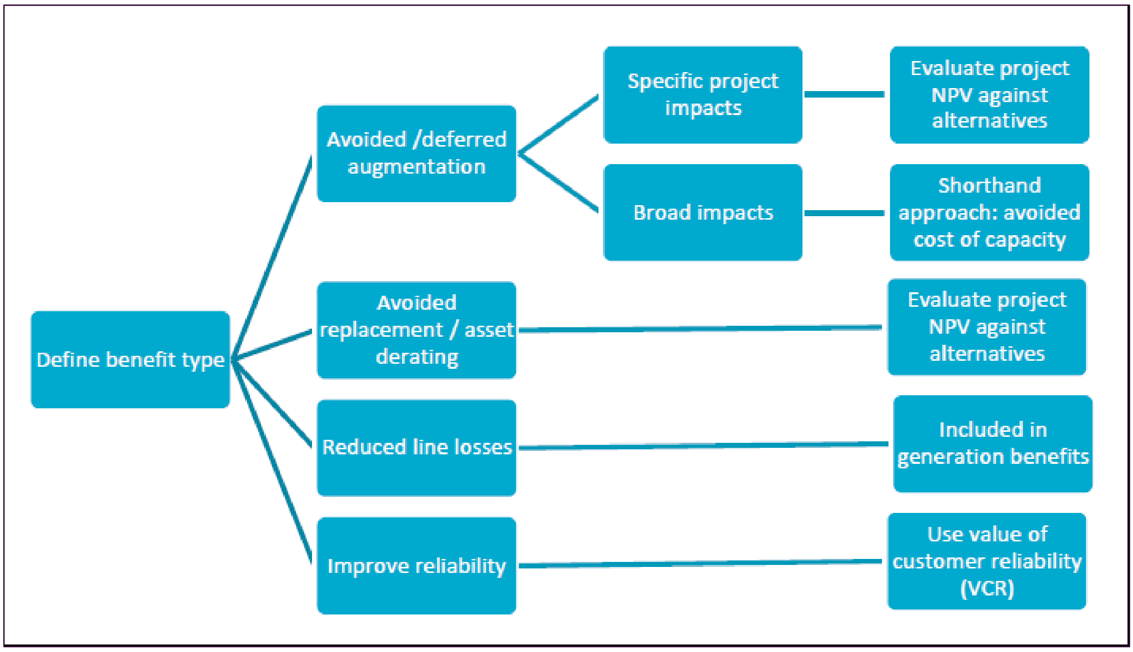
For network benefits of additional DER, there is generally only one way to calculate network benefits, which is the normal network planning processes as described in the RIT-T and RIT-D guidelines. However, there may be some circumstances where a network might use an average avoided cost rather than a specific avoided project cost.

The methodology that DNSPs should use for quantifying network benefits depends on the particular value stream and which of the following is enabled by the proposed network investment:

- Increase in variable energy generation – energy generated by passive DER systems with a profile dictated by technology type and resource conditions (e.g. solar PV, wind)
- Increase in flexible energy generation – energy generated by active DER systems with a profile dictated by tariff structures and/or market conditions to maximise customer returns (e.g. batteries)
- Increase in flexible capacity – active DER capacity available to provide services to wholesale markets (generally Essential Services such as FCAS) or network services including demand management (e.g. batteries and demand response).

The recommended approach for selecting network methods is based on the type of network benefit and whether it derives from a specific network project affecting specific assets or a broad-based project with wider and longer lasting impacts. Figure 4.1 summarises the recommended method selection process for network sector benefits.

Figure 4.1: Method selection process for quantifying network sector benefits



4.2.1 Avoided/deferred augmentation

Increased DER capacity may lead to avoided/deferred transmission augmentation as it may reduce the amount of load supplied from within distribution networks and reduce peak demand at transmission connection points. It may also lead to avoided/deferred distribution augmentation, as it increases the amount of load supplied from within distribution networks and may reduce peak demand at upstream network assets.

If the proposed investment enables an increase in variable energy generation or flexible energy generation, DNSPs may only quantify avoided/deferred transmission and distribution augmentation where generation aligns with the peak,[30] and do so based on the RIT-T guidelines, RIT-D guidelines, or average LRMC approaches.

If the proposed investment enables an increase in flexible capacity, DNSPs may quantify the avoided/deferred augmentation for investments based on the RIT-T, RIT-D or average LRMC approaches.

In deciding whether to adopt an approach under the RIT-D/T guidelines or an average LRMC approach, DNSPs should consider whether there are known short-medium term constraints (specific project impacts). If so, DNSPs should follow the RIT-T or RIT-D guidelines. If there are no known constraints (but rather broad impacts), DNSPs may adopt a shorthand approach such as calculating the average LRMC. To do this for avoided/deferred transmission augmentation, each kW of reduced peak demand contributed by the distribution network to the transmission network is valued at the annualised LRMC of the transmission network. For avoided/deferred distribution augmentation, each kW of reduced peak demand

[30] Or the probability that it will align with the peak, based on the timing of past maximum demand events.

is valued at the annualised LRMC of the distribution network. Both values can be estimated from historical demand growth and augmentation expenditure data.

As noted in section 3, where a DNSP quantifies avoided/deferred augmentation as a benefit associated with a DER integration investment, it should demonstrate that its augmentation expenditure forecast has been adjusted in a consistent manner.

4.2.2 Avoided replacement/asset derating

Increased DER capacity can lower the average load on network assets, enabling asset deratings and when replacement is required, smaller, cheaper assets can be installed. DNSPs may quantify these benefits where the proposed investment to increase hosting capacity leads to changes in other parts of the network where:

- peak demand is not growing over time at the relevant network asset
- peak demand coincides with times when DER exports are enabled
- network asset longevity can be improved by reducing loads.

Any potential benefits in this category are likely to be asset specific, and so DNSPs should quantify the avoided replacement benefits based on the RIT-D guidelines.

As noted in section 3, where a DNSP quantifies avoided replacement/asset derating as a benefit associated with a DER integration investment, it should demonstrate that its replacement expenditure forecast has been adjusted in a consistent manner.

4.2.3 Reduced line losses

Increases in DER generation may result in avoided transmission and distribution losses. DER generation can supply loads within the distribution network, reducing the supply from centralised generators connected to distribution networks by transmission lines, which avoids energy being lost to heat when transported over transmission lines. It can also reduce the distance the energy travels across the distribution network compared to centralised generators, which reduces the amount of energy lost to heat when transported over distribution lines.

The benefit of reduced line losses is captured under the CECV methodology. Specifically, the losses from generation to the regional reference node are considered in the modelling of avoided dispatch costs. DNSPs can use the associated model to estimate losses from the regional node to the relevant transmission connection point and then on to the local distribution network, by inputting the relevant transmission and distribution loss factors for the proposed project.[31]

[31] The CECV DNSP model contains one input where the DNSP can provide the relevant loss factor for each alleviation project. That loss factor needs to account for the losses between the regional node and between the regional node and the area in which the alleviation project is taking. This input will be provided by the DNSP.

4.2.4 Improved reliability

DER can supply individual customers and/or local networks after network faults, where it can be islanded, reducing unserved energy and outage duration.

This benefit is only quantifiable if the proposed investment enables an increase in flexible energy generation and/or flexible capacity, and only where additional batteries have been enabled. Specifically, this value stream may be quantified where:

- the proposed investment includes or incentivises additional investment in battery storage (which would otherwise not be installed)
- the additional battery investment is able to be islanded during a fault
- outages of up to a few hours are common.

The benefit can be calculated by assessing the expected value of unserved energy for each customer that has invested in additional battery capacity as a result of the network's DER integration investment. The assessment of avoided unserved energy must consider whether the battery will have the necessary stored charge to meet household demand for the duration of a typical outage. This could be done by reviewing the proportion of outages that occur at different times of the day and assuming no benefit for the proportion of outages that occur between certain hours (such as late at night when the battery has finished discharging). Each avoided kWh of unserved energy is to be valued using the appropriate VCR value.

4.3 Environmental benefits

Environmental benefits broadly encompass the benefits of avoided greenhouse gas emissions due to additional DER. The NEO does not specifically reference the long-term interest of consumers with respect to climate change or the environment. In making our decisions, we need to consider the achievement of economic efficiency in the long-term interests of consumers with respect to price, quality, safety, reliability and security of the supply of energy or energy services. As suggested by the AEMC, consideration of the long-term interest of consumers in analysis of the impact of decisions on security, reliability, price, security and quality will include consideration of whether such decisions are effected by:

- how policy makers, consumers and investors are responding, or are likely to respond, to the risks presented by climate change or
- how the physical world is changing or likely to change as a result of climate change.[32]

Consistent with the RIT-D, these benefits can be quantified if there is an identifiable tax, levy or other payment associated with environmental or health costs which producers are required to pay or where jurisdictional legislation directs DNSPs to consider the impact of these externalities and has provided a value that is to be used.

[32] Australian Energy Market Commission, 'Applying the Energy Market Objectives', 8 July 2019.

CECVs will capture environmental costs (and benefits) to the extent that renewable energy targets and/or a potential carbon price for electricity generators impact the dispatch procedure and dispatch costs.

If there is a jurisdictional requirement to consider the price of carbon, the DNSP should calculate the carbon benefits associated with its proposed investment. To do this, DNSPs should identify an emission intensity profile for each half hour period over the investment lifespan, and a carbon value that is consistent with the value set jurisdictionally. While AEMO does not currently publish this information, an electricity market model could be used to derive this information consistent with AEMO's Integrated System Plan (ISP).

4.4 Change in DER investment

The treatment of DER investment costs only changes the calculation of benefits if the DNSP varies its forecast of DER adoption between the base case and investment case. In general, DER adoption forecasts in the base case scenario should match those in the proposed investment case, as noted in section 3. In these cases, DNSPs should not include costs or benefits associated with changes in DER investment in their VaDER calculation. However, there may be some exceptions to this, and DNSPs may be permitted to quantify costs and benefits associated with changes in DER investment.

DNSPs should include an estimate of the costs and benefits associated with changes in DER investment when:

- they assume different DER adoption forecasts in the base case scenario and investment case; and
- any of the difference is due to customers purchasing DER.

DER subsidies that the customer receives should be netted off from investment costs.

4.5 Other benefits

We acknowledge that some customers may value other perceived or intangible DER benefits, such as self-reliance or a sense of contribution, and these values could be revealed by customer willingness-to-pay surveys. If proposing additional value streams such as these, DNSPs should:

- consider whether the benefits are already reflected in existing value streams, such as those related to wholesale market or network sector benefits. If they are, the methods stipulated above should be used to quantify the benefits
- demonstrate that values will accrue to producers, consumers or transporters of electricity in the NEM. Where the provision of export services is considered a standard control service, and more specifically, part of the common distribution service, only those benefits that accrue to *all* customers should be considered as part of an expenditure assessment. The NEO relevantly provides consideration of the long-term interests of consumers of electricity and the expenditure objectives relate to the provision of SCS.

Further, the AER Electricity Distribution Service Classification Guideline[33] discusses the common distribution service (as the principal standard control services networks' provide) as that from which *all* customers benefit. Therefore, consideration of customer benefits should be limited to those benefits realised by all customers and not separately identify those accruing directly to exporting customers.[34]

- demonstrate that existing value streams have already been quantified, or considered in the cost-benefit analysis.

[33] AER, 'Electricity Distribution Service Classification Guideline', September 2018

[34] See also Australian Energy Market Commission, 'Applying the Energy Market Objectives', 8 July 2019, that interprets 'consumers' in the context of the energy market objectives as consumers in general, or all consumers, rather than a particular type or group.

Glossary

Term	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Alleviation profile	This is the amount and timing of curtailment that will be alleviated by the DNSPs proposed investment
AMI	Advanced Metering Infrastructure
BAU	Business as usual
CECV	Customer Export Curtailment Value
Curtailment	Any reduction on the capacity of an inverter to export to the grid. This could be caused by inverter tripping in response to voltage disturbances or formally imposed through network static or dynamic voltage limits.
Curtailment profile	This is the amount and timing of the curtailment that would be expected to occur based on the current hosting capacity in the network and the export potential of existing and forecast DER systems.
DER	Distributed Energy Resources
DOE	Dynamic Operating Envelopes
DNSP	Distribution Network Service Provider
ESS	Essential System Services
FCAS	Frequency Control Ancillary Services
Hosting capacity	Ability of a power system to accept DER generation without adversely impacting power quality such that the network continues to operate within defined operational limits (without experiencing voltage or thermal violations).
ISP	Integrated System Plan
LRMC	Long run marginal cost
NEL	National Electricity Law
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
PQRM	Power Quality Response Mode
RIN	Regulatory Information Notice
RIT-D	Regulatory Investment Test - Distribution
SRMC	Short run marginal cost
VaDER	Value of Distributed Energy Resources