
Australian Energy Market Commission

CONSULTATION PAPER

REVIEW INTO CONSUMER ENERGY RESOURCES TECHNICAL STANDARDS

29 SEPTEMBER 2022

REVIEW

INQUIRIES

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ABOUT THE AEMC

The AEMC reports to the Energy Ministers' Meeting (formerly the Council of Australian Governments Energy Council). We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the Energy Ministers' Meeting.

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CONTENTS

1	Introduction	1
1.1	Related market body work	3
1.2	Review milestones	4
1.3	Making a submission	4
2	Context	5
2.1	Record CER investment	5
2.2	Minimum inverter standards in the NER	7
2.3	Stakeholder interest in compliance and enforcement	8
3	Objectives and scope	10
3.1	Objectives	10
3.2	Scope	10
4	Assessment framework	12
4.1	Achieving the NEO and the NERO	12
4.2	Proposed assessment framework	13
5	Issues for consultation	15
5.1	Non-compliance with CER technical standards	15
5.2	Market impact of non-compliance	17
5.3	Regulatory and market context for improving compliance	23
	Abbreviations	27
	APPENDICES	
A	Final terms of reference	28
	TABLES	
Table 1.1:	Related work programs: AEMC, AER and ESB	3
Table 5.1:	Historical power system disturbances	18
	FIGURES	
Figure 2.1:	Total solar PV systems installed in Australia	5
Figure 2.2:	Total residential batteries installed in Australia	6
Figure 5.1:	Estimated distributed PV output	19
Figure 5.2:	PV hosting capacity as compliance increases	22
Figure 5.3:	Roles and responsibilities for CER technical standards	25

1 INTRODUCTION

Australian households, businesses, and other energy users continue to buy and install consumer energy resources (CER)—including rooftop solar PV, battery storage systems, and electric vehicles—at record rates. As a result, the technical standards determining how these devices perform and interact with each other are increasingly relevant to the security, reliability, and affordability of power supply in the national electricity market (NEM).

In this context, the Australian Energy Market Commission (Commission or AEMC) recently set out its work plan for CER technical standards.¹ The plan consists of five distinct roles:

- **Role one:** identify when new CER technical standards are needed
- **Role two:** actively work with the Energy Security Board (ESB) and the Australian Renewable Energy Agency (ARENA)'s Distributed Energy Integration Program (DEIP) to support existing work on CER technical standards
- **Role three:** observe Standards Australia's CER committees to contribute to the established work program
- **Role four:** update CER technical standards in the National Electricity Rules (NER) by assessing any rule change requests to add, update or amend technical standards in the NER, as required
- **Role five:** report on progress adopting technical standards in the NER.

Each role is part of broader efforts to fully realise the consumer benefits from the NEM's technical integration of distributed energy resources (DER), including consumer energy resources (CER).

The Commission has committed to making sure all five essential roles for CER technical standards are being fulfilled efficiently by complementing jurisdictions, other energy market bodies and broader industry initiatives.²

In its recent considerations and consultations with stakeholders, the Commission identified the need to prioritise action under role five. That is, to self-initiate a review of the NEM's progress adopting CER technical standards.

The Commission is initiating this review under section 45 of the National Electricity Law (NEL) and section 232 of the National Energy Retail Law (NERL).³

Commencing with the publication of this consultation paper, the review is focused on:

- compliance with, and enforcement of, CER technical standards in the NER
- the interpretation of standards by NEM participants and others
- interactions between the National Electricity Rules (NER) and other regulatory regimes.

1 AEMC, *Governance of distributed energy resources*, final rule determination, 17 March 2022.

2 AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022.

3 Part 4 of the NEL and Part 9 of the NERL set out the functions and powers of the AEMC. Under Division 5 of Part 4 of the NEL and Division 5 of Part 9 of the NERL, the AEMC has the power to conduct a review into the operation and effectiveness of the National Electricity Rules (NER) and National Energy Retail Rules (NERR), respectively.

While the initial focus will be on the implementation of existing obligations in the NER (namely, AS 4777.2:2020), this will inform a broader analysis of approaches to implementing future CER technical standards.

The experiences from making AS 4777.2 a requirement of standard connection agreements for embedded generation (EG) connections will enable stakeholders and the Commission to consider potential changes that would support improved integration of CER. Improved integration should benefit CER owners as well as distribution networks and the NEM. This is relevant to AS 4777.2 as well as future technical standards such as interoperability and other requirements, such as CSIP-Aus (for more, see section 1.1).

As this review's focus is on consumer outcomes from DER, including the interactions between device owners and the broader power grid, the term CER will be used throughout the project. The exception will be in direct reference to recent changes to the NER where, for example, the concept of 'DER technical standards' is expressly included and defined (for more see section 2.2).

For more on the shift in terminology from DER to CER, see Box 1 below.

BOX 1: DER OR CER? AN EXPLANATION OF TERMINOLOGY

To recognise the central role of consumers in Australia's energy transition, the AEMC has adopted new terminology. 'Consumer energy resources' (CER) refers to behind-the-meter energy resources owned and operated by households. Capable of generating energy or actively controlling demand for grid power, examples of these devices include solar PV, battery energy storage systems, and electric vehicles. By adopting this new terminology, the AEMC aims to make the policy debates and market reforms in support of Australia's energy transition as accessible to consumers as the technology itself.

This approach is consistent with Energy Consumers Australia's recent terminology change.¹

Note: 1. Energy Consumers Australia, Death to DER? Why we need to change the language we use for the energy transition, 2 May 2022.

This consultation paper is intended to initiate public consultation with NEM participants and other stakeholders, including by seeking written submissions. The purpose of this consultation is to better understand the extent of non-compliance with existing standards and consider any rule changes or other reforms that might be needed in response, to address existing compliance issues and establish suitable arrangements for future CER technical standards.

The review will consider the need for potential rule changes to address compliance and enforcement issues identified through analysis and consultations. Where necessary, the review will also consider the need for other actions in response to identified issues. This could include reforms under other jurisdictional frameworks where, for example, action is required by parties other than NEM participants.

In the remainder of this paper:

- Chapter 2 provides further context for this review
- Chapter 3 sets out the review's scope
- Chapter 4 proposes an assessment framework
- Chapter 5 sets out the main issues on which the Commission is seeking stakeholder feedback, including an initial analysis of compliance and enforcement issues.

1.1 Related market body work

Energy market bodies are, collectively, releasing three consultation papers in September and October 2022 as part of the Energy Security Board's (ESB) *Consumer Energy Resources (CER) Implementation Plan*.

The ESB and market bodies welcome stakeholder consideration and input into these processes, noting the interlinked nature of these issues and the importance of considering their impact and outcomes on consumers and market participants holistically.

To support this broader consideration, where stakeholders provide feedback into any one of these processes, these will be shared across the agencies. The ESB and market bodies also plan to hold joint webinars to enable collective stakeholder consideration of issues. Dates for submissions and stakeholder webinars will be published on the ESB website.

The following table summarises the scope of the papers to assist stakeholders plan their engagement:

Table 1.1: Related work programs: AEMC, AER and ESB

MARKET BODY	PAPER	SUMMARY
Australian Energy Market Commission	Review of CER technical standards consultation paper	This paper seeks stakeholder feedback on issues associated with implementing CER technical standards, including existing inverter standards (AS 4777.2). Issues for consultation include the extent of non-compliance with the NER, the market impact of any non-compliance, and the impact of roles and responsibilities across the NER and jurisdictional arrangements. This work was anticipated in the final determination on the <i>Governance of DER technical standards</i> in March 2022.
Australian Energy Regulator	Implementation of Flexible Export Limits by Distribution Network Service Providers (DNSPs) issues paper	This paper seeks stakeholder input on how consumers' interests can best be enhanced through the evolution of regulatory frameworks to support the implementation of flexible export limits including opt in/opt out arrangements for consumers, conformance monitoring, approaches to compliance and rectification, and implications of flexible exports for market participants.
Energy	Interoperability for	Following submissions on the ESB's <i>Interoperability</i>

MARKET BODY	PAPER	SUMMARY
Security Board	Consumer Energy Resources directions Paper	<i>Issues Paper</i> , this paper sets out the ESB's position on priorities and actions to promote greater interoperability of CER. This includes an implementation framework for CSIP-Aus to support a nationally consistent approach to flexible exports limits, and the future development of standards for behind-the-meter interoperability and interoperability for market participants. This paper will highlight roles and responsibility issues raised in the specific context of interoperability that will be investigated more fully through the AEMC CER Technical Standards Review process.

1.2 Review milestones

The review's milestones include:

- publish consultation paper and commence review: **29 September 2022**
- submissions to the consultation paper due by: **3 November 2022**
- publish draft report: **2 March 2022**
- submissions to the draft report due by: **30 March 2023**
- publish final report: **1 June 2023**.

1.3 Making a submission

Written submissions on the review must be lodged with Commission by 3 November 2022 online via the Commission's website, www.aemc.gov.au, using the "lodge a submission" function and selecting the project reference code EMO0045.

The submission must be on letterhead (if submitted on behalf of an organisation), signed and dated.

Where practicable, submissions should be prepared in accordance with the Commission's guidelines for making written submissions on reviews.⁴ The Commission publishes all submissions on its website, subject to a claim of confidentiality. All enquiries on this project should be addressed to Andrew Swanson at andrew.swanson@aemc.gov.au.

⁴ This guideline is available from www.aemc.gov.au.

2 CONTEXT

This chapter provides context for this review and outlines the:

- record CER investment in the NEM
- minimum inverter standards in the NEM
- governance arrangements for CER technical standards
- stakeholder interest in compliance and enforcement.

2.1 Record CER investment

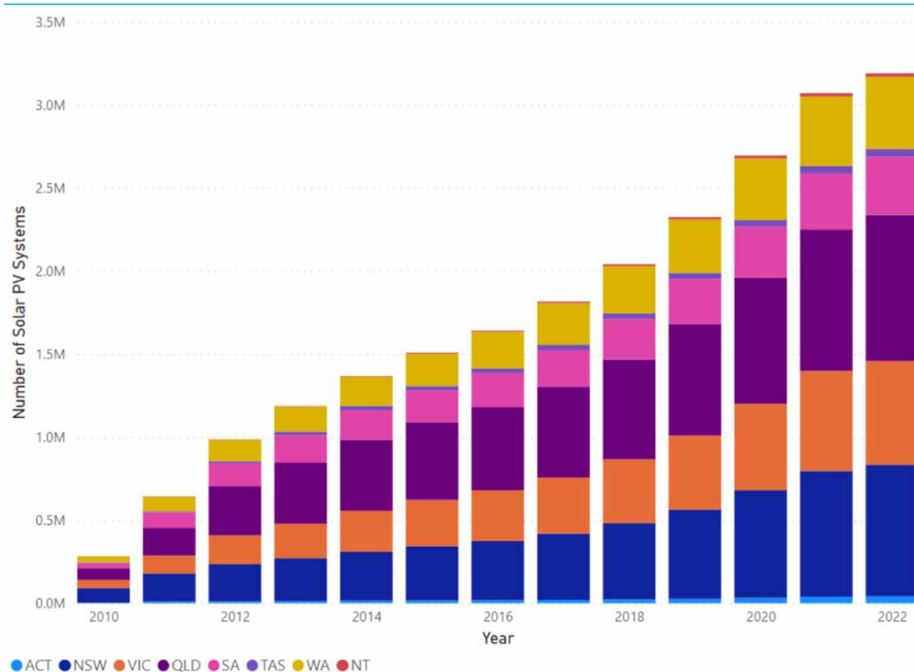
Households, businesses, and other energy consumers continue to install new CER capacity across Australia at record rates. This investment in new CER is part of Australia's overall transition toward greater reliance on decentralised, variable generation resources.

For example, in the NEM today:⁵

- approximately 30 per cent of detached homes have rooftop PV
- the total capacity of rooftop PV is about 15 gigawatts (GW).

The rapid rate at which households have installed solar PV is illustrated by the increasing number of devices installed across Australia since 2010 (see figure below).

Figure 2.1: Total solar PV systems installed in Australia

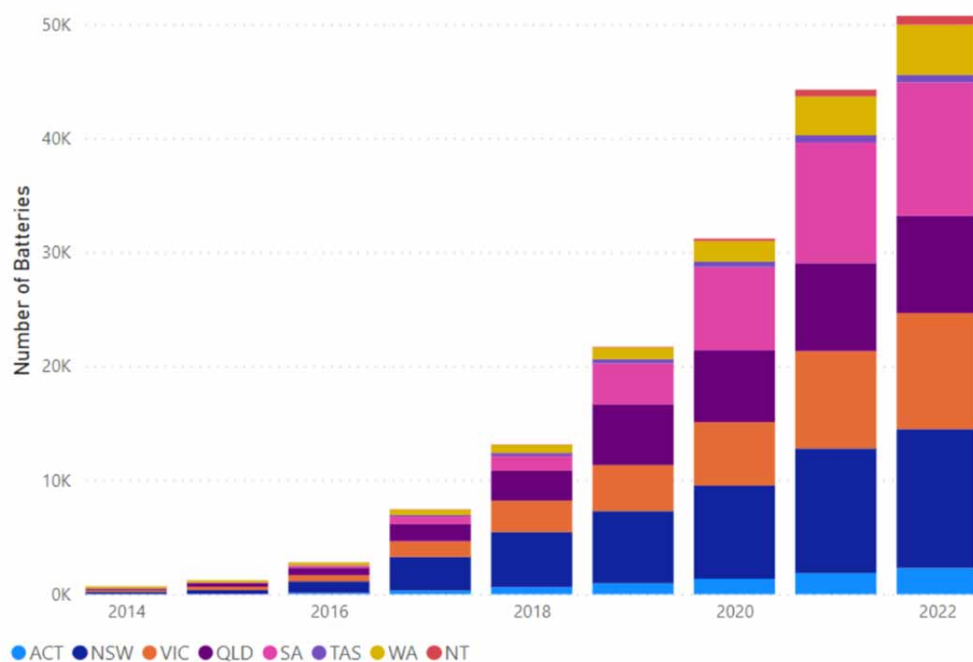


Source: AEMC analysis of Clean Energy Regulator data as of June 2022.

⁵ Clean Energy Regulator data.

Investment in behind-the-meter battery storage systems is also increasing, with the figure below illustrating total residential batteries installed across Australia since 2014.

Figure 2.2: Total residential batteries installed in Australia



Source: AEMC analysis of Clean Energy Regulator data as of June 2022.

CER investment is forecast to continue. The Australian Energy Market Operator (AEMO) estimates that:

- by 2032 more than half of NEM-connected households will have rooftop PV
- by 2050, 65 per cent of NEM-connected households will have rooftop PV, representing 69 GW capacity—in other words, capable of meeting nearly one-fifth of the NEM's total underlying demand.⁶

From a consumer perspective, the ESB Customer Insights Collaboration has highlighted the changing nature of the customer journey for energy, which is becoming more complex and where new risks are emerging.⁷ The Customer Insights Collaboration work program has found that the timely and consumer-friendly standardisation of energy technologies (including installation and operation) can play a critical role in meeting consumer expectations of CER. Relevant technical standards that are effectively enforced can assist in achieving this outcome.⁸

⁶ AEMO, Integrated system plan — step change scenario, 30 June 2022.

⁷ ESB, DER implementation plan customer insights collaboration release 1, June 2022.

⁸ ACIL Allen, *Barriers and enablers for rewarding consumers for access to flexible DER and energy use*, 20 June 2022.

For NEM consumers, the significance of this new investment is that it shifts the power grid towards being more reliant on two-way power transfers. This compares to the original approach of one-way power transfers from a relatively small number of coal, gas, and hydro generators to passive energy consumers.

The increased reliance on two-way power transfers poses both benefits and new risk for operating the grid securely and reliably. For example, the aggregate performance of CER can pose a considerable risk to AEMO's ability to maintain key operational limits in the market, like voltage and inertia. This can lead to increased difficulty balancing generation across dispatch intervals to cater for uncertain CER performance.

The introduction of timely technical standards provides an opportunity for consumers and other CER owners to both benefit from increased investment in CER capacity and contribute to the continued realisation of secure and reliable power supply.

2.2 Minimum inverter standards in the NER

On 25 February 2021, the Commission made a rule to introduce CER technical standards in the NER. The rule was made in response to a rule change request from AEMO.

This rule:⁹

- created DER Technical Standards for embedded generating units connecting to a distribution network through a micro EG connection service
- defined DER Technical Standards as the requirements set out in Australian Standard AS 4777.2:2020 as in force from time to time
- required embedded generating units the subject of model standing offers for basic micro EG connection services to comply with DER Technical Standards
- obliged Distribution Network Service Providers to inform connection applicants about the need to comply with DER Technical Standards, if the connection applicant is proposing to connect a new or replacement embedded generating unit through a basic micro EG connection service
- included a requirement in the minimum content requirements of connection offers for connection applicants connecting a new or replacement embedded generating unit to comply with the DER Technical Standards
- applied DER Technical Standards to new connections or replacement inverters and connection alterations.

The final rule commenced on 18 December 2021. This coincided with the date upon which AS 4777.2:2020 came into effect.

2.2.1 Governance arrangements for DER technical standards

On 17 March 2022, the Commission published its final determination in response to the governance of DER technical standards rule change request. The final rule determination

⁹ See clauses 5A.B.2, 5A.C.3, and Schedule 5A.1 of the NER.

included an AEMC work plan with five distinct roles essential to support the full realisation of CER's potential benefits for consumers.

- **Role one:** Identify when new CER technical standards are needed by consulting with stakeholders on the priorities from CER technical standards.
- **Role two:** Actively work with the Energy Security Board (ESB) and the Australian Renewable Energy Agency (ARENA)'s Distributed Energy Integration Program (DEIP) to support existing work on CER technical standards such as interoperability and dynamic operating envelopes. This work complements existing initiatives to identify the NEM's interests from new and updated DER technical standards.
- **Role three:** Observe Standards Australia's CER committees to contribute to the established work program. The AEMC has expanded its non-voting participation role in Standards Australia's CER-related committees such as those on electrical metering equipment, minimum inverter standards, and smart energy.
- **Role four:** Update DER technical standards in the NER as required by assessing rule change requests to add, update or amend technical standards in the NER.
- **Role five:** Report on progress adopting technical standards in the NER. In conjunction with the work planned under role one, the AEMC will also assess the NEM's progress adopting standards already introduced in the NER (such as minimum inverter standards) to identify any amendments to implementation processes that could be improved for current and future standards.

This work plan utilises the AEMC's existing ability to self initiate a review and establish committees, panels and working groups of external experts as needed. These powers allow the AEMC to consider how existing rules are achieving the national energy objectives and the extent to which reforms may be needed.¹⁰

The final rule determination in which the AEMC set out its work plan for CER technical standards was made in response to a rule change request from Dr Kerry Schott AO, as then Chair of the ESB.¹¹

2.3 Stakeholder interest in compliance and enforcement

In its commitment to self initiate a review of CER technical standards, the Commission published draft terms of reference (ToR) for further consultation with its final determination in March 2022. The draft ToR was intended to set out the initial actions the Commission would take to fulfil roles one and five, as needed, under the work plan for CER technical standards.

The draft ToR proposed a review to:

¹⁰ Part 4 of the NEL and Part 9 of the NERL set out the functions and powers of the AEMC. Under Division 5 of Part 4 of the NEL of the NEL and Division 5 of Part 9 of the NERL, the AEMC has the power to conduct a review into the operation and effectiveness of the NER and the NERR, respectively.

¹¹ AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022.

- identify existing activities (and their prioritisation) regarding the introduction of CER technical standards, including the roles and responsibilities of organisations undertaking these activities
- consider the progress made on implementing CER technical standards
- identify, and prioritise, any new work or action required to develop CER technical standards.¹²

The AEMC has since held multiple meetings with interested NEM participants, other industry stakeholders, jurisdictions, and market bodies over the past six months.

Overall, stakeholders conveyed a strong interest in the review focusing on compliance and enforcement issues related to implementing existing CER technical standards. While stakeholders also raised other issues, such as the overall roles and responsibilities relevant to developing and implementing standards, no other issue was prioritised by stakeholders to the same extent across stakeholder groups and perspectives.

In part, the consensus among stakeholders for the review to focus on compliance and enforcement issues related to the time at which the stakeholder engagement took place. The commencement of minimum inverter requirements on 18 December 2021 means industry and others now have practical experience implementing the standard. This provides the Commission with an opportunity to revisit assumptions informing that rule change, and draw any relevant lessons for both the improved effectiveness of AS4777.2:2020 and future CER technical standards that may be introduced in coming years.

See section 5.2 for more on the AEMC's initial analysis of compliance and enforcement issues.

¹² AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022, pp. 33-34.

3 OBJECTIVES AND SCOPE

This chapter outlines the objectives and scope of this review.

3.1 Objectives

The review's objective is to support CER's successful integration for the long-term benefit of electricity consumers. It will do this by assessing the NEM's 'state of play' implementing CER technical standards and identifying necessary next steps for market participants, market bodies, and other relevant parties.

The review's primary focus will be reporting on the progress in adopting and implementing CER technical standards across the NEM. As context for these implementation issues, the review will also:

- identify existing activities in relation to CER technical standards
- clarify consumer and NEM need for new CER technical standards.

This will allow the AEMC to consider the actions and arrangements to implement CER technical standards to support the NEM's continued transition. It will do this by identifying potential issues requiring further action that would enable improved implementation of existing and future technical standards.

3.2 Scope

In response to initial stakeholder engagement, the Commission has decided to focus this review on compliance and enforcement of technical standards in the NEM.

It will commence with identifying the existing arrangements in place relating to compliance and enforcement of CER technical standards, specifically in relation to AS 4777.2 (as this is the standard that is enforced through the NER).

In addition, the review will seek to clarify the needs and expected outcomes from the successful implementation of CER technical standards, including but not limited to AS4777.2, from the perspective of NEM participants and consumers.

In undertaking the review, the AEMC will publish a report that:

- considers the progress made in implementing existing CER technical standards
- identifies existing activities (and their prioritisation) regarding the implementation of CER technical standards in the NER and related frameworks, including roles and responsibilities related to compliance and enforcement
- identifies, and prioritises, any new work or actions required to better realise the objectives of introducing technical standards in the NER.

It is anticipated that information obtained about the existing standards will be able to inform a generally applicable approach or framework to consider how to achieve improved and workable technical standard compliance across the NEM that balances the needs and objectives of different stakeholders. This would clarify and support the development and

implementation of future technical standards for CER in the NEM, including interoperability requirements.

In carrying out this review, the AEMC will:

- engage with industry stakeholders, consumer representatives, relevant jurisdictional bodies across Australia, the ESB, AEMO, and the Australian Energy Regulator (AER).
- obtain advice as needed from market participants and/or independent consultants through committees, working groups, and reports as relevant
- provide a draft report for consultation before publishing a final report no later than 12 months from the date of commencing the review.

4 ASSESSMENT FRAMEWORK

This chapter outlines the:

- decision-making framework the Commission will apply to determine whether the recommendations made through this review contribute to the national electricity objective (NEO) and the national energy retail objective (NERO)
- proposed assessment framework for this review.

4.1 Achieving the NEO and the NERO

This review is considering potential changes to the NER and the National Energy Retail Rules (NERR). As such, the national energy objectives relevant to this review are the national electricity objective (NEO) and the national energy retail objective (NERO).

The NEO is:¹³

to promote efficient investment in, and efficient operation and use of, electricity services for the longer 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 NERO is:¹⁴

to promote efficient investment in, and efficient operation and use of, energy services for the long term interests of consumers of energy with respect to price, quality, safety, reliability and security of supply of energy.

The Commission must also, where relevant, satisfy itself that a rule is “compatible with the development and application of consumer protections for small customers, including (but not limited to) protections relating to hardship customers” (the “consumer protections test”).¹⁵

Where the consumer protections test is relevant in the making of a rule, the Commission must be satisfied that both the NERO test and the consumer protections test have been met.¹⁶ If the Commission is satisfied that one test, but not the other, has been met, the rule cannot be made.

There may be some overlap in the application of the two tests. For example, a rule that provides a new protection for small customers may also, but will not necessarily, promote the NERO.

¹³ Section 7 of the NEL.

¹⁴ Section 13 of the NERL.

¹⁵ Section 236(2)(b) of the NERL.

¹⁶ That is, the legal tests set out in s. 236(1) and (2)(b) of the NERL.

4.2 Proposed assessment framework

To determine whether the recommendations made through this review would likely promote the NEO and the NERO, the Commission will carry out its assessment of any potential recommendations against an assessment framework. The framework may be refined during the review process. The Commission is seeking stakeholder views on its proposed assessment framework, which includes the following criteria:

Consumer outcomes

- Will compliance with technical standards to maximise the ability of Distribution Network Service Providers (DNSPs) to connect optimal CER capacity be promoted?
- Will enforcement approaches impact on how consumers buy and use CER in practice, including interactions with device installers?

Safety, security and reliability

- **System risks:** What will be the impact of non-compliance on long-term consumer costs from:
 - voltage disturbances
 - procuring ancillary services
 - distribution network constraints
 - remote solar disconnection
 - other grid disruptions.

Implementation considerations

- **Cost and complexity:**
 - How will the market cost from any regulatory interventions to enforce technical standards compare to alternatives for consumers (device owners and non-device owners)?
 - Have options to address any potential unnecessary regulation been considered?
- **NEM-wide solutions:**
 - What is the extent to which the NEM would benefit from consistent approaches to compliance and enforcement of technical standards?
 - Would CER uptake, and the grid consequences of this, differ across NEM jurisdictions as a result of the recommendations?
 - What are the limitations to introducing obligations under the National Energy Rules and Laws?

Principles of good regulatory practice

- **Simplicity and transparency:**
 - Have the interactions between the NER and jurisdictional frameworks for technical standards been considered?
 - Will any information asymmetries between market participants with respect to technical standards be addressed?

- **Principles-based approach:**

- Will a principles-based approach to encourage the greater realisation of CER's potential benefits be beneficial compared with more prescriptive approaches to increase compliance?

Decarbonisation:

- **Timely transition:** What are the contributions of device uptake to emissions reduction?

QUESTION 1: ASSESSMENT FRAMEWORK

1. Is the proposed assessment framework appropriate ?
2. Are there any other relevant considerations that should be included in the assessment framework?

5 ISSUES FOR CONSULTATION

There are three main issues for consultation for this review:

- non-compliance with CER technical standards
- market impact of non-compliance
- regulatory context for improving compliance.

This chapter seeks stakeholder feedback on each issue, including the evidence and assumptions on which the analysis is based.

5.1 Non-compliance with CER technical standards

The first issue for the review to consider is the extent of non-compliance with existing DER technical standards in the NER.

As discussed in section 2.3, industry stakeholders and market bodies are concerned by the significant non-compliance with the technical standard for minimum inverter ride through (AS 4777.2:2020).

Below, the Commission sets out its initial understanding of:

- the level of non-compliance with the existing standard
- potential reasons for non-compliance.

5.1.1 What is the level of non-compliance?

The total level of non-compliance in Australia is difficult to quantify with significant data gaps in certain jurisdictions due to the nature of collecting data on non-compliant devices. There are however some statistics in relation to the level of compliance in both Victoria and South Australia. The data includes:

- analysis of smart meter data estimates on Citipower's network in Victoria shows that up to 80 per cent of all distributed energy resource connections made since December 2019 either have no smart inverter settings or have incorrect settings applied¹⁷
- approximately 50 per cent of new solar inverter installations are compliant with Citipower's own requirements¹⁸
- based on available meter data, in July 2022 SA Power Networks determined less than 30 per cent of relevant CER-connected devices complied with AS4777.2:2020.¹⁹

While this information provides an initial view that compliance with AS 4777.2:2020 is low, understanding non-compliance rates occurring in the various distribution networks across all NEM jurisdictions will help inform the scope and materiality of the issue. Such information may also provide insights into whether there are any systemic reasons for low compliance rates as well as providing a basis upon which to gauge potential solutions. Stakeholders are

¹⁷ Citipower, Smart inverter compliance briefing paper, 30 August 2022, p. 1.

¹⁸ *ibid.*

¹⁹ SA Power Networks.

invited to provide their insights into non-compliance rates in the various distribution network areas and other data relating to compliance of CER devices with AS 4777.2:2020.

5.1.2

What are the reasons for non-compliance?

Over the life cycle of CER devices, compliance with technical standards requires certain action at three distinct stages:

- manufacture
- installation
- ongoing operation.

If devices are non-compliant, this suggests there may be difficulties implementing the technical standard at one or more of these three stages.

Based on preliminary consultation, the Commission understands that for AS4777.2:2020:

- Devices are largely complying with the standard at the manufacturing stage.
 - This understanding reflects largely satisfactory results when testing random samples of devices supplied by original equipment manufacturers (OEMs) for sale in the Australian market.
 - For example, recent bench testing of a sample of AS 4777.2:2020 compliant PV inverters by the University of New South Wales presented promising evidence that compliant and correctly configured inverters are robust to a range of severe voltage and frequency disturbances.²⁰
- There is little evidence for, or incentives to suggest, widespread non-compliance once devices have been installed.
 - Non-compliance during ongoing operations would suggest individual consumers are adjusting or otherwise disrupting device settings once the device is connected to the distribution network.
 - It is unclear many consumers would have the necessary technical knowledge and confidence, or incentive, to make such adjustments after devices are installed.
 - Further, the standard is intended to support devices riding through minor voltage disturbances, and therefore remaining connected to the distribution network for greater periods of time. This suggests any financial incentives for consumers adjusting individual devices points towards greater compliance, due to the potential revenue from feed-in tariffs, rather than less compliance.

By contrast, preliminary consultation suggests there may be some difficulties associated with installing relevant devices in accordance with AS4777.2:2020.

Potential issues during installation include:

- confusion about how to configure devices in accordance with the updated standard
- default device settings are not set for the latest standards

²⁰ [ARENA and UNSW, Addressing Barriers to Efficient Renewable Integration - Milestone Report 6, 2021.](https://arena.gov.au/assets/2022/04/addressing-barriers-to-efficient-renewable-integration-milestone-report-6.pdf)
<https://arena.gov.au/assets/2022/04/addressing-barriers-to-efficient-renewable-integration-milestone-report-6.pdf>.

- the extent to which installers are responsible (if at all) for installing devices in accordance with NER requirements
- uncertainty about the interaction between CER technical standards in the NER and installation requirements under jurisdictional frameworks.

Further, preliminary stakeholder engagement also suggests that there may be a lack of clarity among NEM participants and other industry stakeholders about the process for resolving any differing interpretations of published standards such as AS4777.2:2020.

This review will also consider the extent to which non-compliance can be explained by the need for more certainty about the roles and responsibilities of NEM participants, other industry stakeholders, and market bodies. For more, see section 5.3.

QUESTION 2: COMPLYING WITH CER TECHNICAL STANDARDS

1. What is the rate of compliance with the NER's minimum inverter standards for micro-embedded generation units?
2. Do compliance rates differ between NEM jurisdictions? If so, why would this be the case?
3. What are the reasons for any non-compliance by DNSPs, manufacturers and consumers?
4. Are there differences in the obligations to comply with minimum inverter standards between the NER and jurisdictional frameworks? If so, what do you understand these differences to be? What is the rate of compliance with jurisdictional requirements for minimum inverter standards?
5. What are the rates of compliance with other CER technical standards obligations under jurisdictional frameworks?

5.2 Market impact of non-compliance

The second issue the review will consider is the market impact of any non-compliance with CER technical standards. Potential market impacts include costs for consumers from:

- less secure and reliable power supply
- increased network expenditure
- reduced ability to install DER.

Market impacts also include the potential benefits from regulatory intervention.

5.2.1 Security and reliability of power supply

As noted above, information available to the Commission suggests there is significant non-compliance with the CER technical standards prescribed in the NER in some distribution network areas. If this level of non-compliance occurs in other network areas, then the most likely market impact of non-compliance would be the widespread and unintended disconnection of solar PV following a disturbance in the power grid. Not only would this be

difficult for DNSPs to manage within their networks, but it would also impact on AEMO's operations.

Since 2018, AEMO has undertaken a program of work to understand the aggregate behaviour of distributed PV during and after a voltage or frequency disturbance.²¹ A key finding from AEMO's work is that there is significant evidence of widespread solar PV disconnection following power system disturbances. This uncontrolled disconnection of distributed PV at scale presents a risk to power system security. Without action, this risk will likely increase with continued investment in new CER capacity in the NEM.

When operating normally, a rooftop PV system acts like a generator that is supplying demand behind the meter and/or exporting excess electricity to the grid. When aggregated across a region, solar PV can act like a very large generator, particularly in the middle of the day when the sun is shining.

AEMO's analysis of historical power system disturbances demonstrates that a proportion of installed solar PV consistently disconnects during or after a disturbance. See the table below.

Table 5.1: Historical power system disturbances

EVENT DATE/TIME	REGION	DISTURBANCE	DPV DISCONNECTION (MW/% OF TOTAL DPV)	LOAD LOSS (MW)
03/03/2017 15:03	SA	Voltage	150 / 42%	400
18/01/2018 15:20	VIC	Voltage	120 / 28%	550
25/08/2018 13:11	QLD	Voltage / Frequency	165 / 17%	0
26/11/2019 12:14	QLD	Voltage	240 / 12%	550
04/01/2020 15:10	VIC	Voltage / Frequency	140 / 13%	0
04/01/2020 15:10	NSW	Voltage / Frequency	90 / 7%	0
31/01/2020 13:24	SA	Voltage / Frequency	180 / 30%*	0
24/01/2021 16:13	SA	Voltage	100 / 17%	350
13/03/2021 17:08	SA	Voltage	70 / 15%	160
25/05/2021 14:06	QLD	Voltage / Frequency	119 / 11%	0

Source: AEMO, Behaviour of distributed resources during power system disturbances, May 2021.

Note: DPV = distributed PV.

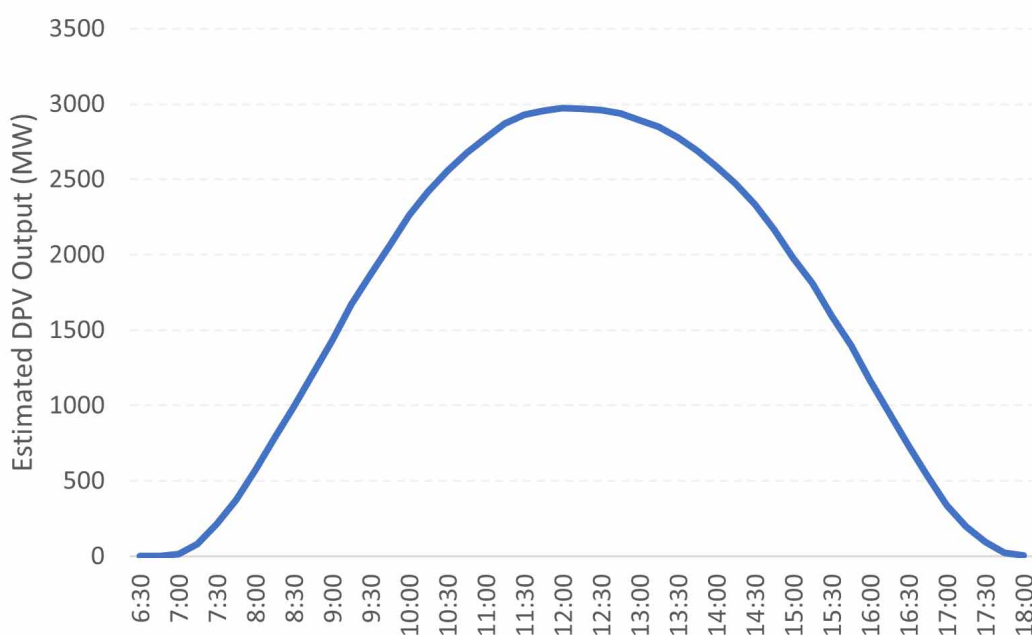
*Part of the aggregate DPV loss was not due to disconnections, but from the correct operation of over-frequency drop response specified in AS/NZS 4777.2:2015.

21 AEMO, Behaviour of distributed resources during power system disturbances, overview of key findings, May 2021: <https://aemo.com.au/-/media/files/initiatives/der/2021/capstone-report.pdf?la=en&hash=BF184AC51804652E268B3117EC12327A>

If solar PV disconnection issues are left unaddressed, the aggregate volume of solar PV at risk of disconnection is likely to continue increasing in line with the increasing number of devices connected to distribution networks. As discussed in section 2.1, AEMO forecasts the NEM's total household PV capacity will be more than double present levels by 2030. This suggests the aggregate capacity at risk of disconnecting will, over time, increase to levels equivalent to the NEM's large generators.

Even today, there are times when the total capacity of solar PV at risk of disconnecting from the grid is approaching risks presented by the NEM's largest generator contingency risk. For example, the figure below shows the estimated solar PV output in Queensland on Wednesday 27 July 2022. This was a cool and sunny winter day. At 11:30 am local time, the estimated output from solar PV in the jurisdiction was 2,958 MW.

Figure 5.1: Estimated distributed PV output



Source: AEMC analysis of Australian Photovoltaic Institute data.

If a voltage disturbance had occurred at 11:30 am that was similar in scale to a previous event in November 2019 and where a similar proportion of solar PV disconnected (approximately 12 per cent), then Queensland would have experienced:

- approximately 355 MW of aggregate solar PV disconnecting²²

²² https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2019/incident-report-south-pine-incident-on-26-nov-19.pdf?la=en&hash=0DF7B519D37BF3CCA1FCF9CF4A4C0CE7.

- a loss of generation output close to that of the jurisdiction's largest generation unit at the time.²³

Given the similar supply risks posed by both types of potential generation loss, AEMO (as market operator) and DNSPs need sufficient measures in place (such as widespread compliance with CER technical standards) to help maintain power supply.

The case above raises further considerations for the security and reliability of power supply during a widespread disconnection of aggregate solar PV. These include the potential for:

- solar PV to become the largest credible contingency risk in the system (net of any concurrent load tripping). This would trigger frequency control ancillary services (FCAS) contingency raise requirements in response.
- aggregate solar PV disconnection exacerbating generation contingencies. For example, a fault on a generator step-up transformer could lead to the disconnection of a large generator while also causing a voltage disturbance that leads to widespread DPV disconnection, thus making the generator contingency worse.
- less effective under-frequency load shedding (UFLS). This is the power system's 'last line of defence' in the event of a major generation contingency. If solar PV disconnected during an under-frequency load shedding event, potential consequences include the power system collapsing.²⁴

Further impacts for NEM consumers could follow from efforts by AEMO to manage the risks outlined above. For example:

- existing consumers with CER may be subject to pre-emptive curtailment or disconnection
- limits imposed on consumers wishing to install CER, for example, zero-export requirements.

In this context, the Commission understands the power system risks outlined above were important considerations in the 2020 revisions to AS4777.2. In particular, the updated standard specifies that inverters need to remain connected and continue generating during and after power system disturbances. This emphasises the need to achieve satisfactory compliance, in practice, with the requirements set out in the updated standard.

5.2.2

Distribution network hosting capacity

In addition to security and reliability considerations, another aspect of AS4777.2020 is that it has the potential to significantly increase the hosting capacity of distribution networks. The AEMC's recent rule change into DER access, incentives and pricing further focused on boosting network capacity as one of its core focuses.²⁵

In technical terms, the updated standard requires solar PV inverters to enable the volt-var response by default (clause 3.3.2.3 of AS 4777.2:2020). Under earlier versions of the

²³ The largest generating unit operating in Queensland at the time was Millmerran Unit 2 operating at 380 MW.

²⁴ https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/psfrr/2022-final-report---power-system-frequency-risk-review.pdf?la=en.

²⁵ AEMC, *Access, pricing and incentive arrangements for distributed energy resources*, rule determination, 12 August 2021.

standard, the volt-var response mode was optional and could be disabled by manufacturers and others by default.

The volt-var response mode in a PV inverter allows it to dynamically control voltages by injecting or absorbing reactive power. Distributed voltage control by PV inverters operating in volt-var response mode helps maintain distribution voltages within network compliance limits. This is particularly important at the ends of distribution feeders, which are the sets of conductors or lines from a DNSP substation that service a local distribution area that have high levels of CER, where high voltages at the upper edges of the allowable voltage range have been observed in many jurisdictions.²⁶

Absent volt-var control, as required by AS4777.2:2020, distribution voltage levels need to be managed by a variety of operational and planning measures. These measures include:

- limiting the installed capacity of CER on a feeder, for instance, capped to a feeder's CER hosting capacity
- dynamically limiting the output of CER via volt-watt response modes (using active power output instead of reactive power to control voltages) or dynamic operating envelopes
- adjusting the distribution or zone substation transformer tap positions, though this option can quickly become impractical and costly if many adjustments are required since the transformer can also run out of tap positions
- augmenting the network by upgrading transformers and/or conductors
- managing the timing of flexible customer loads, e.g. hot water systems.

Absent compliance with AS4777.2:2020, the above measures are likely to be costly for consumers and in some instances have only limited impact. By contrast, the use of distributed volt-var control has been demonstrated to effectively manage distribution voltages and significantly increase CER hosting capacity.²⁷

This indicates that compliance with the existing technical standard means hosting capacity can be potentially doubled in existing distribution networks. As a result, more people within a network would be able to connect solar PV and customers without solar PV connections would also benefit. Therefore, not resolving compliance with the technical standard makes more investment in PV by consumers inefficient until existing hosting capacity has been cleared. The figure below shows the approximate solar penetration rate in South Australia along with how an increase in compliance leads to an increase in PV hosting capacity.

²⁶ For example, refer to the voltage management in distribution networks consultation in Victoria — <https://engage.vic.gov.au/voltage-management-in-distribution-networks-consultation-paper>.

²⁷ For example, J. Seuss, M. J. Reno, R. J. Broderick and S. Grijalva, "Improving distribution network PV hosting capacity via smart inverter reactive power support," 2015 IEEE Power & Energy Society General Meeting, 2015, pp. 1-5.

Figure 5.2: PV hosting capacity as compliance increases



Source: SA Power Networks.

Further, consumers and other users in distribution networks could face restrictions connecting further CER capacity. This would be due to hosting capacity limitations on distribution networks that could have been alleviated through more widespread compliance with CER technical standard. An alternative way of increasing hosting capacity would be to more flexibly optimise existing infrastructure, including through compliance with CER technical standards.

5.2.3

Market benefits of regulatory intervention

In addition to considering the cost of non-compliance with AS 4777.2:2020, it is important to also consider the market costs of any potential enforcement action to remedy non-compliance. The cost of such intervention should be compared with alternative approaches, such as the voltage management approaches outlined above, and investment in expanded distribution network capacity. It will also be relevant to compare any costs from intervening to achieve better compliance with the value placed on consumers from being able to connect additional CER capacity to distribution networks in coming years.

This information will allow the Commission to consider reform options that support the long-term interests of consumers by maximising market benefits.

QUESTION 3: MARKET IMPACT OF NON-COMPLIANCE FOR CONSUMERS

1. What are the costs and benefits for all consumers from device owners complying with the NER's CER technical standards?
2. What are the costs and benefits for device owners from complying with the NER's CER technical standards?
3. Are consumers facing any market-wide costs from non-compliance by device owners?
4. How are consumers able to manage compliance costs?
5. Do consumers face any other detrimental experiences from non-compliance, such as complex experiences installing and operating devices?
6. Are device owning consumers aware of their obligations to comply with CER technical standards under the NER?

QUESTION 4: MARKET IMPACT OF NON-COMPLIANCE FOR DNSP'S AND OTHER NON-NEM PARTICIPANTS

1. What are the costs and benefits for DNSPs complying with the NER's CER technical standards?
2. Are these compliance costs and benefits expected to change with the NEM's increasing reliance on CER?
3. Do DNSPs face any significant challenges complying with jurisdictional requirements for CER technical standards? If so, how do these external challenges affect compliance with the NER?
4. How are DNSPs responding to non-compliant consumers?
5. What are the costs for non-NEM participants (such as OEMs and installers) from complying with the NER's CER technical standards?
6. Do NEM consumers face any indirect costs from compliance obligations on non-NEM participants?

5.3 Regulatory and market context for improving compliance

The third key issue for this review is the regulatory and market context for improving compliance. The two main aspects of this are the:

- diverse roles and responsibilities affecting compliance with CER technical standards
- potential regulatory constraints to improving compliance.

5.3.1 Diverse roles and responsibilities

The regulatory context for CER technical standards is characterised by a diverse number of stakeholders, with complex roles and responsibilities arising under a range of regulatory

frameworks and incentive schemes such as the Commonwealth Government's Small-scale renewable energy scheme (SRES).

In the context of the NER, the final determination on DER technical standards stated:²⁸

Placing the standard in the NER places an obligation on DNSPs to ensure the standard is met. This triggers the AER's existing capability to monitor and enforce this obligation.

This rule amended the requirements for DNSP connection agreements under Chapter 5A of the NER to include a requirement that the connecting micro embedded generator comply with AS 4777.2:2020 as updated from time to time in the NER. Despite this, the roles and responsibilities regarding compliance and enforcement of this NER obligation appear unclear to many parties.

Specifically, there appears to be a lack of clarity for some industry participants on the extent to which DNSPs have options for enforcing compliance with the NER's requirements for micro embedded generators connecting to the distribution network. The Commission understands that DNSPs consider there are limited options available to them to address non-compliance (i.e., the DNSP either requests the customer complies with AS 4777.2:2020, or else disconnects the customer for non-compliance with connection agreement requirements). If there are such limited practical options for enforcement under the framework, there are questions for the review to consider regarding the suitability of the arrangements for DER technical standards that commenced in the NER in December 2021.

The number of other parties involved in the area of CER technical standards, as noted above, appears to add confusion. While some of these roles and responsibilities fall under the NER, many others do not.

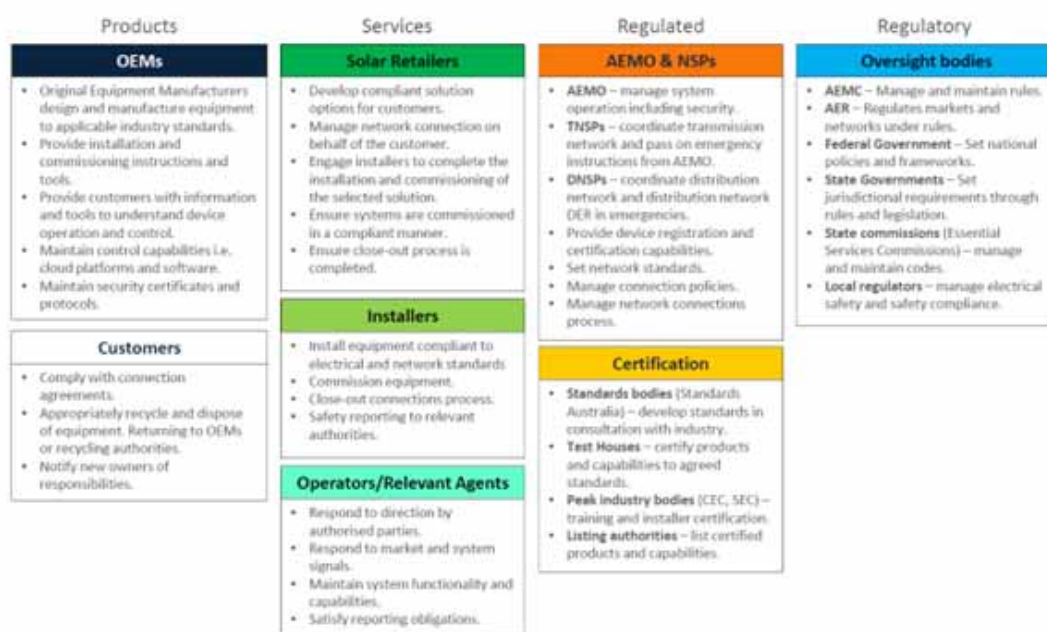
Across the lifecycle of CER devices, the diverse range of roles and responsibilities that can influence compliance outcomes include:

- manufacturing devices (original equipment manufacturers, OEMs)
- installing devices
- certifying devices as compliant with various regulatory and incentive schemes
- operating the distribution networks to which CER devices are connected
- enforcing regulatory regimes under which CER devices operate.

A further range of relevant roles and responsibilities are set out in the figure below as an indicative example of the diverse number of stakeholders involved.

²⁸ AEMC, *Technical standards for distributed energy resources*, rule determination, 25 February 2021.

Figure 5.3: Roles and responsibilities for CER technical standards



Source: SA Power Networks.

In considering options to improve compliance, the Commission will propose solutions to clarify the roles and responsibilities impacting compliance outcomes. Considerations will include:

- existing interactions between the NER and relevant jurisdictional frameworks
- what outcomes can be included with the NER and NERR frameworks and those that require action outside the NER and the NERR.

5.3.2

Potential regulatory constraints

Related to roles and responsibilities are the potential regulatory constraints to improving compliance.

As discussed in the final determination on the governance of DER technical standards, the Commission is bound by certain factors when making changes to the NER. These include:²⁹

- the need to make decisions in accordance with the National Electricity Law (NEL)
- an inability, under the NEL, to direct non-NEM participants such as regulators and other parties acting under regulatory frameworks established under various jurisdictional regimes.

²⁹ AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022.

In other words, for example, the AEMC may determine it is preferable to streamline multiple existing governance arrangements into a single framework. However, any such effort by the AEMC alone, in the absence of changes to jurisdictional frameworks, simply risks creating further regulatory layers for NEM participants and other stakeholders to navigate.

With this crucial context in mind, it will be important to consider what improvements to compliance with CER technical standards could be made that would work within, rather than external to, existing legal frameworks. This will assist the Commission making practical recommendations that can be implemented by NEM participants and others in a timely manner.

In addition, the Commission will consider potential actions and work with jurisdictions and other agencies to further streamline interactions between the NER and jurisdictional and other frameworks as needed. For example, some stakeholders have suggested the need to consider introducing a dedicated technical regulator with national jurisdiction to consider issues such as the implementation of CER technical standards.³⁰

QUESTION 5: ENFORCEMENT AND OTHER POTENTIAL SOLUTIONS

1. How are CER technical standards in the NER enforced?
2. What are the benefits of existing enforcement approaches? Are there any challenges?
3. What, if any, gaps are there in the enforcement framework for DER technical standards?
4. How can the NEM's market bodies work with non-NEM participants such as original equipment manufacturers, to improve compliance?
5. Are you aware of any penalties being applied to NEM participants for non-compliance with CER technical standards?
6. How do jurisdictions enforce CER technical standards (including the use of penalties)?
7. How do jurisdictional frameworks interact with NEM-wide CER technical standards introduced through the NER?
8. Is the ability of NEM participants to comply with technical standards in the NER affected by jurisdictional regulatory requirements?
9. What are some solutions for non-compliance with CER technical standards?
10. Are there any solutions from other jurisdictions that should be considered, both domestically and internationally?
11. Who should be responsible for compliance and enforcement of CER technical standards in the NER?

³⁰ Clean Energy Council, Correspondence to the AEMC, 29 March 2022.

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
CER	Consumer energy resources
Commission	See AEMC
DER	Distributed energy resources
DEIP	Distributed energy integration program
DPV	Distributed photovoltaic
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
OEM	Original equipment manufacturer
SRES	Small-scale renewable energy scheme

A FINAL TERMS OF REFERENCE

This appendix sets out the terms of reference for an AEMC initiated review on CER technical standards.

Context

In the final determination on the governance of CER technical standards, the AEMC identified five distinct roles to support CER technical standards and integration, and realise the benefits of CER:

1. identifying when the NEM needs new CER technical standards
 2. working with the Energy Security Board (ESB) and the Australian Renewable Energy Agency (ARENA)'s Distributed Energy Integration Program (DEIP) to complement existing efforts to identify the NEM's needs from CER technical standards
 3. participating in Standards Australia's CER committees as observing members
 4. updating CER technical standards in the NER, as required
 5. reporting on progress adopting standards and integrating CER.³¹
- The AEMC has also:
 - committed to undertaking each role to the extent it is not already being fulfilled by itself or others
 - noted it could fulfil roles 2, 3, and 4 through its ongoing operations and the rule change process
 - stated that the AEMC may self initiate a review to carry out roles 1 and 5, and may form a committee, working group, or panel of independent experts in support, as needed.³²
 - Under the NEL, the AEMC may conduct a review of the operation and effectiveness of the NER or any matter relating to the NER. Matters related to CER technical standards under existing NER provisions include:
 - Chapter 10: defining 'CER Technical Standards' in the NER
 - Schedule 5A.1: setting out minimum requirements for complying with CER technical standards in connection agreements between connecting parties and DNSPs, including minimum information requirements for standard agreements provided by DNSPs.

Review objective

- The review's objective is to support CER's successful integration for the long term benefit of electricity consumers. It will do this by assessing the NEM's 'state of play' implementing CER technical standards and identifying necessary next steps for market participants, market bodies, and other relevant parties.
- The AEMC will conduct a review to:

³¹ AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022.

³² AEMC, *Governance of distributed energy resources technical standards*, rule determination, 17 March 2022.

- identify existing activities in relation to CER technical standards
- clarify the NEM's needs from new CER technical standards
- report on progress on adopting and implementing CER technical standards across the NEM.
- This will allow the AEMC to consider existing work to develop and implement CER technical standards to support the NEM's continued transition. It will do this by identifying potential gaps requiring further action.

It is intended that the 2022-2023 review of CER technical standards will focus on compliance and enforcement of technical standards in the NEM.

In relation to the objectives for the 2022-2023 review, the AEMC will note the existing arrangements in place relating to compliance and enforcement issues of DER technical standards, specifically in relation to AS 4777.2 as referenced in the NER.

In addition, the 2022-2023 review will note the needs and expected outcomes from the successful implementation of CER technical standards, including but not limited to AS4777.2, from the perspective of NEM participants and consumers.

Scope

- In conducting the review, the AEMC will publish a report that:
 - identifies existing activities (and their prioritisation) regarding the introduction of CER technical standards, including the roles and responsibilities of organisations undertaking these activities
 - considers the progress made on implementing CER technical standards
 - identifies, and prioritises, any new work or action required to develop and implement CER technical standards.

These points will be addressed in the report in the context of compliance with the existing DER technical standards in the NER.

It is also anticipated that information obtained about existing standards will be able to inform a generally applicable approach or framework to consider how to achieve improved and workable technical standard compliance across the NEM that balances the needs and objectives of different stakeholders. This would support the development and implementation of future technical standards for CER in the NEM.

- In addition, the AEMC will:
 - engage with industry stakeholders, consumer representatives, relevant jurisdictional bodies, the Energy Security Board, Australian Energy Market Operator and the Australian Energy Regulator.
 - obtain advice as needed from market participants and/or independent consultants through committees, working groups, and reports as relevant.
 - provide a draft report for consultation in March 2023 before publishing a final report no later than 12 months from the date of commencing the review.