RELIABILITY PANEL AEMC

REVIEW

Reliability Panel AEMC

FINAL REPORT

DEFINITION OF UNSERVED ENERGY

1 AUGUST 2019

INQUIRIES

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ABOUT THE RELIABILITY PANEL

The Panel is a specialist body established by the Australian Energy Market Commission (AEMC) in accordance with section 38 of the National Electricity Law and the National Electricity Rules. The Panel comprises industry and consumer representatives. It is responsible for monitoring, reviewing and reporting on reliability, security and safety on the national electricity system, and advising the AEMC in respect of such matters.

RELIABILITY PANEL MEMBERS

Mr Charles Popple (Chairman), Chairman and AEMC Commissioner
Trevor Armstrong, Chief Operating Officer, Ausgrid
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SUMMARY

1 In the national electricity market, the concept of unserved energy is applied to measure any supply interruptions consumers experience from generation and interconnection inadequacy only. Unserved energy measures the amount of customer demand that cannot be supplied within a region of the NEM due to a shortage of generation, demand-side participation, or interconnector capacity. In other words, it is the amount of wholesale unserved energy that is relevant for the purposes of reporting on the reliability standard.

2 The reliability standard was designed to reflect generation and interconnection adequacy to supply electricity, and signal to the market when and where more generation is needed, based on a trade-off made on behalf of consumers as to the appropriate level of reliability. AEMO, through its forecasting processes, operationalises the reliability standard by modelling and projecting when market participants are not going to meet the reliability standard.

3 AEMO also calculates how much demand went unmet due to a lack of generation, demand response or interconnection capacity i.e. unserved energy for the purposes of the reliability standard, after the end of each financial year. Unlike its projections of unserved energy, this calculation is a backward-looking exercise, done in an ex-post manner.

4 As the power system changes, the Panel considered that it was timely to examine review the calculation of unserved energy. Specifically, this review examined whether the framework that underpins how AEMO calculates how much energy went unserved for the purposes of the reliability standard, was still fit for purposes, giving recent trends such as the growth of solar PV and changing generation mix.

Scope of the review

5 The Panel examined the clarity and transparency of the definition and unserved energy framework that underpins the calculation. The scope of this review only extended to the ex-post calculation of unserved energy. The Panel did not consider if the reliability standard itself, and how it is defined, was appropriate. The Panel considers this issue as part of its reliability standard and settings review.

6 In addition, while the unserved energy framework in clause 3.9.3C(b) of the NER is based on the concepts of credible and non-credible contingency events, the appropriateness of the definition of such events were outside of the scope of this review.

Rationale and recommendations

7 In considering the appropriateness of the definition of unserved energy for the purposes of the reliability standard, the Panel was guided by the following principles:

- an event should only be included if additional investment would have avoided the event from occurring or the market should have planned for such an event
- market participants are expected to meet the reliability standard without the need for interventions.

8 AEMO uses the unserved energy framework specified in the NER, which provides guidance on what types of events should be included in the calculation, and what type of events should

be excluded from the calculation, to calculate how much unserved energy there was in any given financial year. The Panel concludes that this unserved energy framework is largely fit for purpose and in most instances, appropriately captures the right types of events in the calculation.

9 However, the Panel also concludes that there was room for improvement with respect to information provision, clarity and transparency around how unserved energy is calculated.

Recommendation : Improving transparency of the unserved energy calculation

10 To calculate unserved energy, AEMO divides the number of MWh shed in a financial year due to reliability causes by total energy demanded from the grid. The purpose of ex-post reporting is to provide additional information to market participants as to whether or not the reliability standard was met in a particular financial year.

11 The Panel considers that there is a lack of transparency around the unserved energy calculation. To improve transparency and help market participants make better investment and operational decisions, the Panel recommends requiring AEMO to provide more information on how it calculates unserved energy. This requirement would be implemented through AEMO's *Reliability Standard Implementation Guidelines*, which explain how AEMO implements the reliability standard.

Recommendation: Improving clarity of the unserved energy framework

12 While the unserved energy definition and framework are largely fit for purpose, the Panel considers that the NER cannot prescribe an exhaustive list of events to guide AEMO's calculation of unserved energy. Instead, to improve clarity and reduce ambiguity around the existing framework, the Panel recommends the introduction of a principle to guide AEMO when allocating events to unserved energy in order to better reflect the purpose of unserved energy, as an enhancement of the current framework. This would provide additional guidance on what should be included and excluded from the calculation, even if not prescribed in the NER.

13 The Panel also proposes to clarify some minor aspects of the definition of unserved energy to remove ambiguity, including to make it clearer that the calculation should only include events where the root cause was a power system reliability issue, and making it clearer that the unserved energy framework is flexible enough to account for complex events.

Next steps

14 The Panel has submitted a rule change request to the AEMC based on the findings of this review and the recommendations that it has made. The rule change request may be found on the project page.

15 In addition, the Panel also acknowledges other issues raised by stakeholders which were outside of the scope of this review as they relate to broader issues with respect to the reliability standard, as well as issues that require consideration through an examination of the reliability standard.

16 The Panel notes that it has a statutory requirement to review and make recommendations on

the reliability standard and settings every four years. In its 2018 review, the Panel noted that development of long-term forecasts, which underpin the review, was particularly challenging given the recent and upcoming market developments.[1] It stated that, if warranted due to the changing market circumstances, the AEMC may give the Panel terms of reference for an interim review of the reliability standard and settings, prior to the next scheduled four-yearly review.[2]

1 Reliability Panel, Reliability standard and settings review, final report, 30 April 2018, p. v.

2 Ibid.

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1 INTRODUCTION

1.1 Background

On 26 July 2018, the Australian Energy Market Commission (AEMC) published the final report of its *Reliability Frameworks Review*.[3] This report made a series of recommendations to implement and develop mechanisms in the national electricity market (NEM) aimed at supporting reliable outcomes for consumers at lowest cost.

The *Reliability frameworks review*'s final report concluded that it was worth examining the definition of unserved energy, given the broader changes occurring in the NEM.

Among other things, the Reliability Panel (Panel) is required to monitor, review and report on the performance of the market in terms of reliability of the national electricity system.[4] Further, the Panel has a number of responsibilities that are directly related to unserved energy, specifically:

- under the National Electricity Rules (NER), the Panel has an ongoing and periodic obligation to review and provide advice to the AEMC on the reliability standard, which is a maximum expected unserved energy in a region of 0.002 per cent of the total energy demanded in that region for a given financial year, and market settings[5] every four years, with its most recent review of the reliability standard and settings published in April 2018[6]
- in reviewing the reliability standard and settings, the Panel must comply with the *Reliability Standard and Settings Guidelines* that it prepares, the most recent of which was published in December 2016 with this version guiding the most recent review of the standards and settings.[7]

Given these functions, the Panel progressed the AEMC's recommendation, and consulted with stakeholders on whether the current definition of unserved energy for the purposes of the reliability standard in the NER is still fit for purpose.

1.2 Scope of this review

This review focussed on the clarity and transparency of unserved energy as defined in the NER.

Specifically, the review considered what events should be included in or excluded from the definition of wholesale unserved energy in the NER (clause 3.9.3C(b) of the NER) for the purposes of determining whether the reliability standard is met. The NER definition sets out which types of events should be included or excluded, in a non-exhaustive manner, when allocating supply interruptions to unserved energy for the purposes of the reliability standard, in an ex-post analysis.

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3 For more information, see: https://www.aemc.gov.au/markets-reviews-advice/reliability-frameworks-review

4 Section 38 (2) (a) of the National Electricity Law (NEL).

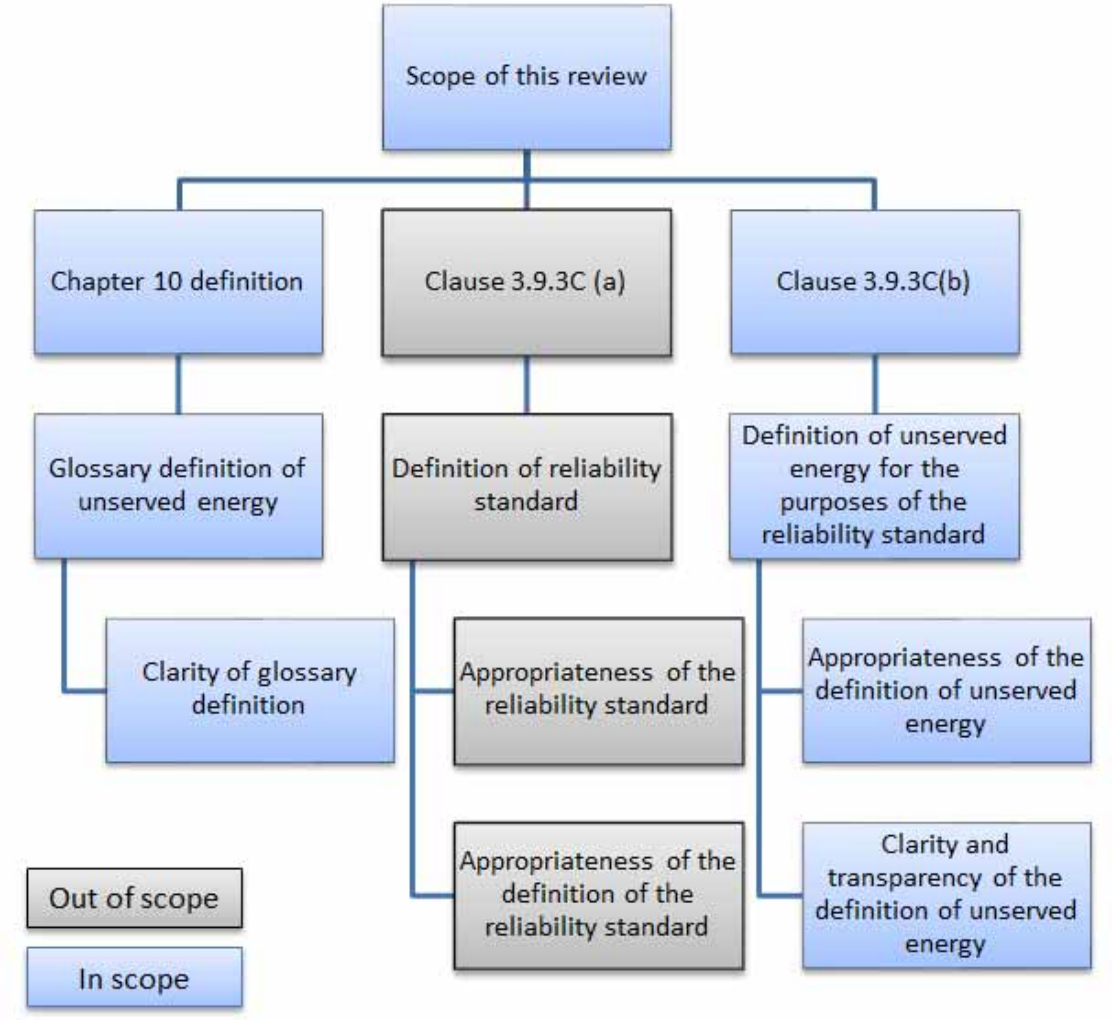
5 Market settings are set by the Panel to allow investment sufficient to achieve the reliability standard. The settings comprise: market price cap, cumulative price threshold, administered price cap and market floor price.

6 Clause 3.9.3A(d) of the NER.

7 Clause 3.9.3A(e) of the NER.

Importantly, the scope of this review only extended to the ex-post calculation. Only the framework that underpins how it is calculated after the end of the financial year (referred to as the unserved energy framework in this report) was within the scope of this review. Similarly, the Panel did not consider if the reliability standard itself, and how it is defined, was appropriate, as shown in the figure below.

Figure 1.1: Scope of this review



In addition, this review only examined if this unserved energy framework was clear, transparent and fit for purpose. In doing so, the Panel did not examine broader issues associated with the contingency framework. The unserved energy framework in clause 3.9.3C(b) of the NER is based on the concepts of credible and non-credible contingency events. However, the appropriateness of the definition of such events was outside of the

scope of this review.[8] Instead, the Panel focussed on whether the unserved energy framework, which is only relevant for the purposes of the reliability standard, was appropriate. The contingency-based definitions, on the other hand, are used across multiple areas in the NER.

1.3 Related work

The Commission and Panel are currently progressing or have recently completed a number of projects which are related to this review or issues raised by stakeholders that were outside of the scope of this review. They are as follows:

- The AEMC's *Enhancement to the Reliability and Emergency Reserve Trader* (RERT) rule change request examined the appropriateness of the reliability standard (i.e. the level and form of the reliability standard and how it is operationalised.[9] The final determination, published on 2 May 2019, concluded that the reliability standard (i.e. form and level) was fit for purpose and that AEMO had the flexibility to change how it operationalises the reliability standard if required.
- The Panel's *annual review of market performance* (AMPR), published on 4 April 2019, reported that a number of key trends continued to play out during the period 2017/18. In particular, the generation mix continued to change, with significant new entry of variable, asynchronous generation. Increasing numbers of consumers are also installing behind the meter energy resources, like rooftop PV and battery storage. When coupled with the likely exit of older, thermal generation over the coming years, these trends will continue to create new challenges and opportunities for the secure and reliable operation of the NEM power system.
- The Commission is currently conducting its *Review of the system black event in South Australia*. As part of the review, the Commission is examining the contingency framework, including the classification framework and broader definitional issues with respect to contingency events. The AEMC intends to publish a draft report in September 2019.
- On 27 June 2019, the AEMC published a directions paper on proposed new measures to give generators the option to pay for firm access rights to the transmission network, as part of its review into the *Coordination of Generation and Transmission Investment* (COGATI). These measures include introducing dynamic regional pricing; creating a transmission hedge; and aligning transmission planning and operation.

Future work by the Panel

The Panel has a statutory requirement to review and make recommendations on the reliability standard and settings every four years.[10] The Panel will consider whether the current reliability standard and settings remain suitable for expected market conditions in 2022 or earlier if terms of reference are received from the AEMC (in respect of settings for the period 2024-2028).[11]

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8 This issue is being considered in the AEMC's South Australian black system review, see https://www.aemc.gov.au/news-centre/media-releases/south-australian-black-system-review

9 For more information, see: https://www.aemc.gov.au/rule-changes/enhancement-reliability-and-emergency-reserve-trader

10 Clause 8.8.1(a)(1b) of the NER.

Specifically, in its 2018 review, the Panel noted that development of long-term forecasts, which underpin the review, was particularly challenging given the recent and upcoming market developments.[12] It stated that, if warranted due to the changing market circumstances, the AEMC may give the Panel terms of reference for an interim review of the reliability standard and settings, prior to the next scheduled four-yearly review.[13]

1.4 Process for this review and next steps

On 4 April 2019, the Panel published the consultation paper to facilitate public consultation on the definition of unserved energy. Submissions to the consultation paper closed on 2 May 2019. The Panel received 10 submissions. Issues raised in submissions are discussed throughout this final report.

Following consultation with stakeholders and based on the feedback received, and the Panel's own considerations, the Panel assessed whether there is benefit in changing the definition of unserved energy in the NER, or if the existing definition continues to be appropriate.

The Panel has identified some areas where information provision, clarity and transparency around the unserved energy definition and calculation could be improved. Detailed analysis of the issues considered is outlined further in this final report.

To address the issues identified, the Panel has submitted a rule change request to the AEMC. The rule change request is attached to this final report.[14]

1.5 Structure of this final report

This report outlines:

- background information relevant to this review, including an explanation of how the reliability framework operates, and principles that guided the Panel in considering the definition of unserved energy
- stakeholders' views and Panel's conclusions in relation to:
  - transparency of the unserved energy calculation
  - the unserved energy framework
  - reliability-related interventions.

The appendix to this report discusses the Panel's views on other minor issues raised in the consultation paper and in stakeholders' submissions.

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11 For example, this could be the case if the AER publishes new value of customer reliability (VCR) numbers that would warrant undertaken the review earlier.

12 Reliability Panel, Reliability standard and settings review, final report, 30 April 2018, p. v.

13 Ibid.

14 The rule change request is available on the project page. See https://www.aemc.gov.au/market-reviews-advice/definition-unserved-energy

2 UNSERVED ENERGY AND THE RELIABILITY STANDARD

This chapter sets out:

- how the reliability framework operates in the NEM, to provide context for understanding the significance of the definition of unserved energy
- what unserved energy is, and what are the possible causes of supply interruptions which lead to unserved energy
- the role of the reliability standard, and the link between the reliability standard and wholesale unserved energy
- the principles that guided the Panel in considering the definition of unserved energy.

2.1 Reliability in the NEM

A 'reliable power system', at the wholesale level, has enough generation, demand response and inter-regional network capacity to supply customers with the energy that they demand with a very high degree of confidence. A reliable power system therefore requires adequate investment as well as appropriate operational decisions, so that supply and demand are in balance at any particular point in time.

The reliability framework that underpins a reliable power system at the wholesale level is different from the framework that underpins power system security. A secure system is one that is able to operate within defined technical limits, even if there is an incident such as the loss of a major transmission line or large generator. Security events may be caused by sudden equipment failure (which may be associated with extreme weather or bush fires) that results in the system operating outside of defined technical limits, such as voltage and frequency.

Reliability issues occur where the demand-supply balance in the system is tight, typically at times of peak demand for electricity, generally on very hot days. For example, when emergency reserves were exercised in both January 2018 and 2019, it was in the middle of the afternoon with the temperature exceeding 40 degrees Celsius in Victoria.[15] In contrast, security issues can occur when the demand-supply balance is tight or at other times. For example, the South Australian state-wide blackout that occurred in September 2016 was a security event, in relatively mild demand conditions.

Reliability and security are distinct but also inextricably linked, particularly over operational timeframes. For example, reliability issues are typically managed through market reserves, emergency reserves or directions (e.g. requiring a generator to increase output). Involuntary load shedding is only used as the last resort, after all other avenues have been exhausted. It is typically done so as to avoid potentially larger issues occurring, such as interconnector

15 AEMO activated reserve contracts to maintain the power system in a reliable operating state. The contracts were activated at 14:00 AEST on 19/01/2018. See: market notice 60843, 19 January 2018, 13:43, market intervention.

flows exceeding secure limits (i.e. the system being in an insecure state), with the risk of more widespread blackouts should a further contingency occur.

To be clear, involuntary load shedding arising from reliability issues is typically instructed by AEMO to return the system to a secure state or maintain power system security. If AEMO does not do so at that point in time, it would be possible for larger blackouts to occur e.g. due to the interconnectors reaching their limit. In that sense, involuntary load shedding is a last resort to guard against the potential for larger blackouts, and return the system to a secure operating state. In this example, the root cause of the power system security issue is a reliability issue that was not addressed by the market, the RERT or directions, leaving AEMO with its last resort power, involuntary load shedding. This is distinct from events where power system security is the root cause, such as the larger blackouts that occur due power system security issues, e.g. due to bushfires or such as the one that occurred during the system black event in September 2016.

2.2 Overview of the reliability framework

Wholesale-level reliability means that the power system has an adequate amount of capacity (generation, demand response and transmission capacity) to meet consumer needs.

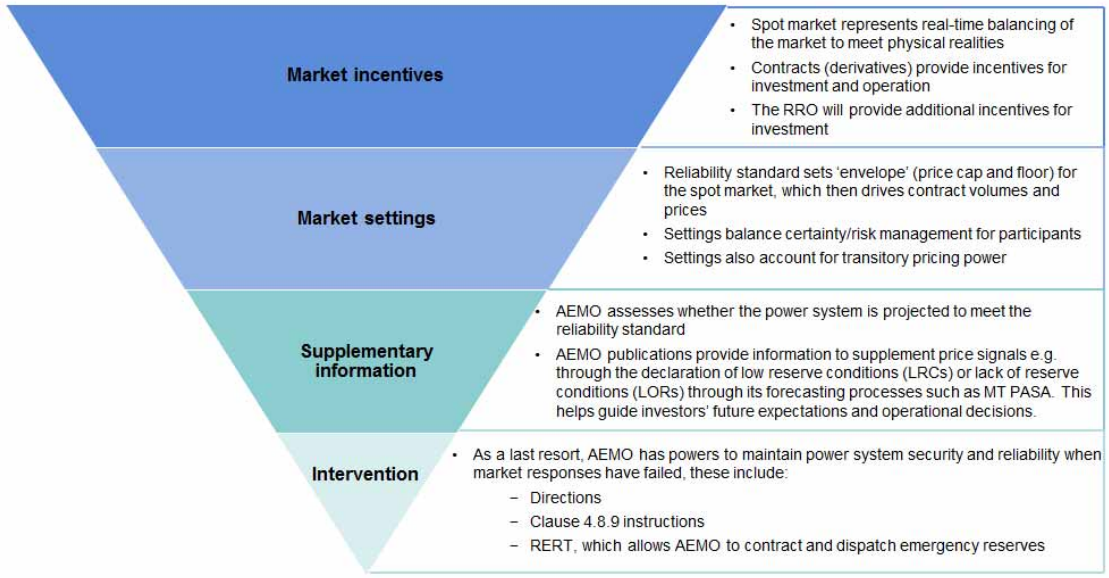
The core objective of the existing reliability framework in the NEM is to deliver desired reliability outcomes through market mechanisms to the largest extent possible. In a reliable power system, in theory, the expected level of supply in the market will include a buffer, known as in market reserves. Supply is expected to be greater than demand. In the event that the supply / demand balance tightens, spot and contract prices would rise, which then informs operational decisions and provide an incentive for entry and expansion, addressing any potential reliability problems as or before they arise. This allows the actual demand and supply to be kept in balance, even in the face of shocks to the system.

Figure 2.1 provides a summary of the current reliability framework and their interrelationships. Each of these four aspects of the reliability framework is briefly discussed next.

The Panel acknowledges that there are, in practice, trends and factors that are affecting how the reliability framework works and operates. Some of these factors were discussed in the AEMC's *Reliability Frameworks Review*, and there is ongoing work in terms of promoting a reliable power system.[16] The Panel has not commented on these trends and factors - instead, it has focussed on the framework itself to provide context for the review of the definition of unserved energy and the purpose of unserved energy.

16 See the AEMC's reliability work plan https://www.aemc.gov.au/our-work/our-forward-looking-work-program/reliability/reliability-work-plan

Figure 2.1: Current framework with escalating series of interventions



Source: AEMC.

2.2.1 Market incentives

Reliability outcomes in the NEM are largely driven by market participants making investment and operational decisions, taking into account expectations and information that is provided on future demand and supply.

Put simply, market participants respond to financial, operational and other incentives (such as information provided by AEMO, including on the reliability standard) to provide the level of reliability that is expected by the reliability standard. Generators and retailers have strong incentives to provide in-market reserves in order to support the operation of the power system in a reliable manner.

In addition, the Retailer Reliability Obligation (RRO) builds on existing spot and financial market arrangements in the electricity market to facilitate investment in dispatchable capacity and demand response. It is designed to incentivise retailers, on behalf of their customers, to support the reliability of the power system through their contracting and investment decisions.

2.2.2 The reliability standard and market settings

The National Electricity Rules contain the reliability standard for the National Electricity Market (NEM), currently at 0.002 per cent maximum expected unserved energy (or USE).[17]

17 Clause 3.9.3C(a) of the NER.

The reliability standard is reviewed every four years following a review by the Reliability Panel,[18] which comprises experts from large energy users, consumer groups, generators, network businesses, retailers and AEMO. Crucially, this is not zero per cent since this would be too costly for consumers. The reliability standard represents a trade-off between the prices paid for electricity and the cost of not having energy when it is needed: increasing levels of reliability involves increased costs.

In addition to the reliability standard, there are also the reliability settings[19] that are closely linked to, and derived directly from, the 'reliability standard'. These form a price envelope for spot prices and are the following market settings: the market price cap,[20] the market floor price,[21] the cumulative price threshold[22] and the administered price cap.[23]

The reliability standard is discussed in more detail in section 2.4 below.

2.2.3 Supplementary information

The NER require AEMO to operationalise the reliability standard.[24] For example, it publishes a range of long-term forecasts in its Electricity Statement of Opportunities (ESOO) as to whether or not the reliability standard is projected to be met in the long-term. In the medium-term, AEMO models the power system through its medium-term projected assessment of system adequacy (PASA) to probabilistically project whether expected USE (i.e. a probability-weighted average across a number of scenarios) for a given year, in a given region, exceeds 0.002 per cent.

The expected values of USE outcomes are proportional to their likelihood of occurring i.e. events with a high probability of occurring are given more weight than events with a low probability of occurring. An expected shortfall, relative to the reliability standard, is termed a low reserve condition.[25] AEMO provides all this information to the market to allow the market to respond to what it projects could be a future shortfall in reserves. In the case of the ESOO, if the expected USE value is higher than the reliability standard, then three years out from the period in which the gap is forecast, the RRO is triggered.[26]

In the short-term (pre-dispatch and short-term PASA), AEMO operationalises the reliability standard through lack of reserve (LOR) declarations.[27] In this case, AEMO forecasts the level of reserves that are required to be in the market (i.e. MW required). This level is at least the size of the largest likely gap in available capacity, or larger to take into account forecasting uncertainty (e.g. that there will be a margin of error in any assumptions that feed into the

18 Under clause 3.9.3A(d) of the NER.

19 Reliability settings are defined in Chapter 10 of the NER.

20 Currently $14,700/MWh, indexed annually.

21 Currently -$1,000/MWh.

22 Currently $221,100, indexed annually.

23 The administered price cap of $300/MWh applies when an administered pricing period is declared by AEMO whenever the sum of the spot price in the previous 336 consecutive trading intervals (that is, seven days) exceeds the cumulative price threshold.

24 Clause 3.9.3D of the NER.

25 See clause 4.8.4(a) of the NER.

26 The provisions of the *National Electricity (South Australia) Act 1996*, as amended by the *National Electricity (South Australia) (Retailer Reliability Obligation) Amendment Act 2019* implementing the RRO commenced on 1 July 2019.

27 See clause 4.8.4(b) of the NER and the *Reliability standard implementation guidelines*.

modelling - this is known as the forecasting uncertainty measure or FUM). If the forecast amount of reserves available falls below the LOR2 level, then AEMO informs the market that market reserve levels are low, expecting a response.[28]

Market participants also make operational decisions based on their expectations of prices, either based on their own forecasts of prices or based on AEMO's forecasts of prices as well. AEMO's processes provide forecasts of prices.

2.2.4 Intervention mechanisms

If market participants do not respond to an expectation from AEMO that the reliability standard will not be met (for example, by making more reserves available or moving planned maintenance), then AEMO may intervene in the market through using the reliability and emergency reserve trader (RERT) mechanism or clause 4.8.9 instructions or directions.

Intervention by procuring emergency reserves under RERT can occur across a number of timeframes:

- To the extent that low reserve conditions are being forecast (i.e. a forecast breach of the reliability standard), AEMO can procure emergency reserves up to nine months prior to the expected shortfall.[29] As from 26 March 2020, AEMO will be able to procure emergency reserves up to one year out.[30] Specifically, between ten weeks out and nine months (soon to be one year) out, AEMO can use long-notice RERT to procure emergency reserves.
- As forecasts move closer to real time and the risks of reserve shortfalls become more accurate, AEMO can use medium-term (between ten weeks and seven days ahead of a projected shortfall) and short-term (between three hours and seven days ahead of a projected shortfall)[31] RERT to procure RERT resources, if there is a breach of the reliability standard.[32]

In addition, if there is a risk to the secure or reliable operation of the power system, AEMO can use directions or instructions under NER clause 4.8.9 to:

- Direct a generator[33] to do any act or thing AEMO determines is necessary (which may include increasing its output, cancelling or shifting an outage or not to go offline),[34] if this is possible and can be done safely and without materially risking damaging equipment.[35] To be effective, the generator must have enough time to 'ramp up'. If the generating unit is not already generating, it can take time for it to start up and to connect to the network

28 AEMO's obligations to notify the market in the event of a low reserve or lack of reserve condition are set out in clause 4.8.5 of the NER.

29 See clause 3.20.3(d) of the NER.

30 This increase in procurement lead time was implemented by the *National Electricity Amendment (Enhancement to the Reliability and Emergency Reserve Trader) Rule 2019 No. 3*.

31 The short-notice RERT will change to between up to seven days ahead of the projected shortfall effective from 26 March 2020.

32 See part 4.1 of the *RERT Guidelines* developed by the Reliability Panel under clause 3.20.8 NER .

33 Note, the issuing of directions are limited to scheduled plant and market generating units only. See clause 4.8.9(a1)(1) of the NER.

34 See clause 4.8.9(a)(1) of the NER.

35 See clause 4.8.9(c) of the NER.

and begin to ramp up. Even generators which are currently generating cannot typically change their output instantly.

- Direct or instruct a large energy user, such as an industrial plant, to temporarily disconnect its load or reduce demand. If there continues to be a shortfall in supply, even after these measures have been implemented, AEMO may instruct a network service provider to commence involuntary load shedding as a last resort to avoid the risk of a wider system blackout, or damage to generation or network assets.[36]

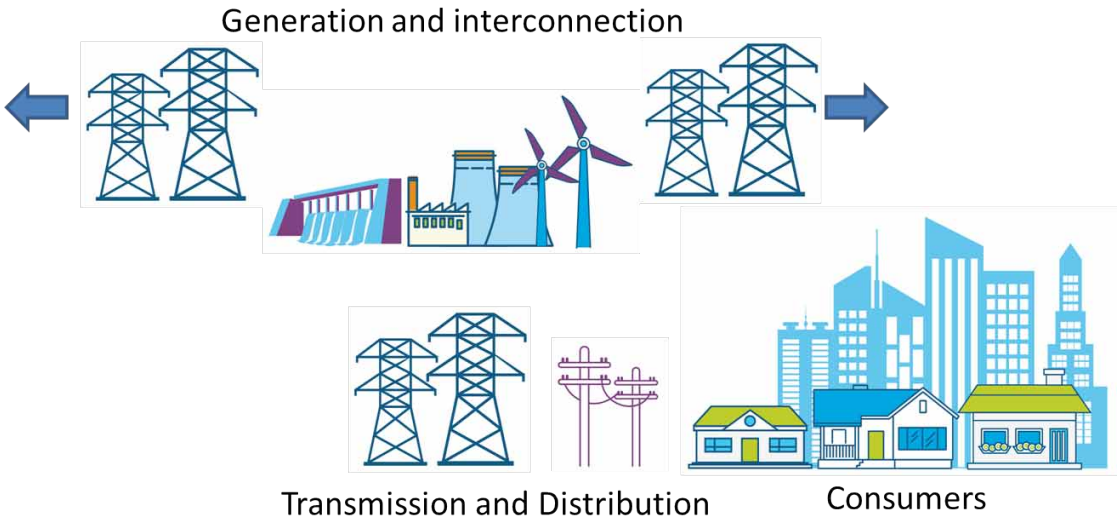
2.3 What is unserved energy?

In general, the term 'unserved energy' refers to supply interruptions or blackouts. It can be described as an estimate of the electricity that would otherwise have been used by customers but for a supply interruption (power cut). These supply interruptions may originate from various parts of the supply chain (illustrated in Figure 1.2 below), namely:

- **insufficient generation and interconnection**:
  - reliability-related supply interruptions (not having sufficient generation or interconnector capacity under normal operating conditions to meet demand in a NEM region);
  - power system security-related supply interruptions caused by voltage stability or other power system security limits.
- insufficient network capacity (**transmission and distribution**)
- **consumer** actions such as to comply with agreements made as part of mandatory restrictions provision in the NER.

Figure 2.2: Split of supply chain for measuring unserved energy

36 Clause 4.8.9(a)(2) of the NER.



Source: AEMC.

When used in the general sense of the word, the term does not differentiate between supply interruptions that were caused by a distribution issue (such as a fallen power line on a residential street due to a car accident) or a technical issue (such as a supply interruption caused by sudden equipment failure due to bushfires). It is best described as reflecting customers' experiences of interruptions - if a customer has no electricity, then, in general terms, it was energy not served.

However, when it comes to wholesale-level reliability, the NER explicitly links the concept of unserved energy to the reliability standard, and explicitly defines it. In this context, unserved energy is applied to measure any supply interruptions consumers experience from **generation and interconnection inadequacy only**. That is, the amount of customer demand that cannot be supplied within a region of the NEM due to a shortage of generation, demand-side participation, or interconnector capacity. In other words, it is the amount of wholesale unserved energy that is relevant for the purposes of reporting on the reliability standard.

Clause 3.9.3C(a) of the NER links unserved energy to the reliability standard:

> The reliability standard for generation and inter-regional transmission elements in the national electricity market is a maximum expected unserved energy in a region of 0.002 per cent of the total energy demanded in that region for a given financial year.

This review is therefore only concerned with unserved energy for the purposes of wholesale-level reliability, i.e. the reliability standard. Clause 3.9.3C(b) of the NER states that unserved energy for the purposes of the reliability standard is to:

> include unserved energy associated with power system reliability incidents that result

from:

- a single credible contingency event on a generating unit or an inter-regional transmission element, that may occur concurrently with generating unit or inter-regional transmission element outages; or
- delays to the construction or commissioning of new generating units or inter-regional transmission elements, including delays due to industrial action or acts of God.

Clause 3.9.3C(b)(2) states that unserved energy for the purposes of the reliability standard is to:

exclude unserved energy associated with power system security incidents that result from:

- multiple contingency events, protected events or non-credible contingency events on a generating unit or an inter-regional transmission element, that may occur concurrently with generating unit or inter-regional transmission element outages;
- outages of transmission network or distribution network elements that do not significantly impact the ability to transfer power into the region where the unserved energy occurred; or
- industrial action or acts of God at existing generating facilities or inter-regional transmission facilities.

Generally speaking, the reliability standard does not include unserved energy caused by transmission and distribution interruptions, and consumer actions. This is because, as mentioned above, the reliability standard was designed to reflect the market and interconnection adequacy to supply electricity, not the customer's experience of having no power regardless of the cause.

Further, from a regulatory perspective, different causes of supply interruptions are treated differently. The part of the supply chain that caused the unserved energy is associated with a different set of arrangements for determining the maximum amount of unserved energy that customers should experience. For example:

- The amount of unserved energy that can be attributed to local network outages is determined by state governments and is measured separately by the transmission and distribution network companies.
- Outages that result from power system security issues are dealt with primarily through the frequency control framework, e.g. through setting frequency operating standards, through managing events using under-frequency load shedding schemes and frequency control ancillary services (FCAS) markets.

These frameworks, standards and processes are completely distinct from the reliability framework that the reliability standard is part of.

2.4 Reliability standard

As mentioned above, the reliability standard (for generation and inter-regional transmission elements) is the maximum expected unserved energy in a region of 0.002 per cent for a given financial year as a share of total energy demanded in that region. In general terms, 'unserved energy' means the amount of customer demand that cannot be supplied within a region of the NEM due to a shortage of generation (including demand response) or interconnector capacity, as discussed in more detail above.

The reliability standard is said to be breached if expected unserved energy exceeds 0.002 per cent of annual demand in a region in a given financial year. In simple terms, the reliability standard requires there be sufficient generation and transmission interconnection in a region such that at least 99.998 per cent of forecast total energy demand in a financial year is expected to be supplied.

2.4.1 What is the reliability standard?

The objective of the reliability standard is to allow for efficient investment sufficient to provide electricity to the agreed standard, while balancing the trade-offs inherent in reliability, made on behalf of consumers.

The reliability standard balances the following costs:

- Costs of reliability - Maintaining reliability involves costs. The higher the level of reliability, the more investment in capacity (e.g. more generation, demand-side resources or network assets) and/or more stringent operating conditions is required, all of which impose costs on parties, and ultimately consumers. For example, having more generation being operated more stringently (i.e. having more generation being operated to meet a higher standard of reliability) creates higher per unit costs of electricity. These costs will be reflected in consumer prices.
- Costs of unserved energy - The alternative to providing energy, no matter the cost, is not to supply the energy under certain conditions. That is to allow for an expected level of supply interruptions to consumers. This also has a cost - reflecting the customer's willingness to pay for the reliable supply of electricity (this is known as the value of customer reliability). If a customer has their electricity supply interrupted, when they were willing to pay to consume electricity, they will face costs e.g. lost production if it is a business; or a colder / hotter home for residential customers with air conditioning.

In other words, the reliability standard represents a trade-off between the prices paid for electricity and the cost of not having energy when it is needed: increasing levels of reliability involves increased costs. The reliability standard is set at a level that provides a balance between delivering reliable electricity supplies and maintaining reasonable costs for customers (i.e. an economic trade-off between affordability and reliability, based on what consumers value).

It is not set at zero, for that reason. Consumers would not be willing to pay for a 100 per cent reliable system, since such a system would also be very costly. Indeed, guaranteeing a reliability standard of zero per cent expected USE is impossible, because it is always

conceivable that some very unlikely combination of events could occur such that there is insufficient supply to meet demand.

Instead, the reliability standard was designed to reflect the market and interconnection adequacy to supply electricity, and signal to the market when and where more generation is needed, based on a trade-off made on behalf of consumers as to the appropriate level of reliability.

2.4.2 Purpose of unserved energy forecasts

As part of the operationalisation of the reliability standard, AEMO is required by the NER to publish various materials which provide information to market participants – and any other interested parties – on matters pertaining to the reliability standard. AEMO publishes USE in two ways:

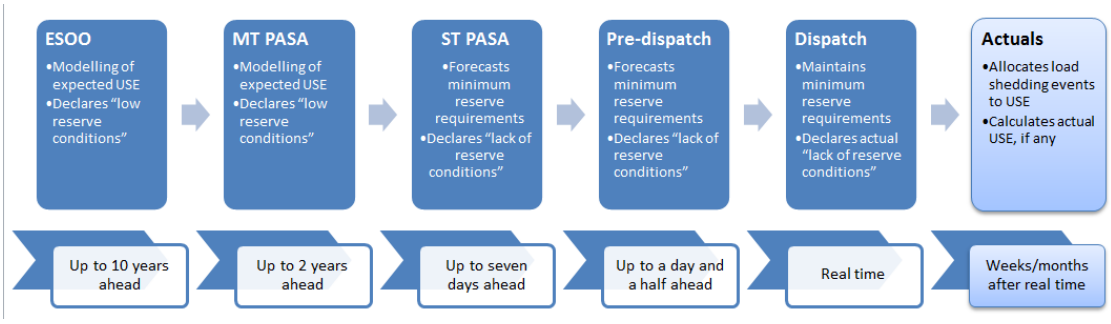
- forward-looking: AEMO projects and publishes forecasts on whether the reliability standard will be met, and
- backward-looking: AEMO calculates ex-post the amount of wholesale unserved energy in a financial year, to be reported against the reliability standard.

The Panel notes that the forecasts on whether the reliability standard will be met, and ex-post reporting against the reliability standard have the same broad purpose - to signal to the market when and in what region more capacity is needed. However, this review is only examining the backward-looking aspect of unserved energy.

In simple and general terms, it can be said that a breach of the reliability standard is a signal to market participants that more investment may be needed in the affected region. However, depending on the different time periods and forecasting processes, there are differences in how the reliability standard is operationalised, in nuances as to what exactly AEMO's reliability forecasts signal, and what the implications are.

The diagram below highlights each process, noting that the scope of this review only includes the "actuals" section. Each process is discussed in more detail next.

Figure 2.3: Forecasting and calculating unserved energy



Electricity Statement of Opportunities

AEMO publishes a range of long-term forecasts in its Electricity Statement of Opportunities (ESOO) as to whether or not the reliability standard is projected to be met in the long-term. The ESOO forecasts electricity supply reliability in the NEM over a ten-year period.

The ESOO process is currently being updated due to the introduction of the Retailer Reliability Obligation (RRO). However, AEMO typically models the power system in the ESOO to probabilistically project whether the expected USE (i.e. a probability-weighted average across a number of scenarios) for a given year, in a given region, exceeds 0.002 per cent. In other words, the reliability standard is operationalised by AEMO as an annual expected USE – so if the current forecast of annual expected USE is less than 0.002 per cent for a given region, then the reliability standard is said to be met.

The purpose of the ESOO is to provide technical and market data that informs the decision-making processes of market participants, new investors and jurisdictional bodies as they assess opportunities in the NEM over a ten-year outlook period. The inputs and assumptions used in the ESOO are primarily based on projections by AEMO, rather than granular input from market participants, given the time period that it examines.

The introduction of the RRO has expanded the role of the ESOO somewhat, with the ESOO now also being used as a trigger for the RRO, specifically, the T-3 instrument three years ahead of a forecast breach of the reliability standard, and a T-1 instrument one year ahead of a forecast breach. The ESOO now includes additional reliability forecast requirements and information provision for the purpose of the RRO. Prior to this, the ESOO was primarily only used to inform AEMO and the market - AEMO did not take any particular action if it forecast a breach of the reliability standard, as stated in AEMO's *reliability standard implementation guidelines* (RSIG).[37] For example, the Panel understands that despite this, AEMO may have used the outputs of the ESOO in the past to inform RERT procurement. However, AEMO is currently updating the RSIG to state that it will now also intervene through RERT, directions or clause 4.8.9 instructions through the ESOO.

However, the overarching purpose of the ESOO, and specifically, the reliability forecasts within the ESOO, remain largely the same: they are meant to signal to market participants when (by financial year) and where (by region) reliability gaps are forecasts. This would be one of a number of information and data that market participants would then use to decide whether or not to invest. For example, market participants may also analyse forward prices, forecasts of demand, technological changes to form their own opinions. They may also choose to only invest if the gap is expected to persist over numerous years.

Medium-term projected assessment of system adequacy

In the medium-term, AEMO also models the power system through its medium-term projected assessment of system adequacy (PASA) to probabilistically project whether the expected USE (i.e. a probability-weighted average across a number of scenarios) for a given year, in a given region, exceeds 0.002 per cent, similar to the ESOO.

37 See https://www.aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/Electricity_Consultations/2018/RSIG-Final/Reliability-Standard-Implementation-Guidelines-June-2018.pdf

This expected USE value is an annual (financial year) value. AEMO repeats this analysis for the two-year horizon - but reports annual USE separately. If the annual expected USE value as determined through the process above is more than 0.002 per cent in a given region then AEMO declares a low reserve condition to inform the market that it has projected USE in excess of the reliability standard.

However, unlike the ESOO, the purpose of the medium-term PASA has historically been for near-term operations and assessment of generator preventative maintenance planning and other operational-type decisions. Medium-term PASA uses more granular, short-term generator availability information. As technology changes, however, a two-year timeframe has more recently been considered as being well within investment timeframes. As a result, the reliability forecasts (including USE) that are published through the medium-term PASA could also be seen as an investment - and operational - signal.

Pre-dispatch and short-term projected assessment of system adequacy

In the pre-dispatch (a day ahead) and short-term PASA (seven days ahead) timeframes, AEMO operationalises the reliability standard through lack of reserve (LOR) declarations in accordance with AEMO's Reserve Level Declaration Guidelines which AEMO is required to update in accordance with the NER.[38]

AEMO identifies that in-market reserves are running low if reserves available in the market fall below the required reserve level as determined by the LOR methodology contained in the Reserve Level Declaration Guidelines.[39]

There is no mathematical link between the LOR framework and the reliability standard. However, AEMO operationalises the reliability standard through the LOR framework.[40] Specifically, LOR2s (described below) and LOR3s (i.e. when the market has run out of reserves and involuntary load shedding is happening or imminent) is an assumption of a breach of the annual reliability standard under the RSIG.

LOR2 is calculated as follows:

- As a minimum, the LOR2 reserve level is the largest identified credible contingency event, typically the loss of the largest generating unit in a region
- AEMO then applies a forecasting uncertainty measure (FUM) to this minimum level in order to account for forecasting uncertainty such as wind or demand forecast deviations. If the FUM is larger than the largest credible contingency event, then the FUM sets the LOR2 reserve level.

The signal provided by the LOR framework is primarily operational since the forecasts relate to the very short term. For example, market participants may decide to offer additional

38 Clause 4.8.4A of the NER. AEMO's *Reserve Level Declaration Guidelines* are available at: https://www.aemo.com.au/StakeholderConsultation/Consultations/Consultation-on-initial-version-of-Reserve-Level-Declaration-Guidelines

39 In accordance with Clause 4.8.4(b) of the NER. For more information, see AEMO's *Reserve Level Declaration Guidelines*.

40 Clause 4.8.4 of the NER describes an LOR condition as being when AEMO determines, in accordance with the reserve level declaration guidelines, that the probability of load shedding (other than the reduction or disconnection of interruptible load) is, or is forecast to be, more than remote.

capacity in response to the LOR2, and would therefore take operational steps such as making sure that there are enough staff on hand on the day.

It is also important to note that an LOR2 signals a potential shortfall in market reserves, in the event of a trip of a large generating unit or in the event of a sudden spike in demand. It does not automatically equate to supply interruptions. While an LOR2 means that there is an increased risk of involuntary load shedding, this does not always eventuate.

2.4.3 Purpose of ex-post reporting of unserved energy

In addition to the forecasts described in the section above, with respect to each financial year, AEMO also calculates the amount of wholesale unserved energy, that is, the amount of energy that was not delivered to consumers due to generation and interconnection inadequacy. In other words, this is a backward-looking exercise which AEMO undertakes to calculate how much unserved energy actually occurred in a given financial year.

AEMO performs this calculation in accordance with clause 3.9.3C(b) of the NER which outlines what events are included or excluded from the calculation of wholesale unserved energy. While the methodology used by AEMO is not publicly available, the Panel understands that, currently, AEMO uses annual operational consumption for the USE calculation.

To calculate the USE percentage, AEMO divides the number of MWh shed in a financial year due to reliability causes (based on the inclusions and exclusions in clause 3.9.3C of the NER) by total energy demanded from the grid (annual operational consumption) as such:

Figure 2.4: Unserved energy calculation

$$Unserved\ energy\ (\%) = \frac{MWh\ shed}{Energy\ demanded} \times 100$$

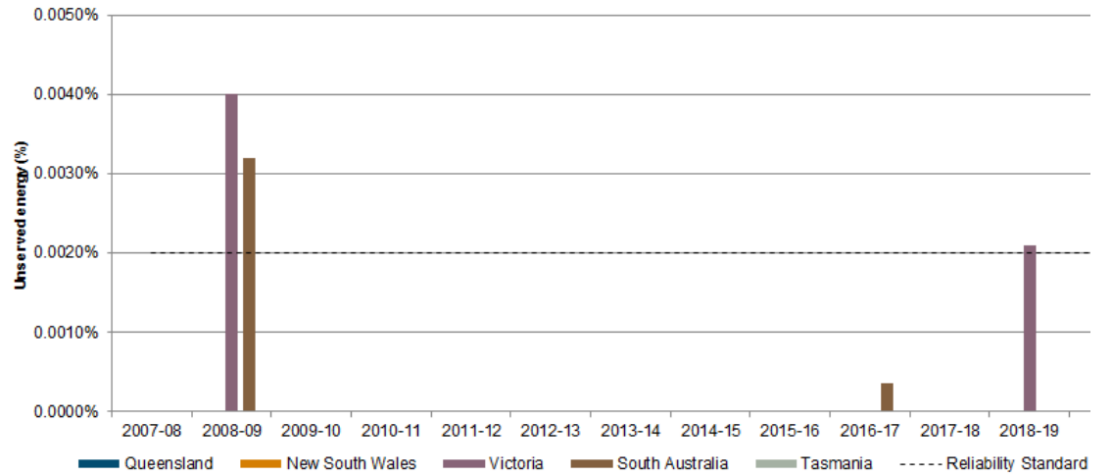
The Panel then reports on wholesale unserved energy and whether the reliability standard was met in a given financial year in each NEM region in its *Annual market performance reviews*.[41] The Energy Security Board also reports on this metrics in its annual *Health of the NEM* report.[42] These reports use AEMO's calculations as an input.

The purpose of ex-post reporting is to provide additional information to market participants as to whether or not the reliability standard was met in a particular financial year. Figure 2.5 shows the reliability outcomes from the last 12 years. Load shedding for the purpose of reliability has been rare, occurring on average about once every ten years, as shown in the figure below.

41 For more information, see: https://www.aemc.gov.au/market-reviews-advice/annual-market-performance-review-2018

42 For more information, see: http://www.coagenergycouncil.gov.au/publications/health-national-electricity-market

Figure 2.5: USE in the NEM (2007-08 to 2018-19)



Source: AEMO.

Note: The 2018-19 USE estimate is based on *Load Shedding in Victoria on 24 and 25 January 2019* event report and on AEMO's submission to the *Enhancement to the RERT* draft determination. It does not include any projections of USE for the remaining of the financial year (noting that there is currently none projected, in any event).

Over the past decade, the reliability standard has only been breached once - in 2008-09. AEMO also expects the reliability standard to have been breached in 2018-19 as well, as shown in the figure above; however, finalised figures on this are not yet available.

Importantly, reporting on USE in this manner is backward-looking - it gives market participants an insight into how the market has fared, but it does not necessarily provide an incentive or signal for investment. It is only one of the inputs in decision-making. Market participants are also likely to use forecasts and expectations of the future before making investment decisions.

2.4.4 What does a breach of the reliability standard signal?

While the reliability standard is an annual standard, a breach of the reliability standard in a given year should not automatically be considered as a signal for more investment.

In *2010 Reliability Standard and Reliability Settings Review*, the Panel recommended reviewing the reliability of the NEM each financial year. Before this change, performance against the reliability standard was measured over the long-term using a moving average of the actual observed levels of annual USE for the most recent ten financial years. This recommendation was supported by the following reasoning:[43]

- Market performance assessment on a yearly basis provides stakeholders with more granular information, which may assist them in making operational decisions.

43 Reliability Panel, *Reliability standard and reliability settings*, April 2010, p. 23.

- Market performance assessment on the ten-year basis requires more than ten years of data to give a statistically meaningful estimate of performance against the reliability standard.
- Use of the moving average over ten years as a measure of market performance complicates the operationalisation of the reliability standard through medium-term and short-term estimates.
- A ten-year delay in measuring performance is not satisfactory if its purpose is to promote continuous improvement of the processes for meeting the reliability standard.

However, while recommending reporting on market performance on a yearly basis, the Panel is of the view that it is not appropriate to assign significant meaning to individual historical outcomes. This is because of the random nature of USE outcome for a given year. That is, for a given year only a single actual USE value is recorded for each region. When an actual level of USE varies from the reliability standard of 0.002 per cent, this does not necessarily mean that the processes in the NEM to ensure reliability are inherently flawed, rather it may be an outlier from the distribution of possible USE values. When the actual level of USE:

- exceeds the 0.002 per cent reliability standard, the year in question may include arduous events, such as extreme temperatures and large generating unit forced outages at the time of the peak demand; or
- is less than the 0.002 per cent reliability standard, it may simply be due to system conditions that are not particularly arduous, such as mild temperatures and no large generating unit forced outages at the time of the peak demand.

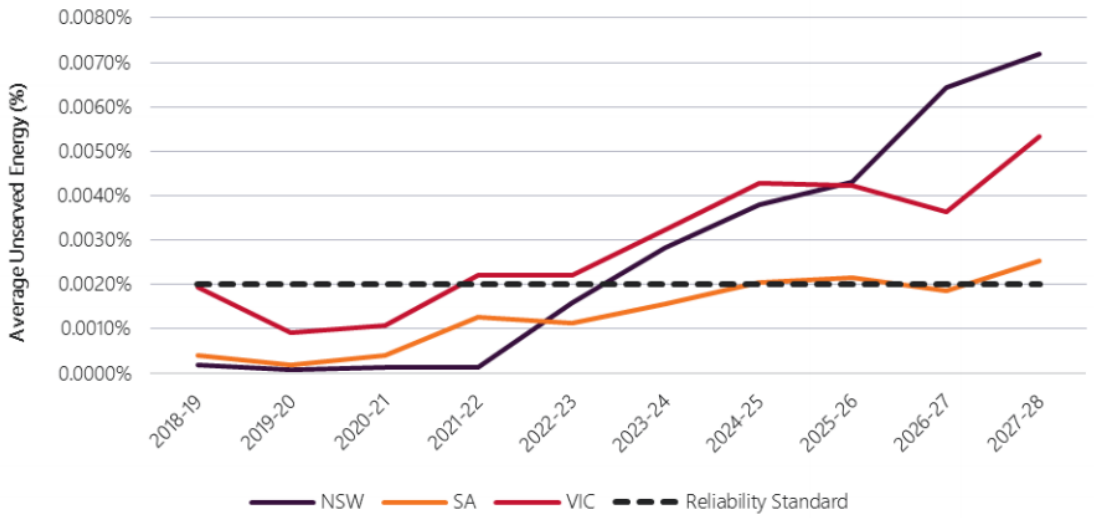
Where the level of USE in a year approaches or exceeds 0.002 per cent it is important for stakeholders to understand whether the resultant USE was consistent with the anticipated performance of the NEM. Factors that would warrant investigation include variations from assumed:

- outage rates or hot weather capacity reductions for generation and interconnectors; and
- demand levels and the demand characteristics.

In some instances, it can be said that the market should have planned for these outages. But in others, that would not be the case. For example, the market is not expected to plan for 1-in-10 year events, as the costs of doing so would outweigh the benefits, as reflected in the reliability standard. So while 1-in-10 year event may lead to a breach of the reliability standard in a given financial year, it may not necessarily signal the need for investment in a new power plant for example, or an additional unit.

On another hand, the breach of the reliability standard across a number of years could be considered as a signal for more investment. For instance, in its *2018 Electricity statement of opportunities*, AEMO forecast the breach of the reliability standard in Victoria and New South Wales for the period from 2022-23 to 2027-28 (the end of the outlook period). This forecast of the reliability standard breach across a number of years and states may signal the need for more investment (see Figure 2.6). However, the Panel notes that the forecast presented below assumes no new generation projects being developed beyond those that were committed at the time of forecasting.

Figure 2.6: Forecast USE outcomes



Source: AEMO, *2018 Electricity statement of opportunities,* August 2018.

Having said that, some new technologies may be more conducive to responding to shorter term gaps. For example, technologies that are not as capital intensive may find it economically efficient to invest even for short-term gaps.

In addition to investment incentives, operational decisions are also underpinned by the reliability standard as discussed in the previous sections. For example, in response to an LOR2, market participants may shift maintenance or may seek to obtain more fuel in order to increase the capacity that they can offer on the day. As a result, a breach of the reliability standard may also signal operational challenges, rather than simply be focused on investment.

2.5 Assessment principles

In considering what load shedding events should be included or excluded from the definition of unserved energy for the purposes of the reliability standard, the Panel considered the following principles to guide its conclusions:

- an event should only be included if:
  - additional investment would have avoided the event from occurring or
  - the market should have planned for such an event
- market participants are expected to meet the reliability standard without the need for interventions

The reasoning behind these principles is discussed next.

2.5.1 Investment and operational decisions

Principle: An event should only be included if additional investment would have avoided the event from occurring

Given that the purpose of the reliability standard (and therefore, of forecasting and estimating unserved energy) is largely about investment signals for generation and inter-regional transmission elements, the Panel considers that the definition of unserved energy should include events that could have been addressed through additional investment in generation or inter-regional transmission element capacity (such as an interconnector).

It is important that only events that could be addressed by new investment are included in the definition and calculation of unserved energy. . Including events which would not have been addressed by new investment would also be costly for consumers, as market participants would have invested in new capacity even though it is not needed, leading to additional unnecessary costs.

Principle: An event should only be included if the market should have planned for such an event

In addition to providing investment signals, unserved energy also plays a role in operational decisions. In particular, close to and up to real time, the LOR framework guides how many reserves is required to be in the market at any point in time. While this framework is not mathematically linked to the reliability standard, it is how the reliability standard is operationalised over the short term. Operational incentives can also extend beyond a week ahead of real time, whereby AEMO forecasts expected unserved energy through medium-term PASA. Market participants also make operational decisions based on their expectations of prices, either based on their own forecasts of prices or based on AEMO's forecasts of prices as well.

As noted above, up to seven days ahead, the LOR2 reserve level has recently been expanded to not just include the largest identified single credible contingency event, but also to take into account forecast deviations such as in wind or demand forecasts. While historically it was said that the market would be expected to plan for one single credible contingency at a time, more recently, due to changes occurring in the power system, the market now also plans for large deviations in forecasts, including for example, changes in demand. As a result, it can be said that the market is expected to plan for the above, including for example, changes in demand resulting from changes in solar PV generation or from wind forecast changes, rather than just single credible contingencies.

2.5.2 The role of interventions

Principle: Market participants are expected to meet the reliability standard without the need for interventions

Consistent with the purpose of the market price cap, the rules specify that the Panel may only recommend a market price cap that the Panel considers will allow the reliability standard

to be satisfied without AEMO using its power to issue directions to market participants or by dispatching or activating emergency reserves.[44] In other words, the market price cap should be set at a level to allow requisite reliability outcomes to be achieved (everything being equal) through price signals incentivising investment in capacity, without AEMO:

- Exercising its power to issue directions to market participants.
- Exercising the RERT through procuring and dispatching emergency reserves.

This implies that, generally speaking, when AEMO intervenes in the market, it does so as a last resort, after the market has not provided the required level of reserves. Assuming they are dispatched as a last resort, the amount associated with the direction or emergency reserves dispatched by AEMO can be described as an amount of energy that has not been met by the market.

44 Established under clauses 3.20.7(a) and 4.8.9(a) of the NER.

3 CLARIFICATION OF UNSERVED ENERGY CALCULATION

This chapter discusses:

- the current arrangements for unserved energy calculation, and what inputs are used
- stakeholders' views on what type of demand should be used in the calculation of unserved energy
- how transparency could be improved in relation to the unserved energy calculation.

3.1 Background

Unserved energy, as described in this review, relates to wholesale level unserved energy, i.e. unserved energy for the purposes of the reliability standard.

The reliability standard is defined in clause 3.9.3C(a) of the NER as follows:

> The reliability standard for **generation and inter-regional transmission elements** in the national electricity market is a maximum expected unserved energy (USE) in a region of 0.002% of the total energy demanded in that region for a given financial year.

Unserved energy is defined in Chapter 10 of the NER as follows:

> The amount of energy demanded, but not supplied, in a region determined in accordance with clause 3.9.3C(b), expressed as:
>
> (a) GWh; or
>
> (b) a percentage of the total energy demanded in that region over a specific period of time such as a financial year.

In the consultation paper, the Panel explored promoting transparency through possible clarification and simplification of the definition of unserved energy for the purposes of the reliability standard. The Panel noted that the current definition of unserved energy for the purposes of the reliability standard could be potentially complex to interpret in the constantly evolving power system.[45]

To calculate USE, AEMO divides the number of MWh shed in a financial year due to reliability causes (based on the definition of unserved energy in clause 3.9.3C of the NER) by the total energy demanded from the grid.

45 Reliability Panel, *Review of the definition of unserved energy*, consultation paper, p. 15.

Figure 3.1: Unserved energy calculation

$$Unserved\ energy\ (\%) = \frac{MWh\ shed}{Energy\ demanded} \times 100$$

The numerator is determined by clause 3.9.3C of the NER, which is discussed in more detail in chapter 4. It is based on assessing whether or not an event was a reliability event, and aims to exclude power system security events, generally speaking.

The denominator is energy demanded, but the NER do not prescribe which type of demand AEMO should use.

There are different types of demand used in the NEM. These are:

- **Native demand:** Demand that is met by local scheduled, semi-scheduled, non-scheduled,[46] and exempt generation,[47] and by generation imports to the region, excluding the demand of local scheduled loads.[48]
- **Operational demand:** demand that is met by local scheduled generation, semi-scheduled generation and non-scheduled wind/solar generation of aggregate capacity ≥ 30 MW, and by generation imports to the region, excluding the demand of local scheduled loads. Operational demand differs from native demand in that it generally excludes demand met by non-scheduled wind/solar generation of aggregate capacity < 30 MW, non-scheduled non-wind/non-solar generation and exempt generation.
- **Scheduled demand:** demand that is met by local scheduled and semi-scheduled generation and by generation imports to the region. Scheduled demand differs from the other key demands in that it excludes the demand met by non-scheduled (wind/solar and non-wind/non-solar) generation and exempt generation, and includes the demand of local scheduled loads.

The Panel understands that for the purpose of the unserved energy calculation, AEMO uses actual annual operational demand, i.e. it excludes non-scheduled wind/solar generation with a capacity of < 30 MW, such as solar PV. The Panel also understands that AEMO uses actual metered data and adds back the amount of load that was shed, to obtain the actual demand level.

In submissions to the consultation paper, a number of stakeholders commented on the inputs that AEMO uses for the calculation of unserved energy, and on AEMO's existing practices on how they calculate and report on unserved energy. While the Panel did not explicitly consult

46 This includes all non-scheduled generating units with aggregate capacity greater than 1 MW for which AEMO has sufficient data.

47 Exempt generation refers to generation that is exempt from registration, under Chapter 2 of the NER and in accordance with the *Guide to NEM generator classification and exemption* issued by AEMO. Typically, this includes generation with a capacity less than 5 MW, or less than 30 MW provided it exports less than 20 GWh in any 12-month period.

48 A market load classified in accordance to Chapter 2 of the NER as a scheduled load. A market customer submits dispatch bids in relation to scheduled loads.

on these issues, the concerns relate to the overall transparency of the USE calculation. The issues raised are discussed in more detail below.

3.2 Stakeholders' views

Types of energy demanded

A number of stakeholders commented that it is unclear which demand (i.e. energy demanded, or the denominator of the calculation) AEMO uses for the calculation of unserved energy value.

ERM Power stated: "...there are multiple terms being used by AEMO with regards to energy consumption forecasts ("energy demanded") all of which are prepared on a different basis with a range of outcomes." ERM Power proposed to define the term "energy demanded", and for this purpose use "native as generated" demand.[49] According to ERM Power, this will be consistent with the original setting of the reliability standard. This was echoed by EUAA's submission.[50] ERM Power also added that other alternatives such as "operational as delivered" would in effect result in a tightening of the reliability standard from that which was originally set. [51]

AEMO supports the clarification of what type of demand is used for the purposes of unserved energy: "...another aspect for improvement to the definition is clarification of the type of demand used to inform the amount of total energy demanded in a region; that is, operational demand, native demand or an alternative to these".[52]

Major Energy Users is of the view that greater clarity is required to set which value for energy provided is to be used as the basis for the calculation of USE. Major Energy Users also noted: "The difference between each of the various measures can be as great as 10- 15%. As the most common value for USE is as a percentage of total supply, using the incorrect value for the amount of energy supplied can provide a biased value for USE as the smaller the denominator used in the USE calculation, the higher the value of USE as a percentage and the greater the impacts on the market for the same volume of USE."[53]

Inclusion of DER

The issue of which demand should be used for the unserved energy calculation closely relates to whether distributed energy resources (DER) should be included or excluded from the calculation. For instance, if the calculation of unserved energy is based on operational demand - small non-scheduled generation would be excluded from the calculation; if it is based on the native demand - small non-scheduled generation would be included.

---

49 Native demand is the electrical energy supplied by scheduled, semi-scheduled, significant non-scheduled, and small non-scheduled generating units.

50 Energy Users Association of Australia, submission to consultation paper, p. 3.

51 ERM Power, submission to consultation paper, p. 2.

52 AEMO, submission to consultation paper, p. 3. Operational demand is the electrical energy supplied by scheduled, semi-scheduled, and significant non-scheduled generating units.

53 Major Energy Users, submission to consultation paper, p. 1.

In the consultation paper, the Panel also noted that there is continued uptake of DER, with continued strong growth of rooftop PV. Currently, the Panel understands that the loss of electricity supplied by DER is not included in the calculation. That is, potentially, there could be instances when reliability-related loss of electricity supply used to operate DER (included in the calculation of unserved energy) leads to higher levels of actual experienced unserved energy due to the interruption in electricity supply provided by DER (excluded from the calculation of unserved energy). The Panel noted that the calculation of unserved energy due to DER trip may present significant methodological and practical challenges.[54]

A number of stakeholders discussed in their submissions whether the definition of unserved energy should account for DER trip due to the reliability-related loss of electricity supply used to operate it.

The Australian Energy Council stated that if it is preferred to include behind the meter generation into the unserved energy calculation, it is necessary to align the denominator in the reliability standard equation to gross demand inclusive of all behind the meter generation throughout the year. The Australian Energy Council also noted: "Clearly this will make the accounting somewhat more complex and require estimates of unmetered behind the meter generation for both the numerator and denominator. Thus the Panel would need to consider the benefits of the change against these complexities. As the numerator and denominator would grow roughly equally, there maybe only minor changes in the resultant calculation of performance against the standard."[55]

AEMO commented that the Panel should consider whether rooftop PV should be included in or excluded from the definition of unserved energy. But if this element is incorporated, it should be reflected in both numerator and denominator in calculating unserved energy.[56]

3.3 Analysis and conclusions

Calculation of unserved energy

The Panel understands that AEMO uses annual operational consumption for calculating USE ex-post, using actual metered data and adding back the amount of load that was shed, to obtain actual energy demanded. Under the existing process, the Panel understands that small non-scheduled generation (which includes solar PV and other types of distributed energy resource) is not explicitly included in either the numerator (MWh shed) nor in the denominator (energy demanded) of the USE equation, but rather acts to reduce the operational consumption from the grid.

In submissions to the consultation paper, stakeholders suggested that solar PV, and DER more broadly, should be included in the ex-post calculation of USE.

The Panel notes that when the reliability standard was developed, small non-scheduled generation (i.e. DER) did not have as material an impact on the market as it has now. As the

54 Reliability Panel, *Review of the definition of unserved energy*, consultation paper, p. 16.
55 Australian Energy Council, submission to consultation paper, p. 2.
56 AEMO, submission to consultation paper, p. 3.

generation mix changes, with distributed energy resources playing an increasingly greater role in the NEM, this warrants consideration of whether small non-scheduled generation should be included in the calculation of unserved energy. In particular, the Panel understands that solar PV penetration in Victoria in particular, is a good example of the impact of DER on the power system.

When considering whether non-scheduled generation should be included in the calculation of unserved energy, the Panel recognises the fundamental difference between small non-scheduled generation and other types of market generation. Specifically:

- Distributed energy resources (DER) cannot be controlled by AEMO in a manner similar to other market generation. Rooftop solar PV, for instance, is not able to be dispatched or curtailed by AEMO. Further, AEMO does not have as good visibility of the operations of these resources, as it has of other generator types. It is difficult to predict the behaviour patterns of a high number of small distributed energy resources. This also could become more complex when considering whether a household is exporting or importing electricity when load shedding occurs, or whether a household has a battery storage which allows autonomous operation of a generation system.
- DER investment is made differently to the rest of the wholesale market. DER are usually the result of private individual investment at a household level. This type of investment is not directly influenced by increasing or decreasing the market price cap.[57] There is also limited correlation between wholesale prices and private investment in DER. However, they are not completely uncorrelated - wholesale prices may indirectly influence household decisions, to the extent that household prices contribute to the ultimate tariffs that consumers pay at the retail level, in the absence of DER.

These factors suggest the need to consider if DER are a part of the energy market, or if they are out-of-market resources. For example, DER do participate in the wholesale electricity market by exporting energy to the grid, although they are paid through feed-in tariffs, rather than through the wholesale market price. Further, the impact on DER affects wholesale forecasts, in particular, load forecasting. The higher the solar PV penetration, and the sunnier it is, the lower the demand forecast that needs to be met by other generators in the market.

Consider the following simple example.

A household has a 5kWh load, which is being met by a 4 kWh solar PV installation operating at 100 per cent capacity with no exports, with the rest coming from the wholesale market. If the household is involuntarily load shed, assuming it has no battery storage, then its lost load is 5kWh. Arguably, market participants are only meeting 1kWh of this demand and not 5kWh. On the other hand, it could be said that market participants were expected to meet 5kWh, through reserves. For example, AEMO's forecasting uncertainty measure, would have captured likely changes in demand as a result of changes in solar PV generation. Market participants would have been expected to respond by offering more reserves.

57 Unless a customer is exposed to the spot price.

In the former, the argument would be that since the market was only provided 1kWh at the time, only 1Kwh should be counted as USE. In the latter, however, 5kWh would be counted as the market was expected to plan for the additional demand.

In consultation with stakeholders and taking into account the work that has already been done and currently is underway to integrate DER in the market, the Panel formed the view that DER is part of the energy market generally speaking, and consequently the loss of small non-scheduled generation during reliability shortfalls should be reflected in the calculation of unserved energy, to the extent that it is possible to do so. The Panel's view is based on the following arguments:

- If energy generation from rooftop PV is lost during a reliability shortfall, clearly it is experienced by consumers and is caused by generation and interconnection inadequacy. That is, under the current practices, there could be instances when reliability-related loss of electricity supply used to operate DER (included in the calculation of unserved energy, based on current practice) leads to higher levels of actual experienced involuntary unserved energy due to the interruption in electricity supply provided by DER (excluded from the calculation of unserved energy, based on current practice). The inclusion of electricity supply provided by DER and lost during a reliability shortfall in the calculation of unserved energy could potentially reflect more accurately the actual wholesale unserved energy.
- DER have a direct impact on both AEMO's operation and market participants' financial outcome. Small non-scheduled generation affect the level of sent-out demand to be met by the wholesale market. Market participants' wholesale position and revenue will also be affected by change in their retail load and wholesale prices due to variations in DER output. AEMO has provided the Panel with the following example: even if sent-out demand is forecast to be 9000 MW in the afternoon, if there is some risk that the rooftop PV might drop by 1000 MW due to weather change, it is unlikely that the market and AEMO will not (or is not expected to) respond to it. This does not mean the market should overbuild capacity to replicate the energy generated by rooftop PV, but it should invest in the right resources (including demand response) and operate them to manage the volatility and other impacts of rooftop PV.

The Panel understands that AEMO accounts for small non-scheduled generation such as solar PV explicitly in its forecasting processes. For example, solar PV is included as part of the supply available to meet demand in its forecasting processes. As a result, it can be said that solar PV forms part of the planning and operational processes that underpin the operationalisation of the reliability standard.

Based on the arguments outlined above and supported by stakeholders submissions,[58] the Panel is of the view that the calculation of unserved energy should in principle, include solar PV and DER. This would mean that for the purposes of calculating USE ex post, the numerator would include any loss of load including that lost from solar PV generating at the time. The challenge, however, as flagged in the consultation paper, is practical in nature, in

58 ERM Power and Energy Users Association of Australia submissions to the consultation paper.

terms of the ability to accurately and usefully estimate how much DER was in use at the time. So while the Panel does recommend this approach in theory, it notes that in practice, it may not be practicable to do so.

If the numerator does include DER, it follows that the denominator should as well. In that case, energy demanded (the denominator) would be based on native demand as generated, rather than operational demand. Native demand in a region is demand that is met by local scheduled, semi-scheduled, non-scheduled,[59] and exempt generation,[60] and by generation imports to the region, excluding the demand of local scheduled loads. Native demand also includes generator auxiliary loads, and both transmission and distribution losses.[61]

In terms of prescription in the NER, the Panel does not consider it would be preferable to prescribe which demand AEMO should use in the NER, given the existing reliability framework and practical challenges of estimating the different types of demand. Prescription would make the ex-post calculation of USE inconsistent with the rest of the reliability framework and would not be flexible, in an area where flexibility is appropriate. For example, there is a significant work program on the integration of DER in the market and more generally on generation thresholds and categories. In addition, the practical limitations and challenges associated with estimating DER means that prescription could lead to unintended consequences. The Panel considers that AEMO should instead publish its methodology, as discussed next.

The Panel does not consider that the existing arrangements in the NER are inconsistent with the above recommendations that AEMO should in theory use native demand and include the appropriate additional load (such as DER) when calculating USE.

The Panel notes that the scope of this review is only about the ex-post calculation. As noted above, AEMO estimates USE over a number of time periods and forecasting processes. The Panel considers that it continues to be appropriate for AEMO to continue to operationalise the reliability standard as it currently does - the Panel is not proposing any changes to how this is done. The recommendations made in this report only relate to the ex-post calculation of USE.

Transparency of USE calculation

The Panel notes that most stakeholders considered that the Chapter 10 definition of unserved energy did not need any further clarification and that it appropriately reflected the reliability standard. The Panel agrees with stakeholders' views on this matter and is not proposing any changes to the chapter 10 definition.

Instead, stakeholders raised issues with the level of transparency of how USE is calculated.

Under the existing arrangements, AEMO performs the USE calculation in accordance with clause 3.9.3C(b) of the NER which outlines what events should be included or excluded from the calculation of wholesale unserved energy. The Panel then reports on wholesale unserved

59 This includes all non-scheduled generating units with aggregate capacity greater than 1 MW for which AEMO have sufficient data.

60 Exempt generation refers to generation that is exempt from registration, under Chapter 2 of the NER and in accordance with the *Guide to NEM generator classification and exemption* issued by AEMO. Typically, this includes generation with a capacity less than 5 MW, or less than 30 MW provided it exports less than 20 GWh in any 12-month period.

61 This also means that auxiliary loads would count towards USE, in the numerator.

energy and whether the reliability standard was met in a given financial year in each NEM region in its *Annual market performance reviews*.[62] The Energy Security Board also reports on this metrics in its annual *Health of the NEM* report.[63] These reports use AEMO's calculations as an input.

There is limited visibility of the actual process AEMO undertakes when calculating the USE - in particular, which demand is used in the calculation, how the load shedding figure in the numerator is estimated and what it is composed of. The Panel agrees with stakeholders that there is a lack of transparency about the calculation. The NER do not require AEMO to develop any particular methodology and is not prescriptive with regard to the calculation. This can lead to confusion about exactly what the USE value represents, and may lead to market participants making inappropriate decisions. There is also an element of asymmetry in the NER as some guidance is provided with respect to the numerator, but no guidance is provided with respect to the denominator.

To promote understanding of, and confidence in AEMO's calculation of USE, the Panel recommends that AEMO should clearly set out and publish how it calculates unserved energy ex post. This would describe:

- how AEMO calculates wholesale unserved energy for the purposes of the reliability standard
- which demand it uses for such calculations

The Panel considers that all unserved energy information and reports should be publicly available given the impact of unserved energy on investments that are passed through to energy consumers, the level of public interest in the reliability standard and system reliability generally. As a result, the Panel considers that AEMO should set out how it calculates unserved energy as part of its RSIG. The purpose of the RSIG is to explain how AEMO operationalises the reliability standard. Extending the RSIG to cover how this operationalisation works in an ex post manner improves consistency of the information provided by AEMO on the reliability standard.

As currently is the case, AEMO is also expected to provide detailed information to the Panel at the end of each financial year for the purposes of the Panel's *Annual market performance review.* This information should include the USE value for the purposes of the reliability standard, and what reliability events contributed to it.

RECOMMENDATION 1: IMPROVING TRANSPARENCY OF THE UNSERVED ENERGY CALCULATION

The Panel recommends that AEMO should be required to:

- set out and publish how it calculates unserved energy ex-post through the RSIG

62 For more information, see: https://www.aemc.gov.au/market-reviews-advice/annual-market-performance-review-2018

63 For more information, see: http://www.coagenergycouncil.gov.au/publications/health-national-electricity-market

- update how it calculates unserved energy as required by updating the RSIG using the rules consultation procedures.

The Panel considers that timely transparency is a key aspect of this recommendation. Updating the RSIG to include how it currently calculates unserved energy can be done relatively quickly given these initial amendments will not need consultation. However, should AEMO wish to change how it calculates unserved energy, then it would be required to consult appropriately.

Section 2.1 of the Panel's rule change request sets out the Panel's rationale and proposal in more detail.

4 CONTINGENCY-BASED FRAMEWORK

4.1 Background

In relation to the definition of unserved energy for the purposes of the reliability standard, clause 3.9.3C of the NER provides the following:

> **3.9.3C** Reliability standard
>
> ...
>
> (b) For the purposes of paragraph (a) unserved energy is to:
>
> (1) include *unserved energy* associated with *power system reliability* incidents that result from:
>
> (i) a single *credible contingency event* on *a generating unit* or an *inter-regional transmission element*, that may occur concurrently with *generating unit* or *inter-regional transmission element outages*; or
>
> (ii) delays to the construction or commissioning of new *generating units* or *inter-regional transmission elements*, including delays due to industrial action or acts of God; and
>
> (2) exclude *unserved energy* associated with *power system security* incidents that result from:
>
> (i) multiple *contingency events*, *protected events* or *non-credible contingency events* on a *generating unit* or an *inter-regional transmission element*, that may occur concurrently with *generating unit* or *inter-regional transmission element outages*;
>
> (ii) *outages* of *transmission network* or *distribution network* elements that do not significantly impact the ability to transfer *power* into the *region* where the USE occurred; or
>
> (iii) industrial action or acts of God at existing *generating facilities* or *inter-regional transmission facilities*.

In the consultation paper, the Panel noted that the current contingency-based definition of unserved energy for the purposes of the reliability standard could be potentially complex to interpret in the constantly evolving power system. It is also possible for forecast and availability deviations, both on the demand and on the supply side, to be larger than the largest credible contingency, particularly on extreme weather days, as reflected in a rule made by the Commission in December 2017 to account for these effects.[64] Further, during some complex events, there may be both a power system security and a power system reliability event occurring in parallel but independent of each other.

64 For more information see: AEMC, *Declaration of lack of reserve conditions*, final determination, December 2017, https://www.aemc.gov.au/rule-changes/declaration-of-lack-of-reserve-conditions

The reliability standard is not designed to limit supply interruptions caused by problems maintaining power system security. AEMO manages power system security to maintain the power system within technical limits via a range of tools, including applying network constraints to the NEM dispatch engine, dispatch of voltage control/reactive power, and requirements for frequency control ancillary services (FCAS).

Increasing generation or demand response capacity, in itself, may not *necessarily* alleviate a power system security issue. For example, additional generating units may not necessarily participate in FCAS markets or provide the specific system security service that is required, such as system strength or inertia. They may indirectly help, but having additional capacity in itself may not always address a specific power system security issue. Further, unlike security events, the management of any reliability events that may emerge would be managed through the existing reliability framework, for example, through the review of the reliability standard and settings. AEMO may also procure RERT to manage a reliability event (but it cannot procure RERT to manage a security event), or issue reliability directions.[65]

Importantly, the NER, as currently drafted, do not exclude all events that directly result from a power system security issue from the definition of unserved energy for the purpose of the reliability standard - it only includes a non-exhaustive list. There could be instances where an event, not captured in the specific exclusions for the calculation of unserved energy set out in the NER, could be captured in the definition and calculation of unserved energy.

4.2 Stakeholders' views

In its consultation paper, the Panel invited stakeholders' views on the appropriateness of the contingency-based definition of unserved energy, and whether power system security events should be explicitly excluded from the definition of unserved energy.

The majority of stakeholders that commented on these issues support the approach of exclusion of security events from the definition of unserved energy, and maintaining the contingency-based definition subject to some clarifications.

AEMO is of the view that there is merit in broadening the range of contingencies that will result in unserved energy under clause 3.9.3C(b) to include any events that result in unmet demand because the market was unable to deliver the required capacity. According to AEMO, this would enable the reliability standard to appropriately consider non-credible contingencies, such as the coincident failure of multiple generating units.

ERM Power supports the continued use of the contingency-based definition of unserved energy, subject to minor improvements. ERM Power also expressed its support to the explicit exclusion of power system security events from the calculation of unserved energy.[66]

The contingency-based definition and the explicit exclusion of all security events from the definition of unserved energy was also supported by Energy Users Association of Australia.[67]

65 AEMO may also issue directions for power system security.

66 ERM Power, submission to consultation paper, p. 4.

67 Energy Users Association of Australia, submission to consultation paper, p. 3

Most stakeholders expressly supported excluding all power system security events from the definition.[68] In relation to security events, AEMO stated: "... load shedding directly as a result of system security issues should be excluded from the unserved energy definition. However, ... AEMO acknowledges the challenge of codifying the appropriate approach for including or apportioning unserved energy associated with incidents that are initially triggered by a reliability event but which result in subsequent system security issues that lead to further load shedding."[69]

Origin added that contingency events should continue to form the basis for the definition of USE, however there may be a need to review the definition of credible and non-credible contingency events more generally.[70] Public Interest Advocacy Centre considers the contingency-based framework to be in need of review because, among other things, classifying events as credible/ non-credible is complex to determine in a changing power system.[71] The Panel notes that the definitions of contingency events are within the scope of AEMC's *Review of the System Black Event in South Australia on 28 September 2016* that is currently underway.[72]

The Clean Energy Council does not see benefit in maintaining contingency events as the base for the definition of unserved energy. This is because it is now possible to have forecast and availability deviations larger than the largest credible contingency. According to the Clean Energy Council, it would be beneficial to develop a more holistic framework for the definition of unserved energy.[73]

Energex and Ergon Energy's submission expressed disagreement with the explicit exclusion of power system security events, as this "underestimates the risks of changing reliability and security levels in an environment where the networks are evolving."[74] Instead, Energex and Ergon Energy suggested that "more detailed analysis of the correlation between reliability, system security, unserved energy and lack of reserves, and how they relate to regional drivers, be undertaken."[75] In relation to contingencies, Energex and Ergon Energy is of the view that credible contingency events should not serve as the sole basis for the definition due to the evolving nature of the power system.[76]

4.3 Analysis and conclusions

The Panel view is that the contingency-based definition that underpins the unserved energy framework should be changed only if the definition is no longer appropriate. To investigate

68 Clean Energy Council, submission to consultation paper, p. 1; Major Energy Users, submission to consultation paper, p. 1; Origin, submission to consultation paper, p. 1; Public Interest Advocacy Centre, submission to consultation paper, p. 1.

69 AEMO, submission to consultation paper, p. 4.

70 Origin, submission to consultation paper, p. 1.

71 Public Interest Advocacy Centre, submission to consultation paper, p. 3.

72 For more information, see: https://www.aemc.gov.au/markets-reviews-advice/review-of-the-system-black-event-in-south-australi

73 Clean Energy Council, submission to consultation paper, p. 1.

74 Energex and Ergon Energy, submission to consultation paper, p. 2.

75 Ibid.

76 Ibid, p. 1.

whether this is the case, the Panel analysed the events that occurred in the system during the last couple of years and how they fitted into the existing framework.

The table below outlines some system events that happened in the system between 2016 and 2019 and caused load shedding. The table also provides how those events were classified.

Table 4.1: **System events**

EVENT	DESCRIPTION	INCLUDED/EXCLUDED FROM THE USE CALCULATION
28 September 2016 - South Australian system black	Tornadoes damaged transmission infrastructure causing faults on the network. These faults led to a reduction in wind farm output, triggered by the specific protection settings of a number of wind farms, culminating in the trip of the Heywood interconnector and the separation of SouthAustralia from the NEM. Without any substantial load shedding following separation, the remaining generation was much less than the connected load and unable to maintain the islanded system frequency. As a result, all supply to the region was lost and the region was considered to be in a "black system" condition.	Excluded from the calculation of USE because this was a power system security incident. It was excluded on the basis of clause 3.9.3C(b)(2)(i) of the NER.
1 December 2016 - South Australia separation event	South Australia was only connected to the Victorian network via one 500kVHeywood Interconnector circuit, because the second circuit, which is normally connected, was out of service due to planned equipment	Excluded from the calculation of USE because the 500 kV transmission line was not an inter-regional transmission element. Clause 3.9.3C(b)(1)(i) specifically states that only single credible contingency events on an inter-regional

EVENT	DESCRIPTION	INCLUDED/EXCLUDED FROM THE USE CALCULATION
	maintenance arranged by AusNet Services. A fault on the Moorabool to Tarrone 500 kV transmission line in Victoria resulted in the loss of the Heywood interconnector between South Australia and Victoria and led to the disconnection of load. The power system was not in a secure operating state after this incident.	transmission element (such as an interconnector), that may occur concurrently with generating unit or inter-regional transmission element outages, are to be included (and only if they result in USE associated with reliability incidents).
8 February 2017	High temperatures contributed to high demand on that day. At approximately six o'clock in the evening, demand was higher than forecast, wind generation was lower than forecast, and thermal generation capacity was reduced due to forced outages that occurred earlier during the day. At this time, ENGIE, the operator of Pelican Point Power Station, notified AEMO that 165 MW of capacity was unavailable. ENGIE advised AEMO of a start-up time for Pelican Point which would not have enabled AEMO to meet the system security requirements under the NER. AEMO instructed load shedding (100 MW for 27 minutes).	Included in USE. This event was automatically included as USE. While AEMO instructed load shedding to return the system to a secure state, the root cause of the event was low reserves, i.e. a reliability event. Clause 3.9.3C(b)(1) and (2) are non-exhaustive so events such as this one, which may not necessarily have triggered by any one particular credible contingency event, are included.
10 February 2017 - New South Wales system event	High temperatures led to high demand conditions on the day. There was a forced outage of the Tallawarra	Excluded from the calculation of USE because the event was classified as a multiple contingency event. Clause

EVENT	DESCRIPTION	INCLUDED/EXCLUDED FROM THE USE CALCULATION
	Power Station (420MW) and two of Liddell's four units (over 800MW) were also unavailable. All four Colongra units (667MW in total) failed to start when required due to the unsuccessful generator switching from gas to diesel (gas supply was exhausted earlier in the day).	3.9.3C(b)(2)(i) states that power system security incidents resulting from multiple contingency events, that may occur concurrently with generating unit or inter-regional transmission element outages, are to be excluded.
24 and 25 January 2019 - Load shedding in Victoria	Simultaneous high temperatures in South Australia and Victoria resulted in high demands across both regions. On 24 and 25 January 2019, reductions in availability of electricity supply due to thermal inefficiencies, unexpected equipment failures, urgent maintenance activity, and reduced generation capacity meant there was not enough power generation in the both regions to supply the demand. AEMO activated RERT contracts to reduce demand in Victoria and South Australia and directed on a synchronous condenser in New South Wales to maximise flows into VIC across the VIC–NSW interconnector. These actions could not avoid the need to shed some load in Victoria to balance the demand with available supply.	The Panel expects this event will be included in the USE calculation, based on preliminary data from AEMO.

Source: AEMO's power system incident reports and the Panel's analysis.

The Panel considers that Clause 3.9.3C(b) of the NER, which provides guidance on how events are to be allocated to unserved energy for the purposes of the reliability standard, is largely fit for purpose. Acknowledging the challenge of foreseeing all possible types of system events, the Panel considers that the existing framework categorises events accurately in the majority of cases.

The Panel notes that the appropriateness of the contingency framework, including the definitions of credible and non-credible contingencies, is outside of the scope of this review. The review only focussed on whether clause 3.9.3C(b) of the NER was appropriate for the purpose of classifying events to unserved energy for the reliability standard.[77]

In a number of submissions, stakeholders expressed the view that more flexibility is required in the current definition of unserved energy to account for reliability events caused by multiple contingencies, or reliability events that occurred in parallel with system security events.

The Panel's view is that the current definition provides enough flexibility to deal with such events by stating that unserved energy, for the purposes of the reliability standard, includes unserved energy associated with power system reliability incidents.[78]That is, the rule provides examples of reliability events that should be included, such as load shedding as a result of single credible contingency, but the list of events provided is not exhaustive - meaning that other events could be included too, if they are reliability incidents.

This includes events where there may have been involuntary load shedding, even with single credible contingencies on generating units of inter-regional transmission element. Consider the example where demand is extremely high. Even if all generation is running and no credible contingency events occur, there could still be instances where there aren't enough reserves to meet demand. Involuntary load shedding would occur, and would automatically be counted towards USE. This would include events that result in changes in forecast demand, for example, even if they are not captured in the definition of single credible contingencies.

Importantly, the starting point for defining whether an event should be included or excluded from the calculation of USE is not what type of contingency it was, but rather whether the USE was associated with a reliability or security incident. Contingencies outlined in the rule are to guide AEMO when deciding whether an event should be included in or excluded from the calculation of unserved energy, but their list is not exhaustive. As a rule of thumb, it is true that a single credible contingency is typically seen as being the proxy for reliability events, and appropriately so. However, more recently, AMEO has changed how they manage reserves in real time to broaden what they take into account to include forecasting deviations. As a result, reliability events that result from these deviations would be captured as well, to reflect how the reliability standard is operationalised. The NER requirement is non-exhaustive.

77 This issue is being considered in the AEMC's South Australian black system review, see https://www.aemc.gov.au/news-centre/media-releases/south-australian-black-system-review

78 Clause 3.9.3C(b)(1) of the NER.

Similarly, the Panel is of the view that there is nothing in the NER that prevents AEMO from apportioning unserved energy associated with reliability and security incidents occurring in parallel, or any other mix of events, assuming that they can easily be separated and identified. For example, consider an example where it is a hot day and there is an LOR2 in place. Independently of that, bushfires lead to the loss of transmission lines, which would be classified as a power system security issue. After all the load is restored as a result of the tripped transmission lines, the LOR2 has deteriorated and turned into an LOR3. This would then trigger more load shedding if the system becomes insecure. Assuming that initial load shedding is classified as a power system security event, it could be excluded. Assuming that the subsequent load shedding is classified as a reliability event, it could be included.

In its submission, AEMO stated the level of guidance for considering load shedding that had mixed causes should be improved.[79] The Panel considers that AEMO is better placed to decide how exactly unserved energy resulted from a mixed cause event should be apportioned. As AEMO correctly noted, it is infeasible for the framework to cover every possible scenario.[80] The Panel also acknowledges that as currently worded, clause 3.9.3C is somewhat ambiguous and it is not clear that the clause allows for some flexibility in terms of being non-exhaustive.

The Panel therefore proposes specific changes to improve clarity and reduce ambiguity, and help with interpretation, discussed next. The Panel considers that these changes are limited to clarity and transparency, and do not fundamentally change the reliability standard, nor the definition of unserved energy.

Clarifying the purpose of USE

To provide more guidance to stakeholders and AEMO, and as proposed by the Australian Energy Council,[81] the Panel recommends instead including in the NER a purpose statement or principle for the definition of USE, to assist with its interpretation.

The principle would aim to specify the purpose of the unserved energy calculation to clarify that only events which the market would be expected to plan for through investment and operational decisions on generation and inter-regional transmission elements.[82]

The Panel considers that this change, while retaining flexibility, will provide more clarity around the intent of USE calculation.

RECOMMENDATION 2: CLARIFYING THE PURPOSE OF USE

The Panel proposes adding the following principle to Clause 3.9.3C:

"A power system reliability incident is to include only those incidents that AEMO considers

79 AEMO, submission to consultation paper, p. 2.
80 Ibid, p. 3.
81 Australian Energy Council, submission to consultation paper, p. 1.
82 Consistent with the definition of the reliability standard.

would have been avoided through additional investment in generation and/or inter-regional transmission elements."

Section 2.2.1 of the Panel's rule change request sets out the Panel's rationale and proposal in more detail.

Clarifying exhaustiveness of the clause

The Panel considers that the principle proposed in the previous section will help to address interpretation. However, it also considers that further clarification may be improve to improve transparency of the clause itself.

The Panel proposes to make it clearer that the intent of the clause is to:

- include unserved energy that results from power system reliability incidents, including the examples provided in the clause
- exclude unserved energy that results from power system security incidents, including the examples provided in the clause.

This would further clarify that events other than those captured by the principle described above should be excluded from the USE calculation.

Power system security incidents resulting from other causes would also be excluded, while power system reliability incidents resulting from causes not specified in the NER would be included. To be clear, the clause is meant to capture the root causes of events. For example, even though AEMO instructs load shedding when the power system becomes insecure, if the cause of the power system becoming insecure if due to an underlying reliability issue (i.e. lack of capacity), then, this would be a power system reliability incident.

Excluding power system security incidents would not exclude this event, as its root cause is not a power system security issue. As this calculation is carried out ex post, typically months after the event in question, AEMO would be able to examine the root causes using all of the information available to it, including its incident reports. It would not be deciding what type of event it is in real time, when it may be more difficult to differentiate between the two, especially during complex events.

The changes would also make it clearer that the distinction is between a wholesale reliability (generation and inter-regional transmission element) issue and other types of interruptions.

RECOMMENDATION 3: CLARIFYING THE CLAUSE AS NON-EXHAUSTIVE

The Panel proposes to clarify Clause 3.9.3C (b) of the NER to make it clearer that:

- it is non-exhaustive
- should include events where the root cause was a power system reliability issue and
- should exclude events where the root cause was a power system security event.

Section 2.2.2 of the Panel's rule change request sets out the Panel's rationale and proposal in more detail.

Minor improvements to the definition of USE

The Panel recommends the following improvements:

- Clause 3.9.3C(b)(2) states that unserved energy for the purposes of the reliability standard excludes unserved energy associated with power system security incidents that result from multiple contingency events, protected events or non-credible contingency events on a generating unit or an inter-regional transmission element (that may occur concurrently with generating unit or inter-regional transmission element outages).
- The Panel notes that protected events are the subsets of non-credible contingency events. Therefore, the Panel recommends deleting *protected events*, as *non-credible contingency events* will suffice.
- The Panel also proposes clarifying that multiple "contingency events" are in fact multiple "**credible** contingency events" since multiple non-credible contingency events would already captured by the clause ("non-credible contingency events"). It also proposes clarifying that non-credible contingency events cover both single and multiple events.

RECOMMENDATION 4: MINOR IMPROVEMENTS TO THE DEFINITION OF USE

The Panel proposes amending clause 3.9.3C(b)(2)(i) of the NER to:

- Delete the term "protected event"
- Clarify that multiple "contingency events" are multiple "credible contingency events"
- Clarify that non-credible contingency events are single or multiple events.

Section 2.3 of the Panel's rule change request sets out the Panel's rationale and proposal in more detail.

5 RELIABILITY-RELATED INTERVENTIONS

This section:

- discusses the role of reliability-related interventions in the reliability framework
- summarises stakeholders views on whether or not reliability-related interventions should be included in the calculation of unserved energy
- sets out the Panel's subsequent analysis, conclusions and recommendations.

5.1 Background

The regulatory and market arrangements for reliability in the NEM are primarily market-based. Decisions about dispatchable capacity are made in response to price signals (subject to the market price cap) and incentives offered by the spot and contract markets. The contract market has been an integral part of the NEM market design since its inception and makes a major contribution to reliability. Contracts exist to hedge uncertainty and manage risk, although participants can also achieve this by creating "natural hedges" through vertical integration, i.e. combining retailing and generation within one business.

Participants typically make investment, retirement, operation and maintenance decisions on the basis of expectations of future spot prices provided by the contract market and the need for investment in new capacity to enter into contracts (or natural hedges) to reduce exposure to future price risk. These types of decisions underpin reliability in the NEM.

Additional mechanisms exist that allow for interventions to be made in certain limited circumstances when the market based arrangements have not – or will not – deliver the desired outcome. The purpose of interventions is to help maintain and/or re-establish the reliability and security of the NEM when regulatory processes or market responses have not delivered desired outcomes.

AEMO may only deploy intervention tools in the event that wholesale and contract market price signals, AEMO's information disclosure processes and its informal negotiations with market participants fail to elicit the outcomes needed to alleviate the projected or actual, reserve shortfalls or system security issue. The fact that intervention mechanisms are considered 'last resort' powers is an attribute strongly supported by stakeholders throughout the Commission's *Reliability frameworks review,*[83] *Enhancement to the RERT* rule change[84] and *Investigation into intervention mechanisms and system strength in the NEM.*[85]

The RERT, directions and instructions are the three key intervention mechanisms available to AEMO if needed for power system security and reliability. In brief, the three mechanisms are as follows:

83 For more information, see: https://www.aemc.gov.au/markets-reviews-advice/reliability-frameworks-review

84 For more information, see: https://www.aemc.gov.au/rule-changes/enhancement-reliability-and-emergency-reserve-trader

85 For more information, see: https://www.aemc.gov.au/market-reviews-advice/investigation-intervention-mechanisms-and-system-strength-nem

- The RERT allows AEMO to pay a premium for additional capacity (known as emergency reserves) to be on stand-by in case of emergencies when the demand and supply balance is tight.[86]
- Directions allow AEMO to require a generator to increase (or decrease) its output or a scheduled load to decrease (or increase) consumption.[87] To be effective, the generator must have enough time to 'ramp up'. If the generating unit is not already generating, it can take time for it to start up and to connect to the network and begin to ramp up. Even generators which are currently generating cannot typically change their output instantly.
- Clause 4.8.9 instructions allow AEMO to instruct a (non-scheduled) network service provider to shed and restore load consistent with schedules provided by the relevant state government.[88] Instructions refer to all remaining registered participants that cannot be subject to a direction (i.e. not scheduled plant or a market generating unit). AEMO may also use a clause 4.8.9 instruction to instruct a large energy user to temporarily disconnect its load or reduce demand - however, this is not typically done by AEMO.

The Panel acknowledges another reliability intervention mechanism, namely, mandatory restrictions. Mandatory restrictions on the use of electricity may be imposed by a jurisdiction as a means of controlling demand and averting a situation where there is insufficient generation capacity to meet demand, particularly in situations where mandatory load shedding is or would otherwise be necessary. Since the introduction, provisions under Rule 3.12A that incorporate mandatory restrictions in the centralised dispatch and pricing process have never been used. However, prior to the introduction of the rule, Victoria imposed demand restrictions in February 2000. The Panel notes that the review of the mandatory restriction mechanism is within the scope of the AEMC's *Investigation into intervention mechanisms and system strength in the NEM* project that is currently underway.[89]

Although AEMO is expected to do all in its power to avoid load shedding using the above intervention mechanisms, there will be times when involuntary load shedding will occur because the level of investment and operational decisions are being driven by a reliability standard that is non-zero.

The current unserved energy calculation indicates customers' experiences in relation to wholesale reliability only. That is, in some instances even though reserve shortfalls are forecast, customers do not experience a supply interruption because of emergency reserves being dispatched by AEMO or because of a direction to a generation to increase output, which then avoids load shedding. However, by excluding reliability-related interventions from this calculation, it may potentially misrepresent the market's ability to meet customer demand.

86 Rule 3.20 of the NER.

87 Under clause 4.8.9 of the NER.

88 Under clause 4.8.9 of the NER.

89 For more information see: https://www.aemc.gov.au/market-reviews-advice/investigation-intervention-mechanisms-and-system-strength-nem

5.2 Stakeholders' views

In the consultation paper, the Panel invited stakeholders' views on whether AEMO's reliability-related interventions should be included into the definition of unserved energy. Three options were discussed:

- excluding reliability-related interventions from the definition of unserved energy
- including reliability-related interventions in the definition of unserved energy to the extent that they were required to meet demand, and
- calculating two values.

There were mixed views among stakeholders on this issue, as discussed next.

Support for two values

The Australian Energy Council noted that: "The quantities will provide more value if distinguished: the total [actual reliability based consumer interruptions] is informative in relation to market settings, and the latter [hypothetical interruptions avoided as a result of interventions] is informative as to the effectiveness of market intervention."[90]

AEMO recognised the benefits of two values be calculated: "The first metric should reflect the customer's actual experience of electricity supply, which excludes involuntary load shedding avoided by intervention from the calculation of unserved energy. This measure would allow assessment of the combined performance of the market and intervention frameworks against the reliability standard. The second metric should include the effect of AEMO intervention in the calculation of unserved energy, to the extent that the intervention avoided involuntary load shedding. It is preferable that the reliability settings incentivise sufficient 'in-market' supply to meet the reliability standard without interventions, so this metric would allow the effectiveness of the reliability settings to be assessed."[91]

In its submission, AEMO also suggested that the Panel consider using two distinct terms for the two metrics to avoid confusion.[92]

Energex and Ergon Energy were of the view that calculating two values "more accurately reflects the market's ability to supply customer demand".[93] It was also suggested that additional analysis be undertaken for all options discussed in the consultation paper to ensure the most effective option is ultimately selected.[94]

General support for including reliability-related interventions

The Clean Energy Council was of the view that including reliability-related interventions in the definition of unserved energy: "would potentially provide the market with a clearer indication of the amount of customer demand that cannot be supplied within a region. Providing the

90 Australian Energy Council, submission to consultation paper, p. 3.
91 AEMO, submission to consultation paper, p. 5.
92 Ibid.
93 Energex and Ergon Energy, submission to consultation paper, p. 3.
94 Ibid.

market with more information for decision making may allow it to meet customer demand without the activation of emergency reserves."[95]

Major Energy Users stated: " If the inability to supply is caused by a shortage of supply (i.e. not caused by network congestion), then any load shedding that actually occurs is effectively unserved energy, and provides a signal that more supply is required. This means that actually dispatched RERT generation (supply) and RERT load shedding implemented should be added to the [unserved energy] calculation."[96]

Stakeholders' concerns

On the other hand, a number of stakeholders advocated against the inclusion of AEMO's reliability-related interventions in the calculation of unserved energy value.

ERM Power did not support the inclusion of AEMO's reliability-related interventions in the definition of unserved energy. According to ERM Power, in general, AEMO's exercise of reliability-related interventions is to maintain regional reserve levels as opposed to preventing or reducing the value of involuntary load shedding, as such the majority of provision of these services would not contribute to reductions in unserved energy.[97] Further, ERM Power stated that seeking to define an additional methodology for how to include reliability-related interventions in the calculation of unserved energy would only increase the complexity of the process and lead to unnecessary confusion.[98]

ERM Power also suggested for the Panel to consider that: "... providers of these reliability-related intervention services are paid for the voluntary provision of the service. Whilst providers may have costs of service provision higher than the prevailing NEM market price cap which would prevent their provision of in-market price responsive demand management or supply services, we believe they should still be considered for the purpose of calculation of [unserved energy] as a normal voluntary demand management or supply response to a price signal even though this price signal in this case is triggered out of market by AEMO."[99]

Energy Users Association of Australia's and Origin's submissions expressed disagreement with the inclusion of AEMO's reliability-related interventions be included in the definition of unserved energy.[100] Origin noted: "The level of [unserved energy] should reflect the quantity of unmet demand after all the tools available to the market are utilised. This will provide a more accurate view of the market's overall reliability performance."[101] Origin also added that the Panel can separately record the level of reliability interruptions that are prevented due to AEMO interventions.[102]

Public Interest Advocacy Centre supported further exploring how out-of-market interventions such as the RERT should be treated for the purposes of reliability, with a view to avoiding

95 Clean Energy Council, submission to consultation paper, p. 2.
96 Major Energy Users, submission to consultation paper, p. 3.
97 ERM Power, submission to consultation paper, p. 4.
98 Ibid.
99 Ibid.
100 Energy Users Association of Australia, submission to consultation paper, p. 3; Origin, submission to consultation paper, p. 1-2.
101 Origin, submission to consultation paper, p. 1-2.
102 Ibid, p. 2.

inflated estimates of unserved energy which would add to inefficient consumer costs. Public Interest Advocacy Centre also added that this would be particularly problematic if RERT becomes routinely and/or frequently invoked so that it becomes 'normal', and so is effectively priced into the market.[103]

5.3 Analysis and conclusions

As discussed in chapter 2, market participants are expected to meet the reliability standard, without the need for AEMO to intervene in the market. Generally speaking, AEMO is only expected to intervene, through reliability-related interventions, as a last resort, only after the market has failed to provide the expected the level of reliability (i.e. up to the reliability standard).

The amount of demand supplied through intervention mechanisms can be seen as demand which was not supplied by the market. In other words, the electricity supplied to consumers from the emergency reserves or through directions ultimately was not delivered (served) by the market itself through the market mechanisms, rather it was delivered by the out-of-market tools.

As a result, *in theory*, the Panel considers that it would be appropriate to include reliability-related interventions in USE. This is because in theory, there is perfect information and AEMO would only truly intervene when the market has failed - all reliability-related interventions would have resulted in loss of supply for consumers, had AEMO not intervened. In this theoretical construct, it would be appropriate to include these interventions as it would mean that they were needed because there was not enough investment. It would be appropriate, therefore, to signal this.

However, there are practical challenges to this. This is acknowledged by stakeholders, as most stakeholders that supported including reliability-related interventions noted that it should be included, to the extent that it would have avoided involuntary load shedding.

To recognise the practical difficulties associated with ex-post calculation of the extent to which a direction or RERT was actually needed to address a failure by the market to meet the reliability standard, while also recognising the additional level of information that including reliability-related interventions would provide, the Panel considers that it is appropriate for AEMO to report both numbers:

- unserved energy without reliability-related interventions (as is currently the practice)
- unserved energy with reliability-related interventions.

This is discussed in more detail next.

Publication of unserved energy without reliability-related interventions

Due to the nature of the RERT and how it is operationalised, AEMO often tends to dispatch emergency reserves on an ex-ante basis (before the actual need), based on a forecast

103 Public Interest Advocacy Centre, submission to consultation paper, p. 3.

LOR2[104], rather than waiting for an actual LOR2 or an LOR3[105] to occur. This was also echoed in the ERM Power submission by stating that reliability-related interventions are often used to maintain regional reserve levels as opposed to preventing load shedding.[106]

The main reasons for AEMO exercising its intervention powers in advance of the actual need are discussed below using RERT as an example:

- There are a number of steps that AEMO must take before it dispatches emergency reserves (an out-of-market, last resort mechanism), which means that in practice, AEMO cannot wait until the very last minute to dispatch emergency reserves. Emergency reserves typically have a pre-activation (getting ready to be called upon, which usually occurs about 20+ hours ahead of a shortfall) and activation lead time (getting ready to be dispatched), which means that they are dispatched ahead of time.
- Forecast or actual LOR2 assumes that there will be a lack of generation capacity (load shedding), if the largest credible contingency event occurs or the prevailing conditions change significantly (for instance, sudden drop in the wind generation). Hence, to account for these possible scenarios, AEMO dispatches emergency reserves in response to a forecast or actual LOR2. Consequently, if a large credible contingency event eventuates or the prevailing conditions change significantly, the ex post analysis may show that the RERT was needed. Alternatively, if there is no change in the system conditions, the ex-post analysis may show that the RERT was not required to meet the demand.
- Further, each RERT contract may have different minimum run times and hours of reserve availability, as well as deactivation lead times (ramping down to zero or ramping up in the case of demand response). It is possible for the actual LOR2 or LOR3 condition being significantly shorter than the minimum run time according to a specific RERT contract. In this case, AEMO has to continue dispatching the RERT according to the contract's terms and conditions, even if the RERT is no longer needed. The ex-post analysis may then show that the RERT was needed for the duration of the LOR2 or LOR3 condition but was not needed for the rest of the activation time.

All the above demonstrate the complexities of calculating the energy proportion delivered through a reliability intervention that was actually needed to avoid involuntary load shedding. The potential for inaccuracies and subjectivity in this calculation could lead to inflated estimates of unserved energy, which in turn may signal over-investment with significant cost implications for consumers.

In addition to the risk described above, the Panel notes that, at present, AEMO assesses market performance against the reliability standard using unserved energy without reliability-related interventions. For example, the reliability direction which occurred in February 2017 was not added to the unserved energy calculation and neither was the RERT in 2017-18.

104 LOR notices are discussed in more detail in chapter X.

105 When load shedding is imminent.

106 ERM Power, submission to consultation paper, p. 4.

As a result, changing market performance to include reliability-related interventions would broaden how the assessment has been carried out in the past. Broadening what is included in the calculation needs to be considered carefully in conjunction with the definition of the reliability standard. In other words, a broadening what is included without a corresponding change to the level and scope of the reliability standard may lead to two different signals:

- a signal that the market is meant to invest up the reliability standard
- an ex-post assessment based on a different assumed level of reliability.

In this instance, the Panel considers that broadening unserved energy to include reliability-related interventions would, in effect, create a potential disconnect between the ex-post calculation and the reliability standard. Further work would need to be undertaken to examine the implications of such a change as part of any review of the reliability standard.

In the meantime, the Panel considers that the market performance should continue to be assessed on the basis of unserved energy calculation that excludes reliability-related interventions due to the risks and issues highlighted above.

Publication of unserved energy with reliability-related interventions

Some stakeholders suggested that it could be beneficial to publish an unserved energy calculation that includes reliability-related interventions to the extent that they were required to meet demand, but as a separate piece of information to the unserved energy calculation used for assessing market performance. Other stakeholders were concerned that publishing two values would be confusing.

The publication of two values, one that excludes and one that includes reliability-related interventions in the unserved energy calculation to the extent that they were required to meet demand may provide additional information to market participants on the amount of customer demand that cannot be supplied within a region. If reliability interventions occur, it would be beneficial to understand how the energy amount supplied through the emergency mechanisms correlates with wholesale unserved energy that actually eventuated, and the reliability standard.

The Panel notes that if AEMO wishes to publish information about the impact of reliability-related interventions on demand, the NER do not prevent AEMO from calculating and publishing the additional value that includes reliability-related interventions. Under the existing arrangements, stakeholders could be provided with both the amount of customer demand not supplied at all (unserved energy calculation used to assess the market performance in financial year) and the amount of demand supplied through intervention mechanisms, not market ones (additional data set for stakeholders to assist in their operational decisions).

The Panel also notes that AEMO has reported on involuntary load shedding avoided due to interventions for the January 2019 load shedding event. In its *Load Shedding in Victoria on 24 and 25 January 2019* report, AEMO stated that without RERT around 1,252 MWh of load

would have been required to be shed involuntarily.[107] AEMO did not specify how it modelled the amount of avoided load shedding through RERT.

RECOMMENDATION 5: RELIABILITY-RELATED INTERVENTIONS

The Panel recommends that AEMO should report two unserved energy values:

- unserved energy without reliability-related interventions (as is currently the practice)
- unserved energy with reliability-related interventions.

The Panel does not recommend any changes to the NER on this aspect of the framework.

The Panel considers that AEMO should continue to assess market performance against the reliability standard using the first number, that is unserved energy excluding reliability-related interventions, as is currently the case. The Panel considers that any expansion of the definition to include reliability-related interventions should be examined as part of any review of the reliability standard.

107 AEMO, *Load Shedding in Victoria on 24 and 25 January 2019,* April 2019, p. 6.

A THE PANEL'S CONCLUSIONS ON OTHER ISSUES RAISED

This appendix outlines the Panel's analysis and conclusions in relation to other issues raised, including on:

- aligning the definition of unserved energy with consumer experiences of supply interruptions
- the treatment of voluntary curtailment and wholesale demand response
- the treatment of intra-regional constraints.

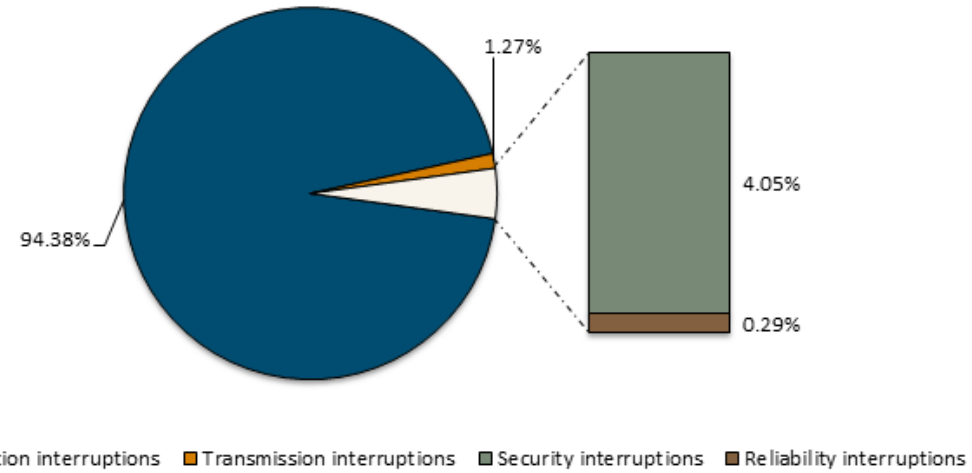
A.1 Matching consumer experience of supply interruptions

In its submission to the Commission's *Reliability Frameworks Review*, Energy Networks Australia suggested that the definition of unserved energy should be aligned with consumer experiences of supply interruptions, whatever their cause. It suggested that consumer expectations should be regarded as an important consideration in defining and attaining a more holistic understanding of unserved energy.[108]

The Panel acknowledges unserved energy for the purpose of the reliability standard is different from supply interruptions as experienced by customers. Reliability interruptions (i.e. not having enough capacity to meet demand) are the only source of interruptions that count towards unserved energy, and they only account for 0.29 per cent of all supply interruptions, as shown in the figure below.

108 Energy Networks Australia, submission to interim report of *Reliability Frameworks Review*, February 2018, pp. 4-5.

Figure A.1: Sources of supply interruptions in the NEM from 2007/08 to 2017/18



Source: AEMC analysis and estimates based on publicly available information from AEMO's incident reports and the AER's RIN economic benchmarking spreadsheets.

Note: With regard to outages on the distribution network in 2017/18, a number of distribution network service providers (DNSPs) have reported unsupplied energy data on a calendar year rather than financial year basis via the RINs. For these DNSPs, the data for the 2017 calendar year was treated as 2017/18 financial year data. The DNSPs reporting unsupplied energy data on a calendar year basis are: ActewAGL, Endeavour Energy, Energex, Ergon, SA Power Networks and TasNetworks.

However, the reliability standard targets the amount of unserved energy that consumers can expect from a particular cause, i.e. insufficient generation/demand response and interconnection within a NEM region. Including every single supply interruption event in the measurement of unserved energy would likely create the mistaken impression that it is possible to reduce all forms of supply interruptions by increasing generating capacity or increasing demand response.

The Panel did not examine the definition of the reliability standard as part of this review. This review examined the definition of unserved energy, given the existing definition of the reliability standard, which is only concerned with generation and interconnection.

It may also have significant implications for reliability in the NEM. Irrespective of whether the reliability standard was met, the yearly assessment would show that it was not. Including all types of interruptions for a metric that is only meant to be used for the reliability framework is not appropriate. Furthermore, broadening the definition of unserved energy to reflect actual consumer experience of supply interruptions may have significant implications for investment. Including every single supply interruption event, as an example, would substantially inflate the amount of unserved energy and lead to over-investment in capacity (i.e. generation supply or demand response) at the wholesale level, with costs ultimately paid for by consumers. This is because the reliability standard only signals investment in generation, demand response and inter-regional capacity. As discussed in chapter 5, broadening the definition of unserved energy without a consistent broadening of the definition of the reliability standard would lead to different signals. Changes to the

broadening of the definition of unserved energy in isolation of an assessment of the definition of the reliability standard would therefore not be appropriate.

Network reliability is managed by the governments in each jurisdiction. There are existing state-based reliability standards that signal the level of reliability expected of a region's network assets (transmission and distribution). Supply interruptions as a result of a network outage therefore count towards a breach of jurisdictional network reliability requirements (typically imposed through licence conditions), rather than a breach of the NEM's reliability standard.

The Panel's conclusion is that this approach remains appropriate because increasing generation capacity would not necessarily improve network reliability. Additional supply would be of no use if network constraints prevent it from being transmitted to where it is demanded. This view was also overwhelmingly supported by stakeholders' submissions to the consultation paper for this review.[109]

A.2 Voluntary curtailment or demand response

During the AEMC's *Reliability frameworks* review,[110] TransGrid noted that actions such as voluntary curtailment and large market responses are not included in the definition, even when the effect on consumers is similar to unserved energy. This was echoed by ENA. TransGrid suggested that a broadening of the definition would better align it with the level of reliability experienced by consumers.[111]

In its submission to the *Definition of unserved energy* consultation paper, TransGrid reiterated its previously expressed view that the definition of unserved energy should be broadened to include voluntary curtailment that occurs so that demand does not exceed supply, such as curtailment due to participation in RERT. TransGrid added that such curtailments also include responding to wholesale price exposure, incentives from third parties or when called upon by a jurisdiction to respond (as occurred in NSW on 10 February 2017). TransGrid is of the view that the distinction between demand response that occurs "in the market" or "out of the market" (such as responding to emergency reserves) is not relevant to consumers - their experience is the same in that they have decided that the cost to themselves or their business would be too great to continue consuming power.[112]

Energex and Ergon Energy are of the view that voluntary load reduction can be considered "in market" where the participant is adequately compensated.[113]

The Panel notes that load shedding for the purposes of the reliability standard does not include voluntary curtailment, including curtailment:

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109 AEMO, submission to the consultation paper, p. 5; ERM Power, submission to the consultation paper, p. 5; Energy Users Association of Australia, submission to the consultation paper, p. 3; Public Interest Advocacy Centre, submission to the consultation paper, p. 1; Australian Energy Council, submission to the consultation paper, p. 3; Major Energy Users, submission to the consultation paper, p. 1.

110 For more information, see: https://www.aemc.gov.au/markets-reviews-advice/reliability-frameworks-review

111 TransGrid, submission to the direction paper of *Reliability Frameworks Review*, May 2018, p. 5.

112 TransGrid, submission to the consultation paper, p. 1.

113 Energex and Ergon Energy, submission to the consultation paper, p. 3.

- to reduce a customer's own exposure to the wholesale price (e.g. demand response due to being spot-exposed)
- in response to incentives from retailers or third-parties (e.g. demand response through a retailer)
- in response to jurisdictions' calls to reduce consumption (e.g. system event in New South Wales on 10 February 2017, often referred to as voluntary curtailment).[114]

Indeed, the Panel considers that voluntary demand response, such as wholesale demand response in the first and second dot points above, is similar to additional generation, i.e. it is capacity at the wholesale level rather than avoided load shedding. The Panel understands that voluntary demand response is treated this way currently through the reliability framework, i.e. it is seen as the same as providing additional generation (in this case, through lower demand). The lower demand is therefore not load shedding and not included in the numerator of the unserved energy calculation (MWh shed). The Panel considers that this remains appropriate. The reliability standard is not meant to reflect all supply interruptions as experienced by consumers - it is specifically targeted at having enough generation (including voluntary demand response) and inter-connector assets.

The Panel's conclusion, supported by the majority of stakeholders' submissions to the consultation paper,[115] is that voluntary curtailment and demand response should continue be excluded from the definition of unserved energy, i.e. from counting towards load shedding.

A.3 Intra-regional constraints

In submissions to the consultation paper, some stakeholders suggested that unserved energy for the purposes of the reliability standard should measure the amount of demand not met by the market due to intra-regional constraints.

AEMO is of the view that: "while interconnectors were traditionally the primary thermal constraint limiting the flow of electricity in the NEM, intra-regional constraints are becoming prominent and therefore should now be considered in the definition".[116]

The Major Energy Users considers that there are transmission network congestion issues that impact the assessment of unserved energy, and they need to be reflected in the calculation of the unserved energy: "If the reason for the loss of supply to some consumers is a result of intra-regional transmission constraints, declaring there is USE when there would have been adequate generation otherwise available within the region (or even from interstate) to provide for the needs of consumers would appear to be sending a signal for more generation supply when in fact more investment in the network is required to ensure all consumers receive supply."[117]

114 AEMO, *System event report New South Wales 10 February 2017*, February 2017.

115 AEMO, submission to the consultation paper, p. 5; ERM Power, submission to the consultation paper, p. 5; Energy Users Association of Australia, submission to the consultation paper, p. 4; Clean Energy Council, submission to the consultation paper, p. 3; Public Interest Advocacy Centre, submission to the consultation paper, p. 2; Australian Energy Council, submission to the consultation paper, p. 3.

116 AEMO, submission to the consultation paper, p. 3.

117 Major Energy Users, submission to the consultation paper, p. 2.

The Major Energy Users suggests that a solution could to have different USE calculations for each cause of the loss of supply – a transport (transmission) USE and a supply (generation) USE.[118]

The Panel considers it would be inappropriate to include in unserved energy calculation the loss of supply that is a result of intra-regional transmission constraints because:

- Unserved energy is applied to measure any supply interruptions consumers experience from generation and interconnection inadequacy, consistent with the reliability standard, i.e. the amount of customer demand that cannot be supplied within a region of the NEM due to a shortage of generation (including demand-side participation), or interconnector capacity. Intra-regional transmission constraints cannot necessarily be addressed by having additional investment in more generation or interconnector capacity. Indeed, signalling investment where there are constraints may worsen the issue if further generation is built behind the constraint.
- Including the impact intra-regional constraints would lead to higher costs borne by consumers. Broadening of the definition of unserved energy may lead to the reliability standard being breached more often. This, in turn, would be reflected in the need to increase the market price cap, which may lead to more investment in generation capacity rather than transmission infrastructure, and ultimately costs borne by end-users. It would also be inconsistent with the definition of the reliability standard.
- In response to the suggestion from Major Energy Users on the provision of a signal for network investment, the Panel notes that a separate framework exists to measure transmission reliability. Outages on the transmission network are measured in system unsupplied minutes which is the amount of energy not supplied, divided by maximum demand, multiplied by 60. The Panel reports on network performance in its *Annual market performance review*.[119] There are also some national requirements that impact upon the reliability of the transmission network. Part B of chapter 5 of the rules includes planning requirements for transmission networks.
- The Panel notes that the treatment of transmission constraints is within the scope of the AEMC's *Coordination of generation and transmission investment* review. The review proposes a number of reforms, including dynamic regional pricing and transmission hedging. Where congestion arises, and transmission constraints occur, pricing regions would be dynamically created through existing dispatch processes which would reflect transmission constraints that are actually occurring at that particular time. Dynamic regional pricing would mean that wholesale electricity prices more accurately reflect the costs of supplying electricity. Transmission hedging would introduce a financial risk management tool for generators, as well as facilitating greater coordination in transmission planning.[120]

Therefore, the Panel does not recommend any changes to how intra-regional constraints are accounted for in the unserved energy calculation.

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118 Ibid.

119 For more information, see: https://www.aemc.gov.au/market-reviews-advice/annual-market-performance-review-2018

120 For more information see: AEMC, *COGATI – access reform*, directions paper, June 2019.

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Commission	See AEMC
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
NGL	National Gas Law
NGO	National gas objective