RELIABILITY PANEL AEMC

REVIEW

Reliability Panel AEMC

FINAL REPORT

2021 ANNUAL MARKET PERFORMANCE REVIEW

28 APRIL 2022

INQUIRIES

Reliability Panel
c/- Australian Energy Market Commission
GPO Box 2603
Sydney NSW 2000

E aemc@aemc.gov.au
T (02) 8296 7800

Reference: REL0083

CITATION

Reliability Panel, 2021 Annual Market Performance Review, Final report, 28 April 2022

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

Charles Popple (Chairman), Chairman and AEMC Commissioner
Stephen Clark, Marinus Link Project Director, TasNetworks
Joel Gilmore, General Manager Energy Policy and Planning, Iberdrola Australia
Craig Memery, Director - Energy + Water Consumer's Advocacy Program, PIAC
Ken Harper, Group Manager Operational Support, AEMO
Keith Robertson, General Manager Regulatory Policy, Origin Energy
Ken Woolley, Executive Director Merchant Energy, Alinta Energy
Peter Price, Head of Corporate Strategy and Executive General Manager Asset Safety and Performance, Energy Queensland
Gabrielle Kuiper, DER Specialist - Institute for Energy Economics and Financial Analysis
Melissa Perrow, General Manager Energy, Brickworks Limited

FOREWORD

I am pleased to present this report setting out the findings of the Reliability Panel's (Panel's) annual review of market performance, for the period 2020-21.

The Panel has reviewed the performance of the National Electricity Market (NEM) in terms of reliability, security, and safety over the 2020-21 period, in accordance with the requirements of the National Electricity Rules (Rules or NER) and the terms of reference issued by the Australian Energy Market Commission (AEMC).

Power system security concerns the operation of the power system within its technical limits and is primarily the responsibility of the Australian Energy Market Operator (AEMO). Power system reliability is about having sufficient capacity to meet customer demand for energy and is primarily driven by investment in capacity in the market. The Panel has considered both historic trends and projections of the security and reliability of the NEM.

This year's review shows that during the reporting period the system maintained high levels of reliability and security in the face of challenging circumstances. In particular:

- Reliability tightened as the power system continued the transition away from coal and towards renewable sources of energy firmed by a range of storage and gas technologies. This is highlighted by an increase in lack of reserve notices issued by the market operator. However, despite this there were no instances of unserved energy caused by reliability events. The reliability and emergency reserve trader (RERT) was activated twice in 2020-21 (in NSW and Queensland), at a total cost of $0.66m. One of these activations was used to manage security outcomes.
- Security outcomes continued to pose challenges as the complexity and difficulty of operating the system within its technical envelope increases. This is evidenced by increases in some metrics, such as the number of market notices issued by AEMO and the number of power system directions. As noted above, the RERT was used once to manage system security outcomes. Despite this there were no incidents where the power system was not in a secure operating state for more than 30 minutes - down from three in the previous reporting period. In addition, the frequency performance of the power system improved significantly with the introduction of mandatory primary frequency response in both the mainland and Tasmanian power systems.

These findings show the continued importance of evolving market and regulatory frameworks to maintain the high levels of reliability and security across the power system that consumers have come to expect and enjoy at an affordable price. Without further efforts to ensure market and regulatory frameworks are fit for purpose as the power system transitions, consumers could be left either paying too much for the reliability and security they demand or with undesirably lower levels of reliability and security. To this end, there is currently a large volume of work being undertaken by the ESB, supported by the market bodies to progress the recommendations from the ESB's post-2025 market design process.

Finally, the Panel greatly appreciates the staff of the AEMC secretariat for their efforts in coordinating the collection and collation of information presented in this report, for their interpretation and analysis of the data, their collaboration with the Panel in developing the report, and for their detailed drafting on behalf of the Panel.

Charles Popple

Chairman, Reliability Panel and Commissioner, AEMC

EXECUTIVE SUMMARY

1 This report sets out the findings of the Panel's 2021 Annual Market Performance Review (AMPR), as required by the National Electricity Rules. The AMPR is conducted in accordance with the terms of reference provided by the AEMC.[1] This review covers the period from 1 July 2020 to 30 June 2021 and includes observations and commentary on the reliability, security, and safety performance of the NEM primarily relating to that period. It also provides commentary on current and emerging trends and issues, including the market and regulatory changes currently underway.

2 Most of the data included in this report is already publicly available in various other reports. As with previous reports, the value of this report comes from the Panel, with its diverse membership, collating and interpreting all the information and data to make sense of what is happening across the power system and market. Accompanying the 2021 AMPR, the Panel has published a data file so that stakeholders can use key data sets more easily.

3 The power system is undergoing a fundamental transformation in terms of how electricity is consumed and in how and where it is supplied. It is transitioning from a system designed around a small number of large, synchronous, thermal generators to a system with a high amount of inverter-based resources (IBR), such as variable renewable energy generators and batteries, geographically dispersed at both a utility-scale level and a distributed level. This transformation is highlighted through a number of key trends, many of which have become established over recent years and are only expected to accelerate into the future:

- Thermal generators are retiring faster than previously expected, and also increasingly changing their on-line operations — for example operating at low levels or going into stand-by. They are being replaced by wind, solar, and increasingly batteries, which connect to the system through inverters.
- The decreasing proportion of thermal generators and increasing proportion of IBR creates a range of new challenges for security.
- Wholesale prices are decreasing, driven by the increasing proportion of low-cost variable renewable energy (VRE) generation. This is creating challenging operating conditions for less flexible generators such as coal-fired units and is likely the driver behind early thermal unit retirements.
- The installed capacity of distributed solar PV and distributed batteries is growing exponentially, albeit with the growth of batteries from a lower base. Distributed energy resources (DER), particularly solar, are an increasingly dominant driver of trends in system load.
- Minimum system load is trending down, with South Australia already experiencing zero system load at times.

1 For the complete standing terms of reference, see appendix A

- Intraday system load variation is increasing, particularly during the 'evening ramp' period when distributed and utility-scale solar is tapering off but underlying demand is peaking for the day

4 This seismic shift in the topography and composition of the power system requires an equally large shift in the frameworks that manage the security and reliability of the NEM. The Panel notes that there is an extensive reform program underway to ensure that the system is best able to manage the transition. In 2021, the ESB delivered its post-2025 market design advice to Ministers, with the implementation of the package currently underway. Commentary on the reforms currently progressing is provided under the Reliability and Security headings below.

Reliability

5 A reliable power system has enough generation, demand response and network capacity to supply consumers with the energy that they demand with a very high degree of confidence.

What happened in 2020-21?

6 The Panel has found that reliability outcomes in the NEM in 2020-21 were satisfactory. There were some signs of strain on reliability, however, the reliability framework was robust in dealing with these events. Key reliability outcomes in 2020-21 include that:

- The reliability standard and interim reliability measure (IRM) of 0.002% and 0.0006% unserved energy (USE) respectively were not breached
- AEMO forecast no breach of the reliability standard in the 2021 ESOO until 2028-29 in Victoria and 2029-30 in NSW. Additionally, no breach of the interim reliability measure is forecast while it is in force. It should be noted, however, that this was calculated prior to Origin's announcement that Eraring's retirement would be brought forward to 2025, and as such AEMO is in the process of producing an updated reliability outlook.
- There were no reliability events (actual LOR3 conditions) where supply was interrupted due to a shortfall of available capacity and reserves.
- AEMO issued 53 actual lack of reserves notices, a large increase from 17 in the previous period. This was driven by an unprecedented increase in LOR1 events, which is the first level of alert of a shortage of market reserves.
- RERT was activated on two occasions (in NSW and Queensland). However, on one of these occasions the RERT was used to manage security outcomes in the NEM. The total cost of these activations was $0.66m, down from $40.6m in the previous period.
- The cumulative price threshold (CPT) was not breached for energy, and so the administered price cap (APC) was not triggered. The CPT was breached for frequency control ancillary services (FCAS) on 5 June 2021 in the fast contingency raise service in Queensland. The APC was consequently applied until 10 June 2021.
- Load forecasting accuracy was marginally worse in 2020-21 than in 2019-20. Wind energy forecast accuracy improved, and solar energy forecast accuracy was flat compared to the previous year.

- The number of participants producing self-forecasts for renewable energy generators has increased substantially, with the accuracy of these forecasts exceeding AEMO's wind and solar energy forecasting systems as would be expected.
- Transmission unsupplied minutes decreased in NSW, Victoria, and South Australia, and increased in SA and Tasmania.

What are the implications and how are they being addressed?

7 The Panel notes that while there was no unserved energy recorded in 2020-21, the period saw continued challenges to reliability. This is best illustrated in the large increase in lack of reserve notices, reflecting an increase in periods where the system is operating with a smaller reserve margin than has occurred in the past. The underlying causes of this decline in reserve margin vary depending on the particular circumstances prevailing at the time but include coincident generator outages and transmission outages, particularly on interconnectors. This reflects the increasing complexity of operating the system and increasing regional inter-dependency, which is linked to the regional correlation of renewable energy resources.

8 While the frameworks are adequate to manage reliability challenges in the present, looking forward and extrapolating current trends suggests that changes to existing reliability frameworks and the introduction of new ones will be necessary. A key example is the exit of thermal plant, the schedule of which is accelerating and may lead to significant reliability challenges if not addressed in a timely and coordinated manner.

9 There is currently an extensive work program to ensure that NEM reliability frameworks are suitable to manage the energy transition, across the ESB, Panel, and AEMC. 2020-21 saw one key change to reliability frameworks:

- The introduction of the interim reliability measure and interim reliability reserves– this implemented a new reliability standard of 0.0006% unserved energy. This level is used to trigger long-notice RERT contracts, allowing AEMO to intervene at lower levels of forecast USE. Similarly, the RRO is activated at this level of forecast USE.

10 Additionally, several changes to reliability frameworks occurred after the reporting period or are ongoing, including:

- The commencement of five-minute settlement on 1 October 2021[2] — this change aligns the price signal seen by generators with the interval on which AEMO clears the energy market. It is a key step towards incentivising fast generator technologies such as batteries and demand response.
- The Panel's 2022 reliability standard and settings review[3] — this review examines the NEM's reliability standard and key reliability settings to establish whether they remain appropriate, and if not, recommends what they should be for the period from 1 July 2025 to 30 June 2028. The final report is due to be published on 1 September 2022.

2 For more information on *five-minute settlement* see: https://www.aemc.gov.au/rule-changes/five-minute-settlement

3 For more information on the *2022 reliability standard and settings review* see: https://www.aemc.gov.au/market-reviews-advice/2022-reliability-standard-and-settings-review

- The Panel's 2022 frequency operating standard review[4]— this review is examining whether the NEM's frequency operating standard needs revision in either form or level, as there have been several recent changes in the way frequency is managed in the NEM.
- *Transmission planning and investment review*[5] — this AEMC review is examining transmission planning and investment frameworks in the context of ensuring the timely and efficient delivery of major transmission projects.
- *Updating short-term PASA*[6] — In December 2021 the AEMC published a draft rule to move to a principles-based approach in ST PASA. This has been done to provide AEMO with more flexibility in the way it operates the ST PASA process. A final determination is due for publication on 5 May 2022.
- The AEMC is currently considering a rule change request on *Enhancing information on generator availability in MT PASA*.[7] The rule was recommended as part of the ESB's resource adequacy workstream and aims to improve transparency in the market around intermittent and seasonal operating regimes. This will be particularly important as thermal generators near their retirement and move to cyclical operating regimes to maintain profitability. A draft determination is due to be released on 26 May 2022.
- The ESB is currently carrying out further design work on the capacity mechanism, recommended as part of its post-2025 package of reforms and following consultation on the initiation paper published in December 2021.[8] A paper detailing the proposed design of the mechanism is expected to be published in April 2022.

11 Together, this package of reforms should help the NEM continue to maintain the high level of reliability that it has historically and is expected by energy consumers, while the system transitions.

Security

12 Power system security involves maintaining the numerous components within their allowable equipment ratings, maintaining the system in a stable condition within defined technical limits and returning the power system to operate within normal conditions following a disturbance.

What happened in 2020-21?

13 While overall security outcomes were good in 2020-21, security continues to remain a challenge for the sector. This reinforces the need to focus on the progression of the ESB's post-2025 market design project recommendations on essential system services. This is particularly driven by the effects of climate change as well as the decreasing reliability and

4 For more information on the *2022 frequency operating standard review* see: LINK WHEN AVAILABLE

5 For more information on the *Transmission planning and investment review* see: https://www.aemc.gov.au/market-reviews-advice/transmission-planning-and-investment-review

6 For more information on *Updating short-term PASA* see: https://www.aemc.gov.au/rule-changes/updating-short-term-pasa

7 For more information on the *Enhancing information on generator availability in MT PASA* rule change request, see: https://www.aemc.gov.au/rule-changes/enhancing-information-generator-availability-mt-pasa

8 For more information on the ESB's capacity mechanism design work see: https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-electricity-market-reforms/post-2025-market-design/post-2025-market-design-capacity-mechanism-initiation

retirement of ageing thermal generators.

14 Key security outcomes for 2020-21 include:

- There were no events where the power system, was not in a secure operating state for more than 30 minutes, down from three in 2019-20.
- Reviewable operating incident numbers were similar to 2019-20. These are 'unusual power system events' and are set out in the Panel's *Guidelines for identifying reviewable operating incidents*.[9]
- The upward trend in the number of power system directions continued. These directions were almost exclusively used to manage system strength in South Australia where there is a high penetration of IBR.
- Frequency performance improved notably in both the mainland and Tasmania following the mandatory primary frequency response implementation rollout beginning in September 2020.
- FCAS costs are trending down, however, localised FCAS requirements in Queensland and concurrent coal unit outages resulted in higher costs in the second quarter of 2021.
- The number of changes to constraints in NEMDE was more than 2019-20 but less than 2018-19.
- There was a large increase in the number of market notices issued by AEMO in 2020-21, driven by automated dispatch price reviews and lack of reserve notices.

What are the implications and how are they being addressed?

15 The Panel notes that 2020-21 continued the trend of increasing complexity in managing power system security. The key driver of this trend is the increasing penetration of IBR. The pace of change is faster than has previously been forecast, and as such a number of security issues continue to present challenges for operating the power system. These include issues associated with minimum system load, system strength, inertia, and voltage control.

16 At present, due to difficulties in unbundling and defining the individual services to address these issues, AEMO manages the system in a secure state through unit combinations. These are specific configurations of network and generating assets in the power system that are known to result in secure dispatch, that must be maintained at all times. If these units de-commit for economic reasons, AEMO will direct them to turn on.

17 There is an extensive work program underway to ensure NEM security frameworks are suitable to manage the energy transition, across the ESB, AEMC, and Panel. 2020-21 saw one key change to security frameworks:

- *Implementing a general power system risk review*[10] — a final rule was made that replaced AEMO's power system frequency risk review with a broader general power

9 *Guidelines for identifying reviewable operating incidents* are available at: https://www.aemc.gov.au/sites/default/files/2018-02/Final-revised-guidelines.pdf

10 For more information on *Implementing a general power system risk review* see — https://www.aemc.gov.au/rule-changes/implementing-general-power-system-risk-review

system risk review. This aims to increase the transparency of emerging security risks that occur on the system.

18 Additionally, several changes to reliability frameworks occurred after the reporting period or are ongoing, including:

- *Fast frequency response market ancillary service*[11] — on 15 July 2021 the AEMC made a final rule to introduce very fast contingency raise and lower FCAS services. At lower operating levels of inertia, increased volumes or faster-acting frequency control services are required to arrest and stabilise the system frequency following a contingency event. The new services address this need.
- *Efficient management of system strength on the power system*[12] — on 21 October 2021 the AEMC made a final rule to evolve the existing system strength provision framework to one that is more proactive.
- *Enhancing operational resilience in relation to indistinct events*[13] — on 3 March 2021 the AEMC made a final rule to expand the contingency event framework to allow AEMO to manage the risk of events that are uncertain, unpredictable and can impact multiple power system elements (indistinct events).
- *Operational security mechanism*[14] — The AEMC is currently considering two rule changes relating to the efficient and explicit valuing of essential system services that have historically been supplied as a by-product of energy by synchronous generators. A draft determination is due on 30 June 2022.
- *Operating reserves and ramping services* [15]— The AEMC is currently considering two rule change requests that propose additional services in the NEM to help respond to rapid, unexpected changes in supply and demand. AEMO will provide technical advice to the AEMC on this by 30 June 2022. A draft determination is due by 30 June 2023.

19 The large volume of security framework reform underway across market bodies will help to efficiently manage power system security as the power system transitions.

Safety

20 The safety of the power system and associated equipment, power system personnel and the public is covered in general terms under the National Electricity Law (NEL). There is however no national safety regulator specifically for electricity. Instead, state and territory legislation governs safety generally which includes the safe supply of electricity and the broader safety requirements associated with electricity use in households and businesses.

21 The Panel notes that its safety role for the purposes of this report is narrow and relates

11 For more information on the *Fast frequency response market ancillary service* see the: https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service

12 For more information on *Efficient management of system strength on the power system* see: https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

13 For more information on *Enhancing operational resilience in relation to indistinct events* see the project page — https://www.aemc.gov.au/rule-changes/enhancing-operational-resilience-relation-indistinct-events

14 For more information on the *OSM* see: https://www.aemc.gov.au/rule-changes/operational-security-mechanism

15 For more information on *Operating reserves and ramping sevices* see: https://www.aemc.gov.au/rule-changes/operating-reserve-market and https://www.aemc.gov.au/rule-changes/introduction-ramping-services

primarily to the operation of assets and equipment within their technical limits and not to the broader safety requirements governed by jurisdictional legislation.

22 AEMO noted that there were no incidents in 2020-21 where AEMO's management of the power system has resulted in a safety issue with respect to maintaining the system within relevant standards and technical limits.

23 There were also no instances in 2020-21 where AEMO issued a direction and the directed participant did not comply on the grounds that complying with the direction would be a hazard to public safety, or materially risk damaging equipment or contravene any other law.

CONTENTS

APPENDICES

TABLES

FIGURES

1 INTRODUCTION

This report has been prepared as part of the Reliability Panel's Annual market performance review of the National Electricity Market. It covers the 2020-21 financial year. The review is a requirement of the National Electricity Rules.

1.1 Background and purpose of the report

The functions of the Panel are set out in section 38 of the National Electricity Law. Among other things, the Panel is required to:

- Monitor, review, and report on, in accordance with the Rules, the safety, security and reliability of the national electricity system
- At the request of the AEMC, to provide advice in relation to the safety, security, and reliability of the national electricity system
- Undertake any other functions and powers conferred on it under this Law and the Rules.

At the completion of a review, the Reliability Panel must give a report to the Australian Energy Market Commission. If requested to do so by the AEMC, the Reliability Panel must provide advice to the AEMC in relation to the safety, security, and reliability of the national electricity system.[16]

Consistent with these functions, clause 8.8.3(b) of the NER requires the Panel to conduct a review of the performance of certain aspects of the market, at least once every financial year and at others such times as the AEMC may request.

The Panel must conclude each annual review under this clause by the end of the financial year following the financial year to which the review relates. The Panel must conduct its annual review in terms of:

- Reliability of the power system
- The power system security and reliability standards
- The system restart standard
- The guidelines referred to in clause 8.8.1(a)(3) of the NER[17]
- The policies and guidelines referred to in clause 8.8.1(a)(4) of the NER[18]
- The guidelines referred to in clause 8.8.1(a)(9) of the NER.[19]

The AEMC may provide, from time to time, the Reliability Panel with standing terms of reference in relation to the annual market performance report. The AEMC Terms of Reference are provided in appendix A.

16 Division 3 section 38 (1) - (4) of the NEL.

17 The guidelines referred to in clause 8.8.1(a)(3) of the NER govern how AEMO exercises its power to issue directions in connection with maintaining or re-establishing the power system in a reliable operating state.

18 The policies and guidelines referred to in clause 8.8.1(a)(4) of the NER govern how AEMO exercises its power to enter into contracts for the provision of reserves

19 The guidelines referred to in clause 8.8.1(a)(9) of the NER identify, or provide for the identification of, operating incidents and other incidents that are of significance for the purposes of the definition of 'reviewable operating incident' in clause 4.8.15 of the NER.

Consistent with these requirements, the Panel publishes a market performance update in slide-deck format, followed by a more fulsome report (i.e. this report).

1.2 Scope of the report

As noted, the Panel has undertaken this review in accordance with the requirements in the NER and the Terms of Reference issued by the AEMC. The AEMC requested that the Panel review the performance of the market in terms of reliability, security, and safety of the power system.

In this report, the Panel has considered the following definitions of reliability and security:

- A secure system is one that can operate within defined technical limits, even if there is an incident such as the loss of a major transmission line or large generator.
- A reliable power system has enough generation, demand response and network capacity to supply customers with energy that they demand with a very high degree of confidence. A reliable power system will also be a secure power system, however, the opposite is not necessarily true; a power system can be secure even when it is not reliable.

The two concepts are closely related operationally, and it is not always simple to separate them. For consumers, the result of either a reliability event or a security event may be indistinguishable given both may result in an outage for a customer.

The Panel considers it important to clearly describe and identify how these two aspects of power supply work, and the extent to which each is responsible for final interruptions to consumers. This is because each is managed using different tools and regulatory frameworks, and where further actions may be needed to improve outcomes for consumers, it is helpful to know which parts of the framework to focus on.

For this review, the matters considered included:

- Key market trends: The Panel has considered some trends occurring in the NEM, and how these may be impacting power system reliability and security. Specifically:
  - Supply side trends, including new generation entry and withdrawals
  - Demand side trends, including the continued uptake of Distributed Energy Resources (DER)
  - Wholesale market trends, including price outcomes
  - Network trends, including supply interruptions
- Reliability performance of the NEM: The Panel has reviewed the reliability performance of generation and bulk transmission (i.e. interconnection). In doing so, it has considered:
  - Actual levels of unserved energy in 2020-21.
  - Actual and forecast supply and demand conditions
  - Market reserve levels
  - AEMO's use of the reliability safety net mechanisms in 2020-21

- Security performance of the NEM: The Panel has reviewed the performance of the power system against the relevant technical standards. In particular, the Panel has had regard to:
  - Frequency operating standards, voltage limits, interconnector secure limits and system stability
  - AEMO's use of the security safety net mechanisms in 2020-21
- Safety performance of the NEM: The National Electricity Law and rules set out the functions and powers of the Reliability Panel, which include a function to monitor and report on safety in accordance with the rules. The rules do not specify additional requirements in relation to safety performance monitoring. However, the Panel also has the function of advising in relation to the safety of the national electricity system at the request of the AEMC.

This review considers these matters over the period from 1 July 2020 to 30 June 2021, a window that is limited by and set by the Terms of Reference provided to the Panel by the AEMC.

2 MARKET TRENDS

This chapter outlines some key trends and challenges occurring in the NEM, and how these may be impacting power system reliability and security. This chapter also outlines a number of the key outcomes for the NEM that occurred in 2020-21. These are specifically related to:

- Supply-side trends, including new generation entry and withdrawals
- Demand-side trends, including continued uptake of distributed energy resources (DER)
- Wholesale market trends, including price outcomes

2.1 Supply-side trends

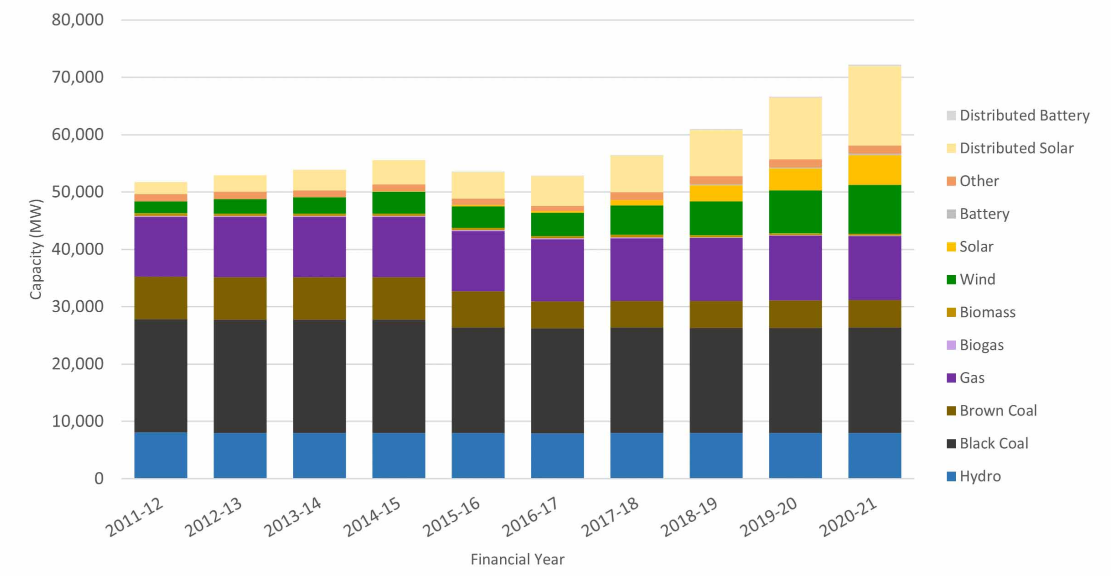
This section highlights the important trends in the supply of electricity over the 2020-21 financial year, and the implications of these for power system security and reliability:

- Generator entry and exits and installed capacity
- The change in generation output
- Investment environment

2.1.1 Generator entry and exits and installed capacity

The generation mix in the NEM continues to evolve with significant new unit entry and as well as units reaching end-of-life or being retired early for economic reasons. Several trends in generator entry and exit have become well established since 2016-17. The principal driver of these trends is the entry of large amounts of renewable energy generation at both a grid-scale and distributed level.

Figure 2.1: NEM installed generation capacity by technology

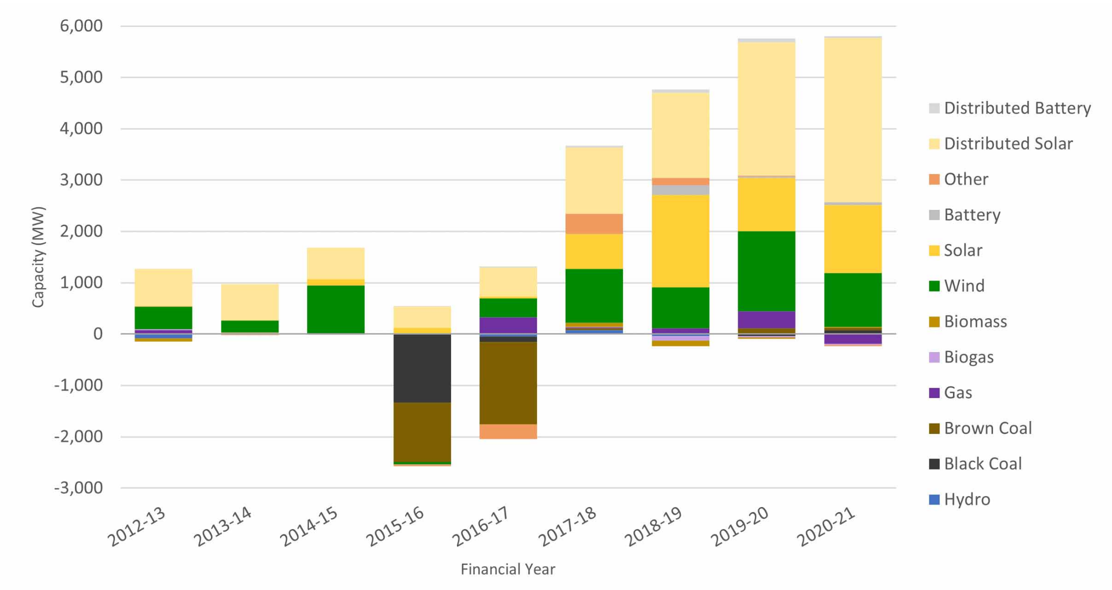


Source: Panel analysis of AEMO generator information survey data

During 2020-21, large volumes of new VRE generation entered the NEM. This included 1.04 GW of new wind capacity, 1.3 GW of new grid-scale solar capacity and 3.2 GW of distributed solar capacity. The only notable reduction in installed capacity in 2020-21 was a 189 MW decrease in gas-fired generation due to the exit of Torrens Island A units 2 and 4. This 240 MW withdrawal was partially offset by re-ratings and upgrades at other gas-fired units.

The amount of grid-scale storage is increasing, however, there is currently a small total capacity installed relative to other generation technologies. 50 MW of new grid-scale battery capacity was added in 2020-21, however, there is a significant amount of battery generation in development. 350 MW of additional capacity has entered service since July 2021, while 133 MW of capacity is currently committed, and 268 MW is anticipated.[20] Additionally, a large amount of battery capacity is proposed, which is covered in more detail in section 2.1.4.

Figure 2.2: NEM capacity entry and exit by technology



Source: Panel analysis of AEMO generator information survey data and Clean Energy Regulator installation data

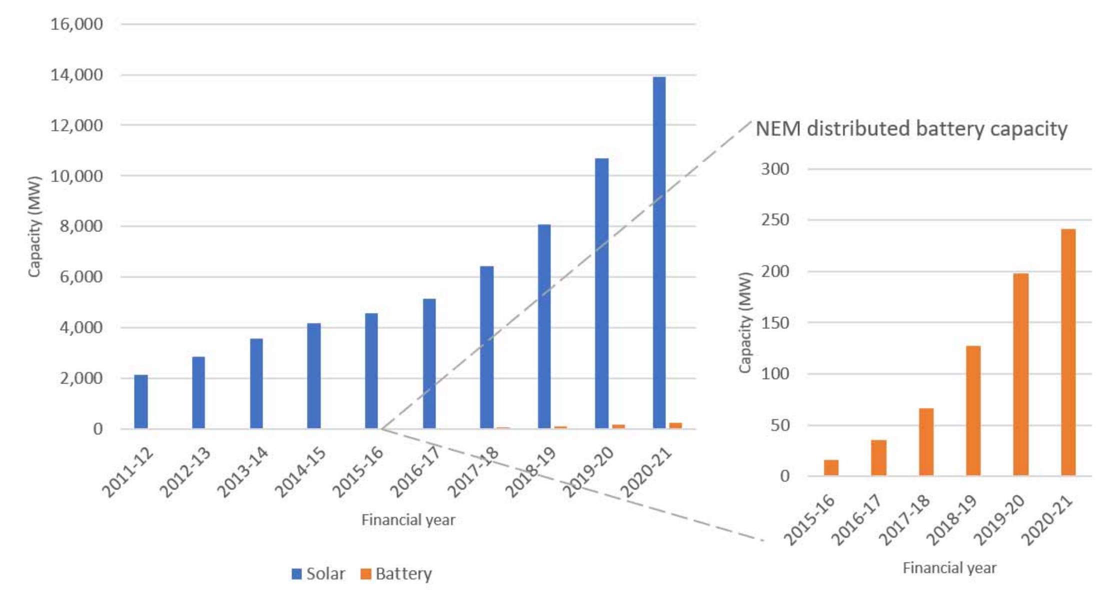
The installed capacity of distributed PV continues to grow at an apparently exponential rate, something that does not appear likely to slow in the foreseeable future. A contributing factor is that many older PV systems are reaching their replacement age, and are typically replaced by much higher capacity systems.

Installed distributed battery capacity is also growing at a rapid rate, however, it remains a fraction of installed PV capacity. This can be seen in Figure 2.3 below. The Panel will continue

20 *AEMO Generation Information February 2022*. Committed refers to projects that will or are extremely likely to proceed, Anticipated refers to projects that are sufficiently progressed towards meeting at least three of five commitment criteria, and are considered committed for ISP purposes. For more information see the Background Information sheet of the Generation information workbook, available at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/generation_information/2022/nem-generation-information-feb-2022.xlsx

to monitor the impact of distributed storage on system load as it expects the impact to become more pronounced in future.

Figure 2.3: Installed DER capacity

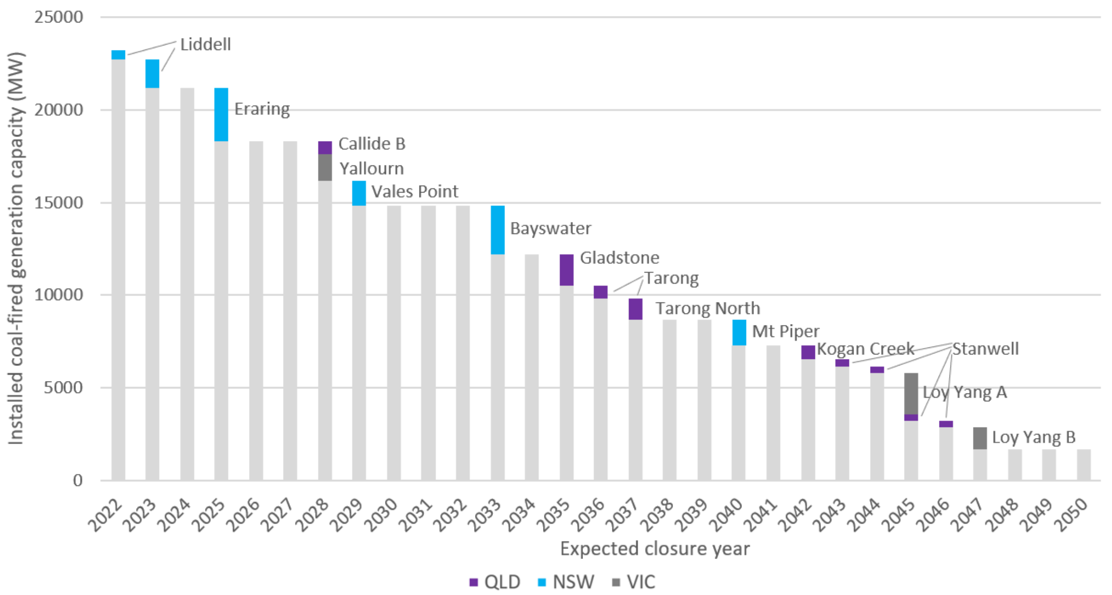


Source: Panel analysis of CEC installation data

2.1.2 Generator closures

The schedule of coal-fired generator retirement has been significantly brought forward. Expected closure years for coal-fired generators in the NEM are shown in Figure 2.4. A number of notable changes to closure dates, shown here and detailed further below, have occurred more recently than the review period.

Figure 2.4: Coal-fired generation expected closure year



Source: Panel analysis of AEMO generation information data

The recent changes to expected coal-fired generator closure dates include:

- Liddell unit 3 closure was brought forward to 2022 from 2023 and Liddell unit 4 closure was pushed out to 2023 from 2022
- Loy Yang A closure was brought forward to 2045 from 2048
- Eraring closure was brought forward to 2025 from 2032
- Bayswater closure was brought forward to 2033 from 2035

In addition to the above coal-fired generation closures, the closure of gas generation will bring about changes in how the NEM is operated, particularly in SA where the synchronous generation fleet consists primarily of gas generators. Notable gas generator expected closures in SA include:

- Torrens Island A unit 3, which is due to close in September 2022
- Osborne, which is due to close in December 2023

2.1.3 Generation output

2020-21 saw the continuation of several trends in the energy generated by each technology, that have emerged over the last few reporting periods.

Decreasing energy sourced from:

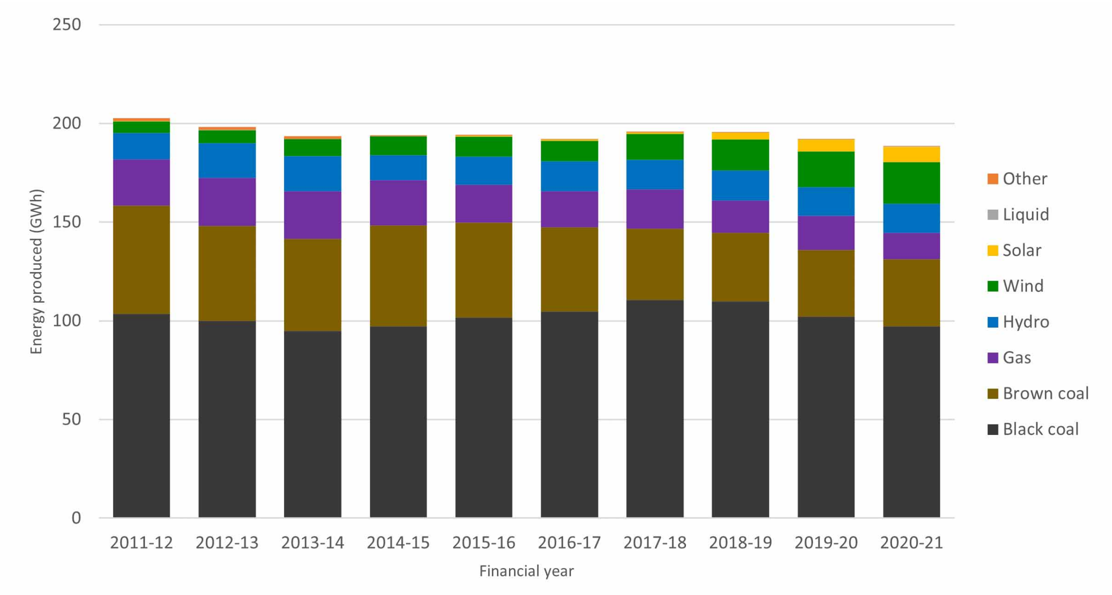
- grid-scale sources[21] — total energy generated by grid sources decreased by 1.9% from 2019-20
- coal-fired generators — energy generated by coal-fired generators decreased by 3.4% from 2019-20
- gas-fired generators — energy sourced from gas-fired generators fell by 22.5% from 2019-20 — this relatively large drop compared to coal suggests that new IBR generators are displacing gas-fired generation

Increasing energy sourced from:

- wind generators — energy sources from wind generators increased by 16.7% from 2019-20
- solar generators — energy generated by grid-scale solar generators increased by 29.1% from 2019-20

These trends are shown in Figure 2.5 below and are illustrative of a system that is trending toward higher penetrations of inverter-based resources, such as renewable energy. Interestingly, the proportion of demand being met by gas-fired generators has been trending down over the last eight years, something that is likely symptomatic of the decline in average wholesale prices driven by increasing VRE penetrations.

Figure 2.5: Energy produced by grid-scale generation technology



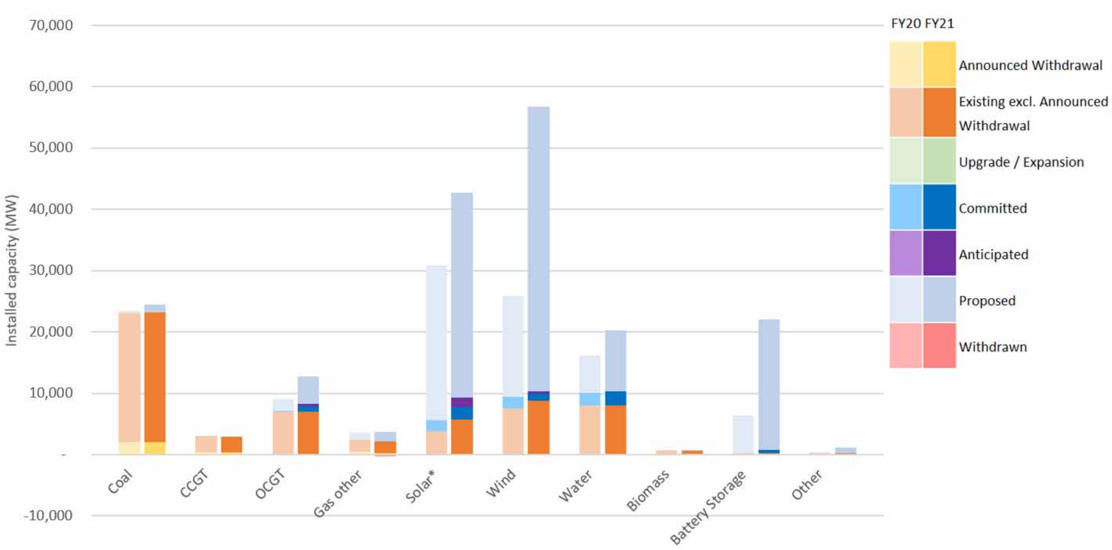
Source: Panel analysis of AEMO data

21 Grid-scale sources refers to wholesale participants that are classified as scheduled or semi-scheduled. AEMO considers non-scheduled participants as 'negative load'

2.1.4 Investment environment

In comparison to 2019-20, the investment environment has substantially improved in 2020-21. This is evident in the large increase in proposed generation, as seen in Figure 2.6, below.

Figure 2.6: Change in existing generation and planned generation investment between 2019-20 and 2020-21



Source: Panel analysis of AEMO generation information data

This includes an increase from 2019-20 in proposed capacity of 30 GW wind, 8 GW solar, 15 GW battery, 4 GW hydro and 2.5 GW gas-fired.

There are multiple factors underlying this increase, including:

- state-based renewable energy zone programs driving proposed VRE and grid-scale storage investment in these areas
- waning impact of COVID-19 lockdowns
- an accelerating schedule of coal-fired unit closures necessitating and stimulating large amounts of proposed replacement capacity

2.2 Demand-side trends

This section highlights the important trends in the demand of electricity over the 2020-21 financial year, and the implications of these for power system security and reliability, including:

- maximum and minimum system load
- diurnal system load profile evolution

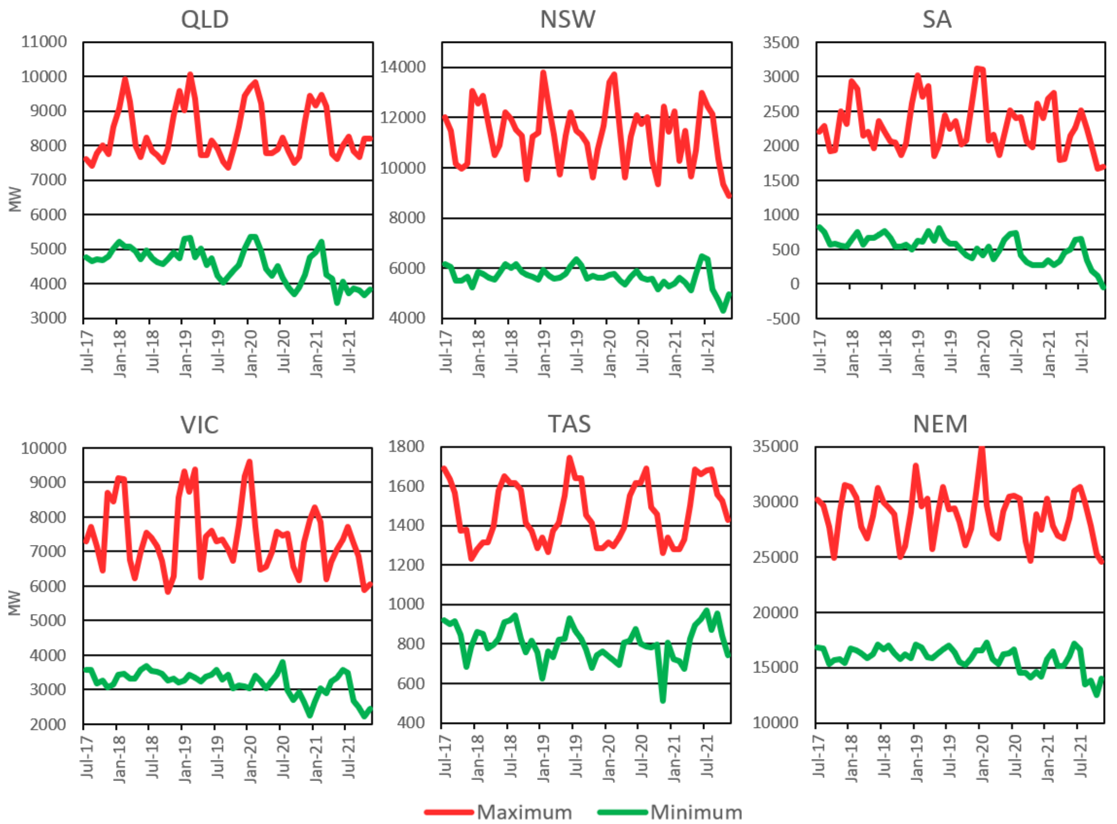
The key demand-side takeaway from 2020-21 is that distributed energy resources are becoming the driving force behind trends in system load in the NEM. The two key trends resulting from this are:

- Intraday system load variability (the difference between daily minimum and maximum system load) is increasing, leading to increased ramping requirements from dispatchable generators
- Minimum system load is decreasing in mainland states, creating challenges around maintaining a secure system at these times

2.2.1 Maximum and minimum system load

Maximum and minimum system load are important parameters for the operation and planning of the power system. They represent the edges of the technical envelope in terms of system load, and the system needs to be optimised around the values that are expected into the future. System load refers to the load that is met by scheduled and semi-scheduled generators, meaning distributed energy resources influence system load. Monthly minimum system load is shown below for each NEM region as well as the system as a whole.

Figure 2.7: Maximum and minimum system load by month and state



Source: Panel analysis of AEMO data

From Figure 2.7, minimum system load is trending down in all mainland states. This results from the large, ongoing uptake of distributed solar. The output from distributed solar is seen at a system level as a reduction in load as the demand is being met at the point of consumption. This is creating some scenarios where the system is experiencing extremely low levels of system load, particularly in South Australia. For example, on 21st November 2021 South Australia experienced negative system load. These unprecedented levels of minimum system load necessitate changes to the security frameworks in the NEM including:

- Additional operational levers for AEMO, including the ability to curtail distributed solar generators in South Australia when necessary for security.[22]
- Unbundling essential system services that have traditionally been supplied by synchronous generators

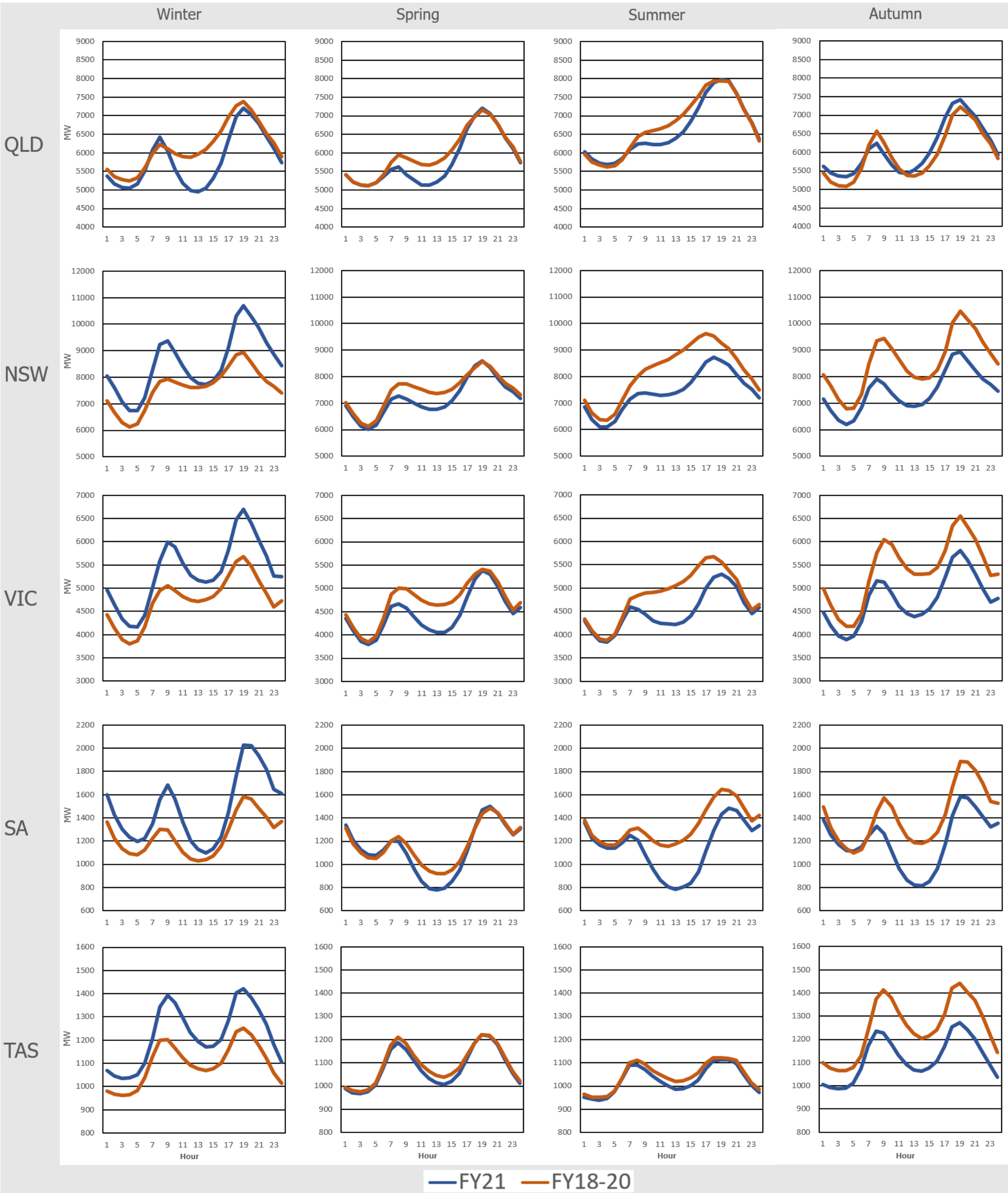
Maximum system load, by comparison, shows no clear trend across states, with some flat, some increasing and some decreasing. This reflects the more variable drivers of maximum system load such as weather and COVID-19 lockdowns.

2.2.2 Diurnal system load profiles

Diurnal system load profiles represent the average system load at various points across the day – in this case, each hour. The following analysis compares the average diurnal profile for each season for 2020-21, with the combined profile from financial years 2018-2020.

22 For more information see *Regulatory changes for smarter homes* - https://energymining.sa.gov.au/energy_and_technical_regulation/energy_supply/regulatory_changes_for_smarter_homes

Figure 2.8: NEM diurnal average system load profiles, by state and season



Source: Panel analysis of AEMO data

The variability of system load across the day continues to increase as the installed capacity of distributed PV increases. This is resulting in increased ramping requirements in the evening period when solar PV generation is tapering off and evening load is peaking. This effect is particularly pronounced in winter and in mainland states.

There appears to be some variability in load patterns for each season over time. For example, in 2020-21 it appears that Winter loads increased in southern states compared to the two previous reporting periods, while the Autumn load profile was slightly lower in 2020-21. Notably, load was mostly lower in 2020-21 throughout the middle of the day when compared with the two previous reporting periods, particularly in Spring, Summer and Autumn. Some variability across reporting periods is likely caused by weather patterns in a given year and temporary factors such as the regional nature of COVID lockdowns. The pronounced and enduring trends of reduced load during daylight hours and increasing variability of system load into the evening hours, however, are driven by the increasing penetration of solar PV and are expected to continue.

2.3 Wholesale market trends

This section highlights key wholesale electricity market trends over the 2020-21 financial year, and the implications of these for power system security and reliability, including:

- market price cap and market price floor events
- diurnal wholesale electricity price profile evolution
- wholesale price distribution
- futures trends

The key wholesale market takeaway for 2020-21 is that the distribution of spot prices across the NEM is showing a tighter distribution around a lower price range, while also becoming more volatile. This is driven by increasing penetrations of variable renewable energy driving prices down but also driving volatility at the extremes of aggregate renewable generation availability.

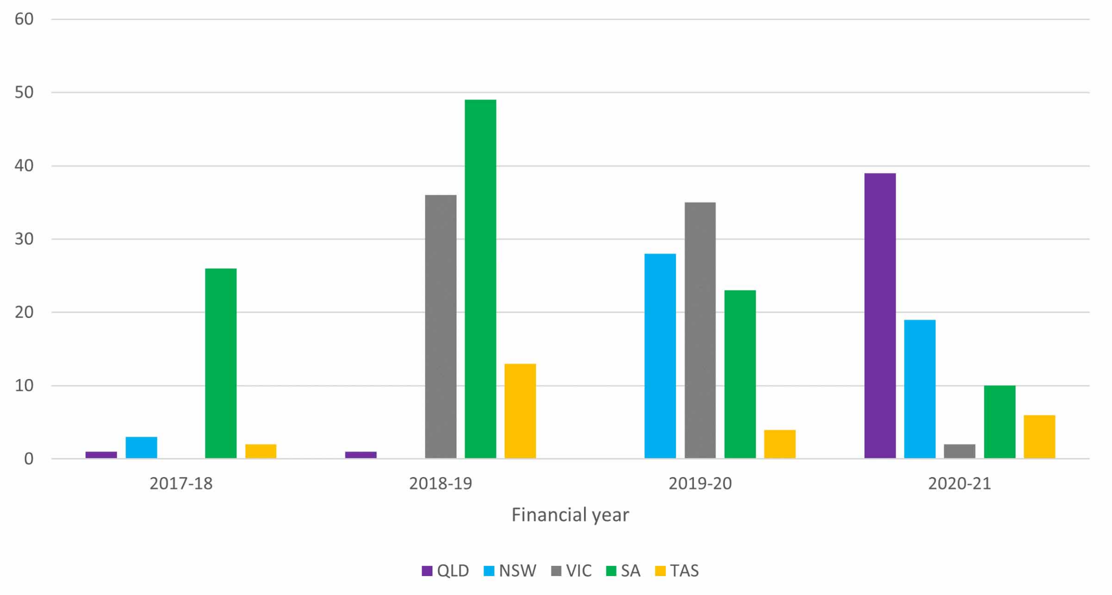
2.3.1 Market price cap events

The market price cap (MPC) is a key reliability parameter of the market. It indicates that there is an extreme scarcity of supply and is typically set at a very high level compared to average prices to incentivise participants to generate even where the short-run costs to do so are very high. The appropriate value is considered every four years in the Panel's reliability standard and settings review (RSSR). It is also updated annually to keep pace with inflation.

The total number of MPC events is down in 2020-21 compared to 2019-20 from 90 to 76. The distribution across regions has also changed from the previous period with more MPC events being observed in Queensland than in previous years. The lack of any discernible trend here points to the main drivers of MPC events being separate from wholesale market trends such as systemic generation shortages.

The year-on-year variation in MPC events is largely random in nature, which suggests the wholesale market is largely responsive to price signals over investment cycles. Potential drivers of the variations in MPC event outcomes across time could include unplanned generator outages and flow restrictions on interconnectors, as is likely the case for Queensland in 2020-21.

Figure 2.9: Market price cap events



Source: Panel analysis of AEMO data

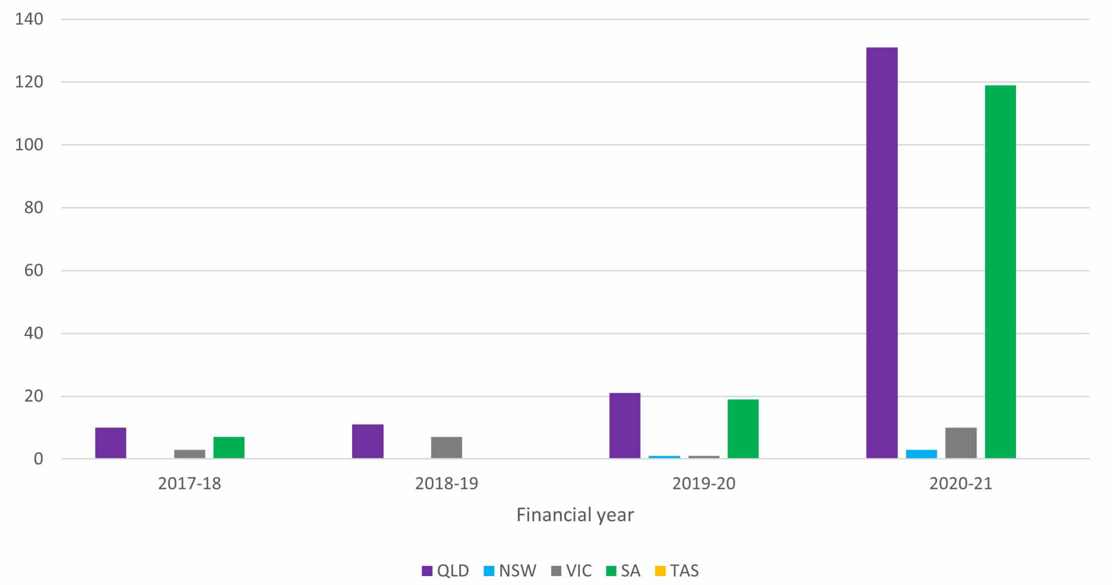
2.3.2 Market price floor events

Similar to the MPC, the market price floor (MPF) is a key reliability parameter of the market. It indicates that there is an extreme surplus of supply and is typically set at a low level compared to average prices to incentivise participants to decrease their generation unless they are inflexible. The appropriateness of this is considered every four years in the RSSR. However, it is not updated for inflation like the MPC.

In 2020-21 there was an unprecedented increase in MPF events in mainland states. This increase was particularly pronounced in Queensland and SA due to the high penetration of solar PV in both states, as well as their lower capacity interconnection with other states (compared to Victoria and NSW). The Panel anticipates that there is likely to be a decrease in floor price events next reporting period due to the introduction of five-minute settlement reducing incentives for disorderly bidding. This has already been observed in the market.[23] There are also several other factors that are likely to reduce the number of MPF events, including proposed interconnection upgrades to QLD and SA, and a move away from energy offtake agreements that encourage generators to generate at any price level.

23 AEMO, *Quarterly Energy Dynamics Q4 2021*, p4

Figure 2.10: Market price floor events



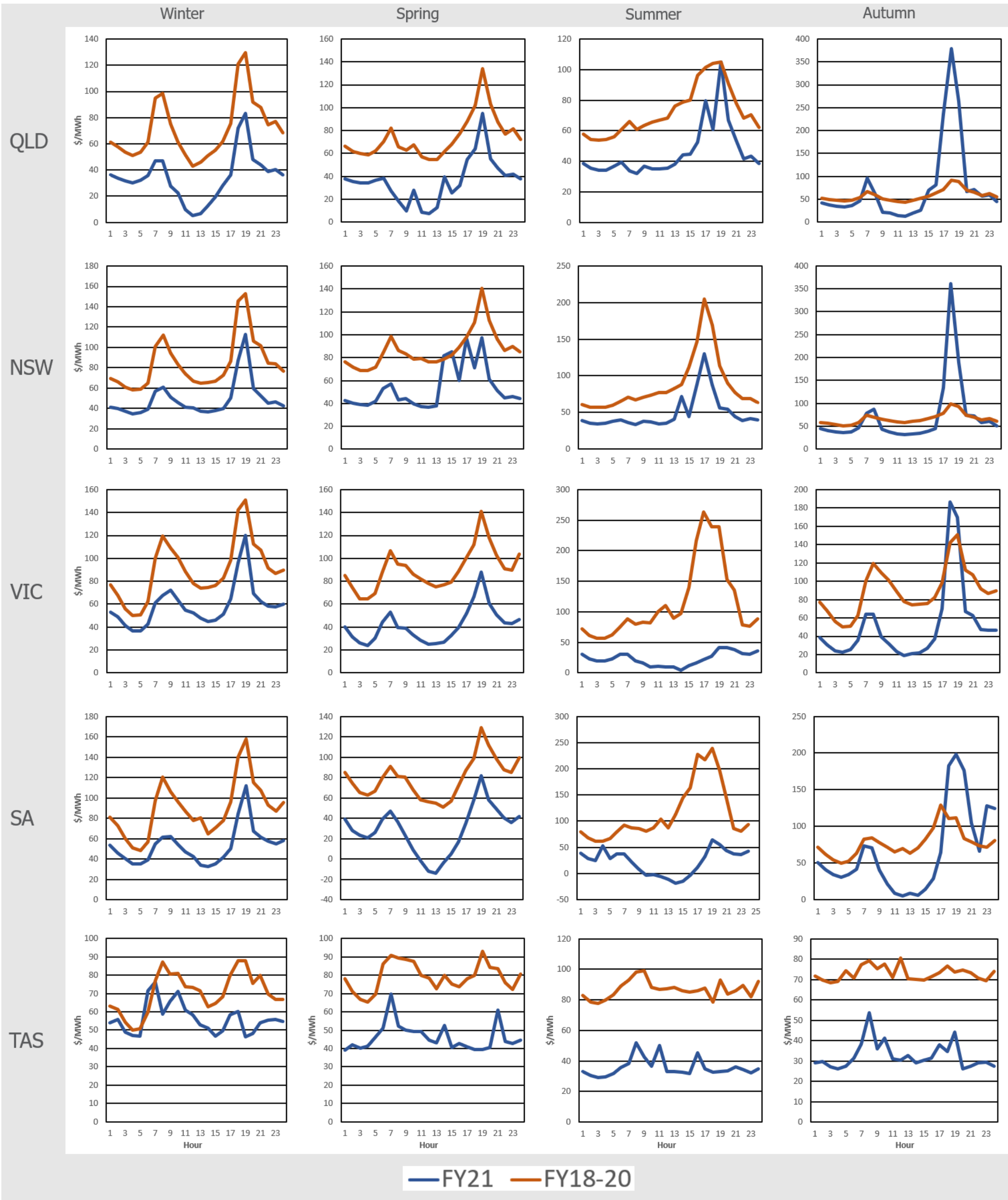
Source: Panel analysis of AEMO data

2.3.3 Wholesale electricity price profiles

As mentioned earlier in this report, average wholesale prices trended down in the 2020-21 reporting period.[24] Price variability across the day increased, however, driven by the evening transition from large amounts of low-priced solar PV, to more expensive dispatchable generators (operating at lower capacity factors) for the evening demand peak.

24 There is evidence, however, that this trend has not continued in the period after 2020-21.

Figure 2.11: **NEM diurnal average price profiles, by region and season**



Source: Panel analysis of AEMO data

Of particular note, the combined impact of distributed solar PV reducing system load, and increasing volumes of large-scale solar energy offered at low wholesale prices has seen a substantial reduction in wholesale prices during daylight hours. The wholesale price reduction between FY18-20 (averaged) and FY21 across states and seasons is shown below in Table X.

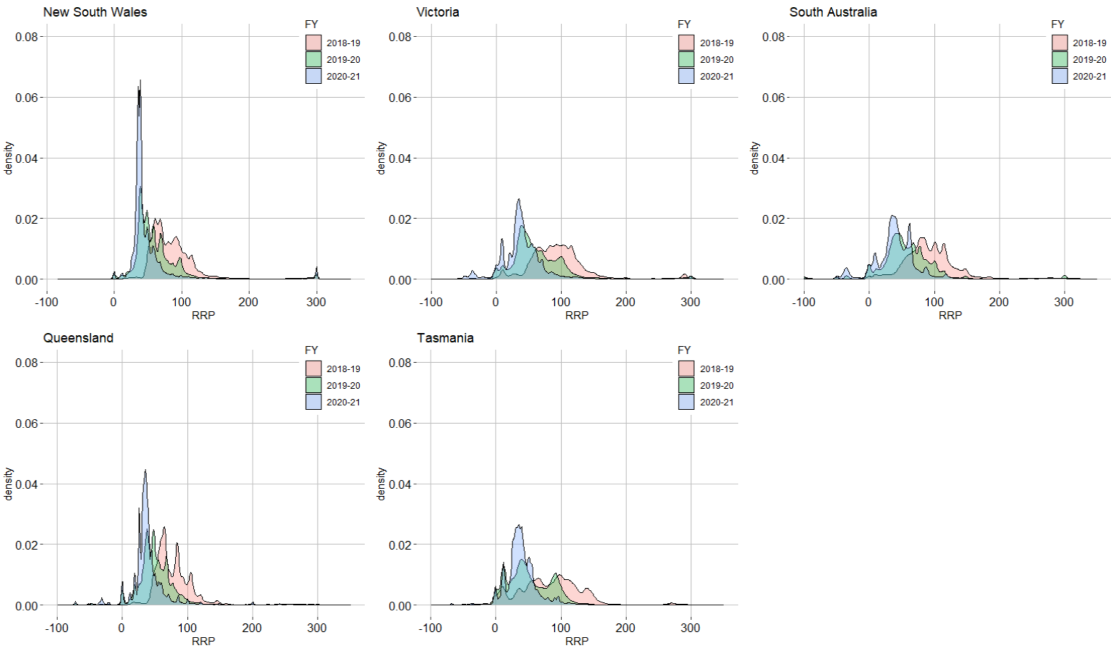
Table 2.1: Change in daytime average wholesale prices between FY18-20 and FY21

	WINTER	SPRING	SUMMER	AUTUMN
QLD	-$38.77	-$40.21	-$33.80	-$21.81
NSW	-$30.46	-$25.60	-$41.44	-$27.00
VIC	-$30.65	-$51.10	-$94.17	-$42.76
SA	-$38.64	-$60.45	-$111.99	-$59.56
TAS	-$14.29	-$32.33	-$50.74	-$40.83

Source: Panel analysis of AEMO data
Note: This table depicts the change in daytime (0900 - 1500) average wholesale prices between the aggregated period of 2017-18 to 2019-20 and the period of 2020-21.

The implication of this large reduction in day-time wholesale prices is that less flexible units that cannot reduce output quickly or turn off when prices are low or negative are likely to become less profitable. This effect is likely to be particularly pronounced for coal-fired units that typically have a much lower ability to vary their generation over the course of a day than other generator technologies. The Panel considers that this is partly contributing to the accelerating schedule of coal-fired unit retirements and shifting the drivers of retirement from technical to economic factors, illustrated earlier in Figure 2.4. The downward trend in wholesale prices in every state is also shown in the price distributions in Figure 2.12, below.

Figure 2.12: Wholesale price distribution



Source: Panel analysis of AEMO data

2.3.4 Contract prices

Wholesale market participants enter into various wholesale hedging contracts to manage financial risks and increase certainty over their wholesale energy costs.

Both buyers and sellers in the wholesale market are exposed to variations in the spot price in the wholesale market. They appreciate that large swings in spot prices have a similar but opposite effect on their costs and revenue and consequently their profits. This encourages both buyers and sellers to agree to contracts that convert volatile spot revenues and costs to a more certain cash flow which can also help underwrite further investment in both generation and retail assets. These are generally expensive, long-term investments in a more uncertain investment environment.

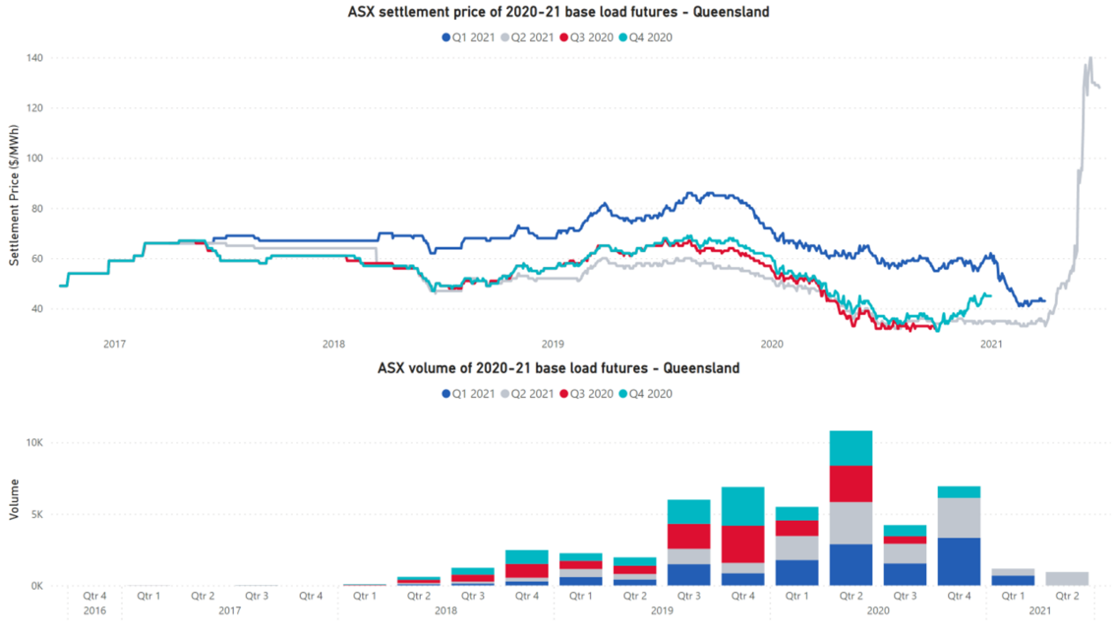
While the primary role of entering into these contracts is to manage risk and cash-flows, contracts can be considered as another means of expressing the price of the same underlying product, meaning that the spot and contract prices are intrinsically linked. The price of hedging contracts reflects the balance of expectations as to the level and volatility of future wholesale spot price outcomes, and therefore supports reliability by informing both investment and operational decisions.

Contracts for the NEM are traded either on the ASX or bilaterally. ASX futures prices for New South Wales, Queensland, South Australia and Victoria over the 2020-21 financial year are shown inFigure 2.13 - Figure 2.16.

On analysis of these Figures, the Panel notes:

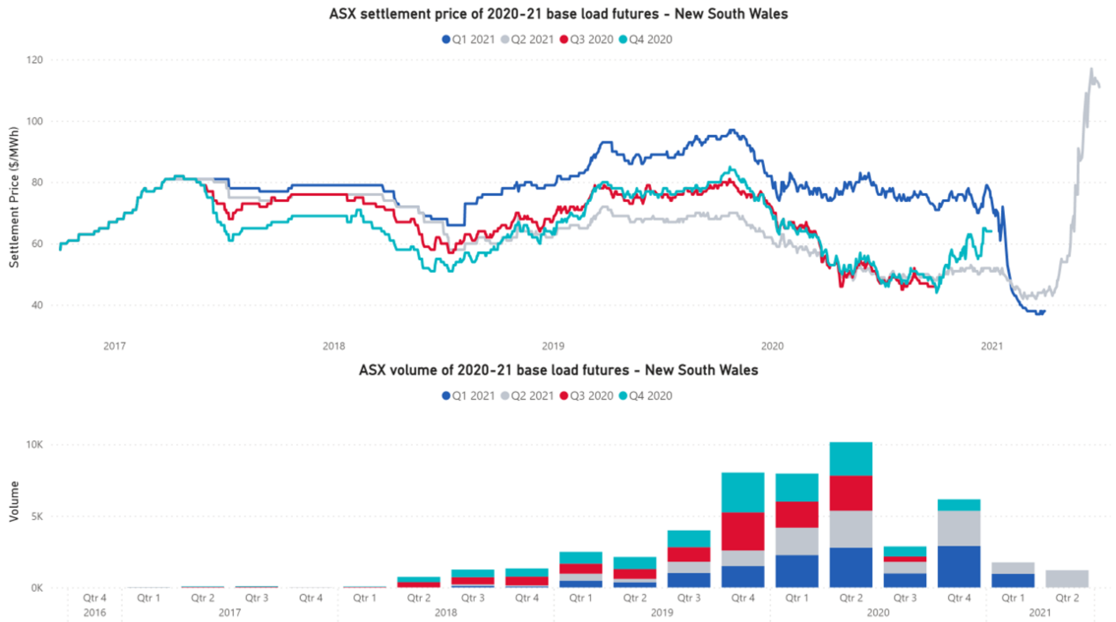
- Queensland, NSW and Victoria all have high levels of liquidity in their respective ASX futures markets with volumes traded all reaching around 10 GW in a quarter.
- South Australia has a lower level of liquidity in its futures market, which is likely related to the lower volume of energy consumed and the concentration of ownership of baseload generation in the state.
- Wholesale pricing expectations broadly trended down from the end of 2019, with one notable exception. Futures prices for 2021 Q2 increased substantially through the quarter across all regions, this may have been caused by the large number of unavailable coal-fired units at the time, on both planned and unplanned outages, combined with interconnector constraints. The result of this was high and volatile wholesale prices and higher than usual interregional price differences in the quarter.

Figure 2.13: ASX Queensland base load quarterly futures — price and volume traded



Source: Panel analysis of ASX Energy data

Figure 2.14: ASX NSW base load quarterly futures — price and volume traded



Source: Panel analysis of ASX Energy data

Figure 2.15: ASX Victoria base load quarterly futures — price and volume traded

Source: Panel analysis of ASX Energy data

Figure 2.16: ASX SA base load quarterly futures — price and volume traded

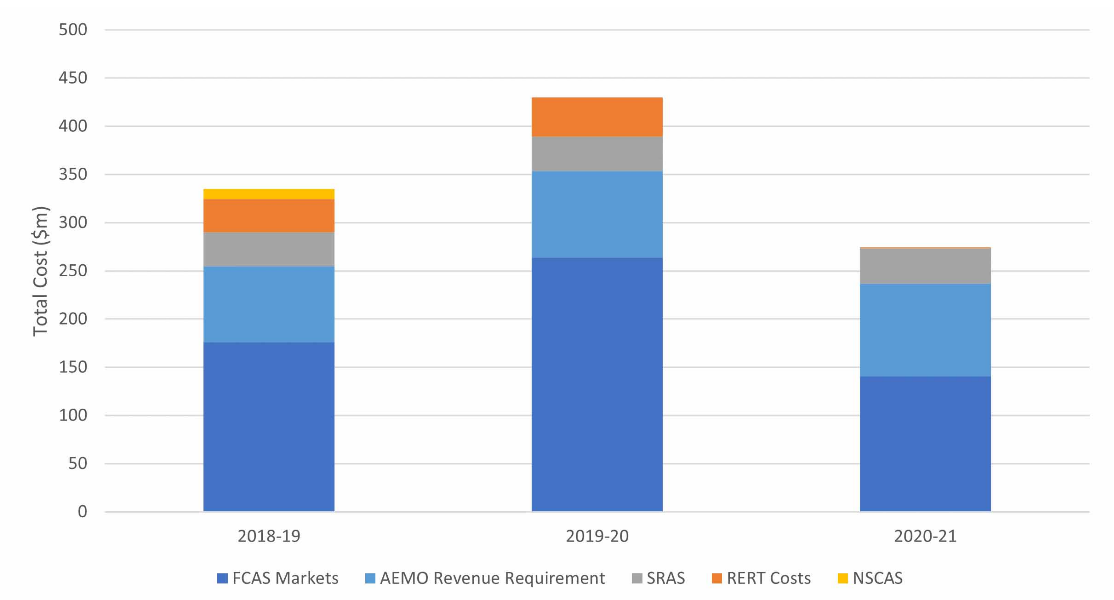
Source: Panel analysis of ASX Energy data

2.4 Costs of operating the system

To keep the power system in a secure and reliable state, a number of additional costs are incurred, including but not limited to:

- Maintaining power system frequency
- Having services available to restart the power system if needed
- Emergency reserves for maintaining power system reliability and security
- Other services needed to maintain the secure operation of the power system
- Costs incurred from intervening in the market, including costs of compensating affected participants
- Costs of running and administering the market.

Figure 2.17: Costs of operating the system



Source: AEMO, AER

In 2020-21:

- $140m was paid out through FCAS markets, down from $264m in 2019-20
- Total RERT costs were $0.66m, a decrease from $40.6m in 2019-20
- System restart ancillary services (SRAS) costs were $36.9m, a slight increase from $35.8m in 2019-20
- AEMO's revenue requirement was $95.7m, an increase from $89.7m in 2019-20

These costs are relatively small compared to the total value transacted through the wholesale market, however they still represent costs that are recovered from market participants, and ultimately consumers.

3 RELIABILITY

A reliable power system has enough generation, demand response and network capacity to supply consumers with the energy that they demand with a very high degree of confidence. It requires:

- A well-functioning electricity spot and contract market that provides clear price signals, along with forecasts and notices from AEMO, backed up by policy certainty from governments. This gives market participants incentives and information to supply generation and demand response when and where it is needed. In addition to this, a sufficient level of reserve or buffer is necessary to ensure that demand and supply can be kept in balance in the face of external shocks.
- A reliable transmission and distribution network.
- The system to be in a secure operating state, meaning that it is able to withstand shocks to its technical equilibrium.

As outlined in section 1.1, one of the key responsibilities of the Panel that is set out in the NEL is to monitor, review and report on the reliability of the national electricity system and provide advice on the reliability of the national electricity system at the request of the AEMC.[25] This chapter considers the reliability performance of the NEM over the 2020-21 financial year in line with the Panel's obligations and the review's Terms of Reference.

This chapter sets out:

- What reliability is and how it is delivered
- The reliability performance of the NEM in 2020-21.
- Changes to reliability frameworks both in the review period and ongoing.

The Panel plays an important role in determining the standard and settings to deliver a reliable power system in the most efficient way to minimise costs for consumers. The Panel is currently undertaking a review of the reliability standard and settings. The reliability settings are:

- The Market Price Cap
- The Cumulative Price Threshold
- The Administered Price Cap
- The Market Floor Price.

The AEMC considered a rule change request from Dr Kerry Schott AO (former Chair of the ESB) seeking to remove the need for the Panel to review the reliability settings for the 2022 review. It was submitted as a transitional rule that would not apply to future RSS reviews. The AEMC has published a final determination that requires the Panel to:

- consider the reliability standard and settings of an energy-only market that it recommends should apply for 1 July 2025 to 30 June 2028; and

25 Section 38 of the NEL

- provide its final report to the Australian Energy Market Commission, with any recommendations for change to the reliability standard and settings by 1 September 2022.

3.1 What is power system reliability and how is it delivered

Reliability issues occur when the balance of supply and demand in a region is tight and there may not be enough generation or network capacity to meet all end-user demand for electricity. Historically, the NEM has generally provided a high level of reliability, meaning that generation and network capacity have been sufficient to meet customer demands, even at the highest points throughout the year.

The NEM operates as a gross pool market. It uses a high market price cap to incentivise operating and investment decisions during times of supply scarcity. This is supported by the contracts market. As noted, the design of the NEM also incorporates a series of standards and settings that set the nature and scale of incentives that guide and inform participant decisions, as well as tools AEMO can use to intervene when necessary to maintain reliability. These mechanisms provide strong financial incentives for participants (generators, retailers, aggregators, and customers) to make investment, retirement, and operational decisions that support reliability.

BOX 1: SUMMARY OF RELIABILITY OUTCOMES IN 2020-21

- Overall reliability outcomes in 2020-21 were relatively good — there was no unserved energy recorded. There were — as have been in previous years — some signs of strain on reliability. However, the existing framework was robust in dealing with these events.
- The reliability standard and interim reliability measure of 0.002% and 0.0006% unserved energy (USE) respectively, were not breached
- There was no unserved energy recorded in 2020-21
- AEMO forecast no breach of the reliability standard in the 2021 ESOO until 2028-29 in Victoria and 2029-30 in NSW. Additionally, no breach of the interim reliability measure is forecast while it is in force. It should be noted, however, that this was calculated prior to Origin's announcement that Eraring's retirement would be brought forward to 2025, and as such AEMO is in the process of producing an updated reliability outlook.
- There were no reliability events (actual LOR3 conditions) where supply was interrupted due to a shortfall of available capacity and reserves
- AEMO issued 53 actual lack of reserves notices in 2020-21, a large increase on the 17 issued in the previous period. This was largely driven by an increase in LOR1 conditions.
- RERT was activated on two occasions in 2020-21 (in NSW and Queensland), with one of these occasions being used to manage security outcomes in the NEM, and RERT costs were $0.66m.

- The CPT was not breached for energy, and the APC was not put in place. The CPT was breached for FCAS on 5 June 2021 in the fast contingency raise service in Queensland. The APC was consequently applied until 10 June 2021.
- Load forecasting accuracy was marginally worse in 2020-21 than in 2019-20. Wind energy forecast accuracy improved, and solar energy forecast accuracy was flat compared to the previous year.
- Net inter-regional energy flows continue to follow the patterns of recent history.
- Transmission unsupplied minutes decreased in NSW, Victoria, and South Australia, and increased in Queensland and Tasmania. Distribution network performance was assessed in terms of interruption duration and frequency indices, outcomes varied across states and DNSPs. These indices are commonly called system average interruption duration index and system average interruption frequency index respectively.

3.2 Reliability outcomes in 2020-21

The Panel has considered the following metrics as a way of assessing how the power system performed in terms of reliability in the 2020-21 financial year:

- **The reliability standard and unserved energy** — whether the standard was met and the amount of customer demand in 2020-21 that was not supplied within a region due to a shortage of generation or interconnector capacity, and the forecasts for unserved energy in the future.
- **Reliability events** — the number of occasions, if any, in 2020-21 where customers experienced supply interruptions specifically because demand was higher than available supply.
- **Energy market reserve levels** — the amount of spare capacity that was available in 2020-21, considering the amounts of generation, forecast demand, demand response and interconnector capability.
- **Use of AEMO interventions and powers** — whether AEMO intervened in the market to maintain reliable supply using the three key intervention mechanisms related to reliability: the RERT, directions and instructions, and controllable load shedding.
- **Accuracy of forecasts** — how accurate forecasts have been. Forecasts help inform operational and investment decisions to deliver reliability.
- **Network performance** — outage minutes, upgrades, and other performance outcomes from interconnectors, transmission networks and distribution networks.

As in previous reports of the AMPR, these indicators have been examined to assess the overall reliability of the NEM.

3.2.1 Reliability standard and unserved energy (USE)

Consumers can experience supply outages for a variety of reasons, however, this section focuses on incidents where supply interruptions occur because there is not enough supply to meet demand i.e. those outages that are due to 'reliability' issues. Reliability outages, measured in terms of USE have historically made up a small proportion of overall supply outages.

There are two key definitions of USE in the current framework.[26] The reliability standard is designed to reflect generation and interconnection adequacy to supply electricity, and signals to the market when and where more generation is needed, based on a trade-off made on behalf of customers as to the appropriate level of reliability. The reliability standard currently targets a maximum USE in a region of 0.002% of the total energy demanded in that region for a given year.

The IRM was introduced more recently into the regulatory framework. The IRM for generation and inter-regional transmission elements in the national electricity market is a maximum expected USE in a region of 0.0006% of total energy demanded in that region for a given financial year. This was developed as part of the ESB work to improve the reliability of the electricity system through interim measures while more enduring reforms are developed.

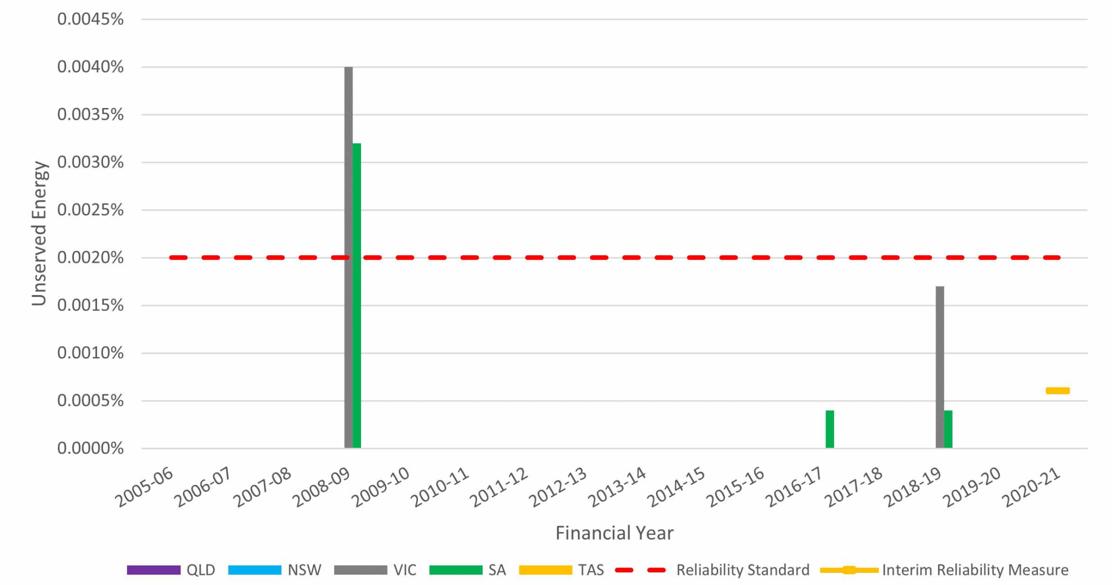
AEMO is required by the NER to publish various materials that provide information to market participants — and any other interested parties — on forecast USE across different time periods.[27] Through its forecasting processes, AEMO operationalises the reliability standard by modelling and projecting when the market is not going to meet the reliability standard in the future.

AEMO also calculates how much actual USE was observed in each region. In doing so, AEMO uses the definition of USE to assess which types of events should be included or excluded, which then informs AEMO's calculation of USE for the purposes of the reliability standard. If activation of RERT avoids USE, it is not recorded because the purpose of RERT is to avoid a breach of the reliability standard.

26 AEMC, *Transparency of unserved energy calculation* — https://www.aemc.gov.au/rule-changes/transparency-unserved-energy-calculation

27 Clause 4A.B.1

Figure 3.1: Actual unserved energy in the NEM



Source: AEMO

The NEM has historically provided a high level of reliability, however, reliability issues sometimes occur when the balance of supply and demand in a region is tight. Reliability issues have mostly arisen only on very hot days, as hot weather can affect both consumer usage patterns and the power system's ability to provide supply. More recently, there have been times when reliability issues have been emerging during 'shoulder' period.[28] Maintenance on generators and transmission infrastructure is increasingly occurring in these periods, reducing supply. Figure 3.1 illustrates the reliability of the performance of the NEM by comparing USE in each region in the NEM since 2005-06 to the reliability standard. 2020-21 is also compared to the IRM.

No actual USE was recorded in the NEM in 2020-21. Therefore, the reliability standard and the IRM were not breached. This occurred despite multiple events when the supply/demand balance in the NEM was tight. More information on these events can be found in section 3.2.3.

Forecast unserved energy

As mentioned above, one of the requirements of a reliable power system is the provision of forecasts and notices from the system operator to notify the market of the need for future investment. One way that AEMO provides this information is through the annual Electricity Statement of Opportunities (ESOO) report.[29] The ESOO includes projections of future USE

28 In the context of the NEM, 'shoulder period' typically refers to Spring and Autumn.

29 For more information see AEMO's *2021 Electricity statement of opportunities* - https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo.pdf

(both in terms of the reliability standard and IRM). These projections are provided to the market with the intention of eliciting a response from market participants to address any projected shortfall.

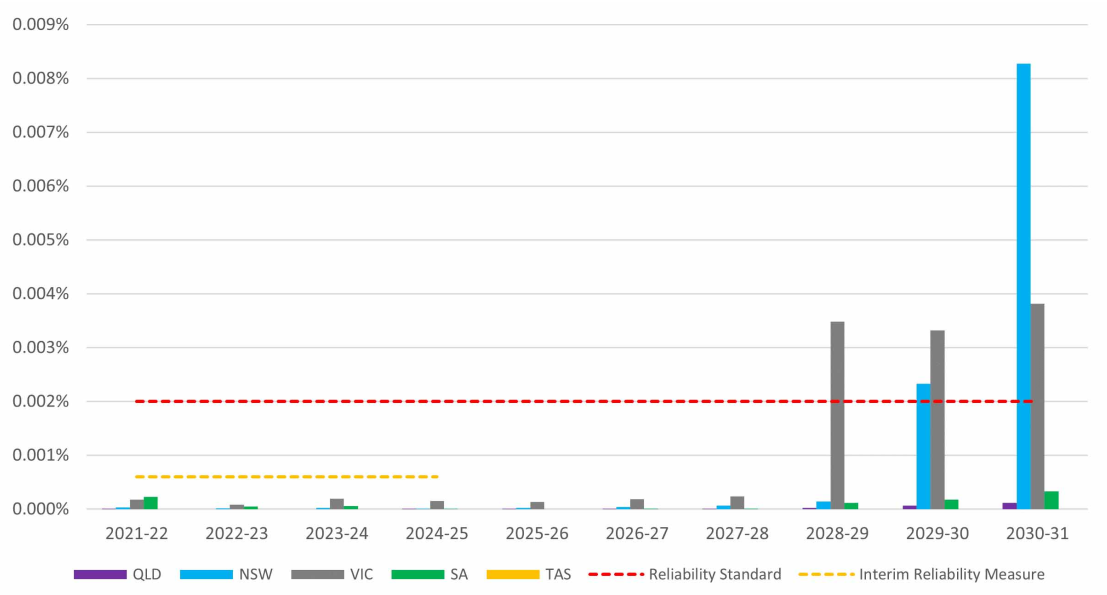
AEMO published the 2021 ESOO in August 2021. As required under NER clause 3.13.3A, the ESOO includes projections of aggregate demand and energy requirements for each region, generating capabilities of existing and committed units, planned plant retirements, and committed network development.

The 2021 ESOO identified key insights for the future reliability performance of the NEM, including:

- The reliability standard is not expected to be breached until 2028-29 in Victoria when Yallourn is scheduled to close. This is caveated, however, with the ESOO noting that if the Morwell River diversion fails and the Yallourn coal mine floods, the standard may be breached in 2021/22.
- The reliability standard is not expected to be breached until 2029-30 in NSW, when Vales Point is scheduled to close.[30]
- Queensland, South Australia, and Tasmania are all forecast to remain within the reliability standard for the duration of the forecast horizon, out to 2030-31.
- USE is expected to remain below the IRM in all regions while the measure is in force.

These outcomes are illustrated in Figure 3.2 below:

Figure 3.2: Forecast NEM unserved energy



Source: AEMO 2021 ESOO

30 The reliability standard may be breached earlier with the recent announcement that Eraring power station will be closing in 2025. AEMO is currently modelling an updated ESOO to assess this.

AEMO notes in the ESOO that there are a number of possible actions to address the forecast increase in USE in Victoria in 2028-29 and New South Wales in 2029-30. These projects are progressed in their development but do not meet AEMO's definition of 'committed', and consequently are excluded from ESOO USE modelling.[31]

In Victoria these projects include:

- Continued generation and storage investment and development of additional DSP resources, including the 350MW/1400MWh Jeeralang Battery[32]
- The VNI West augmentation, to increase New South Wales to Victoria transfer limits, and support the development of additional renewable energy zones (REZs) in north-west Victoria and south-western New South Wales.
- Development of MarinusLink to increase transfer capacity between Tasmania and Victoria

In New South Wales these projects include:

- The HumeLink augmentation to help unlock the reliability benefits provided by the expected commissioning of Snowy 2.0 in 2025-26.
- Reinforcement of the transmission network around Sydney, Newcastle, and Wollongong to support power transfer into the Sydney load centre in peak periods following the retirement of Vales Point Power Station and Eraring Power Station.[33]
- Continued generation and storage investment, including the anticipated development of Tallawarra B and investment facilitated through the New South Wales Electricity Infrastructure Roadmap.
- Implementation of the New South Wales peak demand reduction scheme and increases in wholesale demand response and demand-side participation.

Figure 3.3 illustrates the improvement in reliability forecast if just some of these projects are completed, where solid lines indicate ESOO projections, while dashed lines take into account the additional capacity under development.[34]

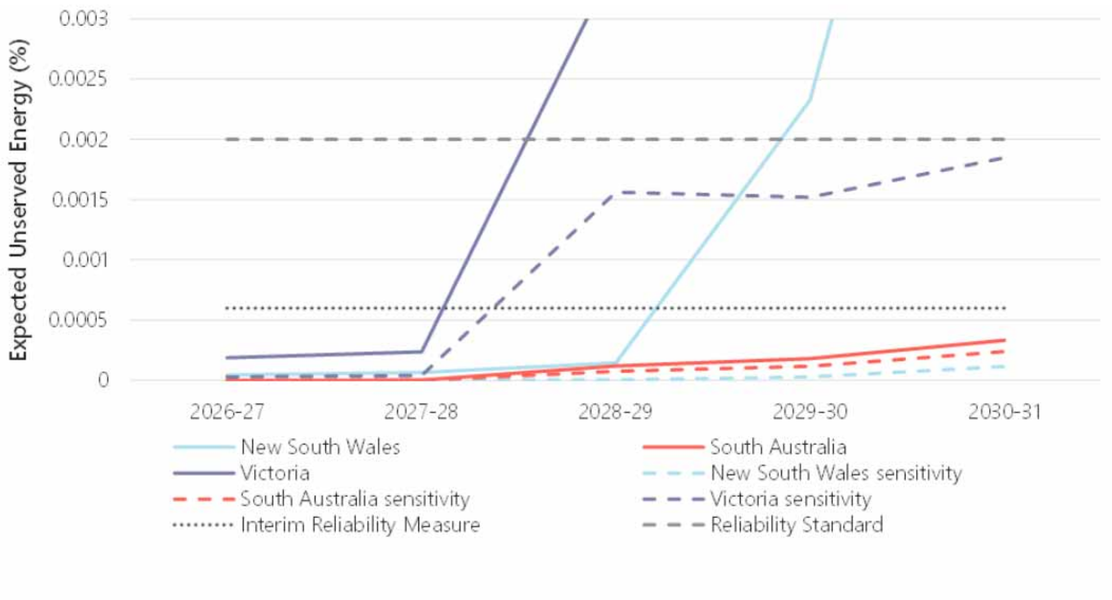
31 For more information on these projects, see AEMO's *2021 Electricity statement of opportunities*, p8

32 The project is being developed by 2026 as part of Energy Australia's agreement with the Victorian Government to deliver an orderly retirement of Yallourn Power Station. While this project does not yet meet AEMO's commitment criteria, the project is underway and, once built, would close much of the forecast reliability gap in Victoria towards the end of the decade – AEMO *2021 Electricity statement of opportunities*, p8

33 The 2020 ISP identified preparatory activities on a future project for this purpose, as existing network limitations restrict the ability to transfer power from regions beyond the Hunter Valley into the Sydney load centre.

34 The sensitivity analysis assumes the anticipated development of Tallawarra B occurs, the Jeeralang Battery in Victoria and Torrens Island Battery in South Australia are developed, and HumeLink and Sydney Reinforcement transmission projects proceed to enable the reliability benefits of Snowy 2.0 to be fully realised.

Figure 3.3: Reliability impact of projects well advanced, but not yet meeting AEMO's commitment criteria



Source: AEMO 2021 ESOO, p46

Note: This forecast does not include the recently announced changes to Bayswater and Eraring expected retirement dates, AEMO is working to produce an updated ESOO accounting for these changes.

3.2.2 Reliability events

A reliability event for the purposes of this report is one where there was insufficient generation, demand response or interconnector capacity to meet consumer demand. These conditions in the system are also referred to as a lack of reserves 3 (LOR3) situation, meaning that the available electricity supply is equal to or less than the operational demand.[35]

In the 2020-21 financial year, there were no actual LOR3 conditions in the NEM. There have been only 4 events in the past decade in which an actual LOR3 condition has been declared: twice in South Australia in 2016-17 and twice in Victoria in 2018-19.

3.2.3 Market reserve levels

Market reserve levels refer to the amount of spare capacity available given the amount of generation, demand and demand response at any point in time. In simple terms, market reserves can be thought of as the "buffer" that is made available by the market as part of the usual operation of the power system and expectations of future price outcomes in the energy market.

35 AEMO, LOR Fact Sheet, https://aemo.com.au/-/media/files/learn/fact-sheets/lor-fact-sheet.pdf?la=en

A market reserve level indicates the amount of available resources in the market to meet demand. Reserves help cater for unplanned power system events, such as unplanned transmission outages, sudden loss of generation (for example by a fault, or a reduction in renewable energy resources) or a sudden increase in system load.

AEMO uses its medium-term projected assessment of system adequacy (MT-PASA) reports to provide regular assessments of any projected shortage of market reserves that may result in a failure to meet the reliability standard. This enables market participants to make decisions about supply, demand, and the timing of planned outages of transmission networks and generation assets for periods up to three years in advance.

In the short-term (from real-time to seven days into the future), AEMO conducts its short-term PASA (ST-PASA) process that includes forecasts of the level of reserves to inform market participants of a potential supply shortage. This can encourage a response from market participants and transmission network service providers (TNSPs) to respond by providing more capacity into the market or a shift of planned outages respectively. For example, generators may offer more supply, or consumers may reduce their demand. Both responses have the effect of improving market reserve margins, helping maintain power system reliability.

In real-time when AEMO has certainty regarding demand and supply conditions, AEMO may declare that there is an actual LOR condition in effect.

Actual LOR notices signal to the market that there is a present shortage of reserves, while forecast LOR notices indicate that shortages of reserves may occur in the future. There are three levels of lack of reserve notices that AEMO can issue depending on market conditions.[36] These are:

- **Lack of reserves 1 (LOR1)** — when the consecutive occurrence of both the largest and the second-largest relevant credible contingency events would result in LOR load shedding occurring as a result of a shortfall of available capacity reserves (actual LOR1), or for a period within the LOR assessment horizon when the forecast of available capacity reserves in the short term PASA or pre-dispatch schedule is less than the two largest credible risks (forecast LOR1), or when the forecast of available capacity reserves in the short term PASA or pre-dispatch schedule is less than the forecast uncertainty measure (FUM)[37] for the relevant period and region (forecast LOR1)
- **Lack of reserves 2 (LOR2)** — when the largest relevant credible contingency event would result in LOR load shedding as a result of the shortfall of available capacity reserves (actual LOR2), or for a period within the LOR assessment horizon when the forecast of available capacity reserves in the short term PASA or pre-dispatch schedule is less than the largest credible risk (forecast LOR2), or when the forecast of available

36 See AEMO's *Reserve Level Declaration Guidelines* for more information - https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Reserve-Level-Declaration-Guidelines.pdf

37 The FUM introduces a probabilistic element into the determination of LOR levels alongside the traditional deterministic approach which allows for the impact of estimated reserve forecasting uncertainty in the prevailing conditions when calculating the LOR levels. These estimates are made on the basis of modelling past reserve forecasting performance for demand, output of intermittent generation and availability of scheduled generation.

capacity reserves in the short term PASA or pre-dispatch schedule is less than FUM for the relevant period and region (forecast LOR2)

- **Lack of reserves 3 (LOR3)** — when LOR Load Shedding is occurring as a result of a shortfall of available capacity reserves i.e. the available electricity supply is less than or equal to operational demand (actual LOR3), or for a period within the LOR assessment horizon when the forecast of available capacity reserves in the short term PASA or pre-dispatch schedule is at or below zero (forecast LOR3)

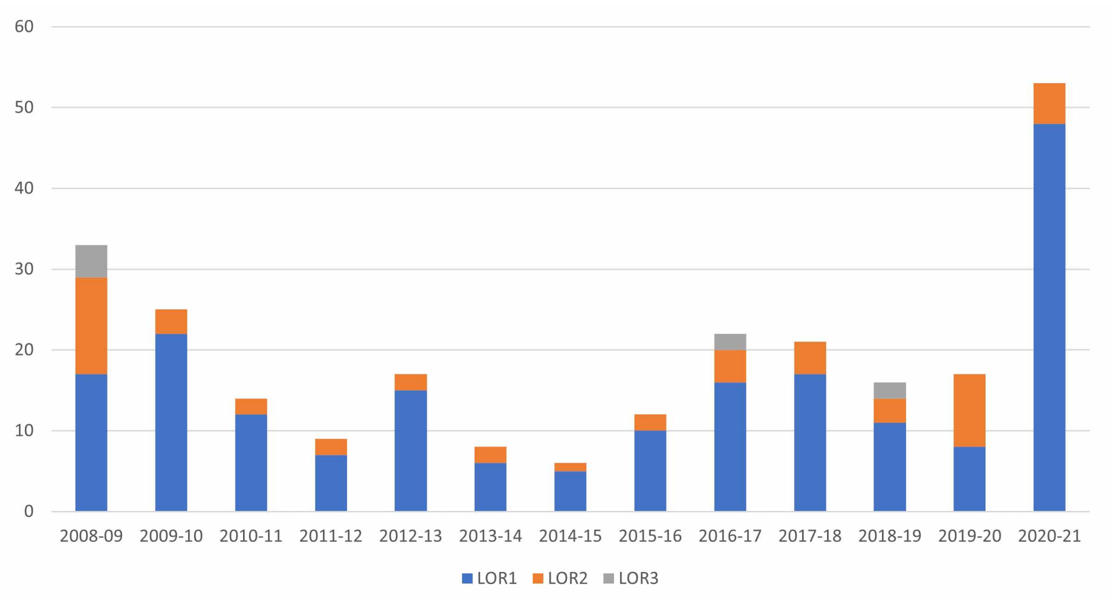
Under the existing LOR framework, AEMO is required to provide analysis on how the LOR framework is operating during the relevant reporting periods.[38] The reports are published within one month of the end of each calendar quarter, and must specify:

- AEMO's observations of any trends in when and why LOR conditions are being declared under the reserve level declaration guidelines.
- A summary of the leading factors or causes of any LOR conditions declared.

Total actual LOR notices

Figure 3.4 shows the number of actual LOR notices that were issued in the NEM each financial year since 2008-09. As noted, actual LOR notices indicate a situation where AEMO has declared that there is a present shortage of market reserves.

Figure 3.4: Actual LOR notices 2008-09 to 2020-21



Source: AEMO

There were 53 actual LOR notices issued in 2020-21. This included 48 LOR1 and 5 LOR2 notices. This represents a significant increase from previous years and is unprecedented in

38 Clause 4.8.4B of the NER

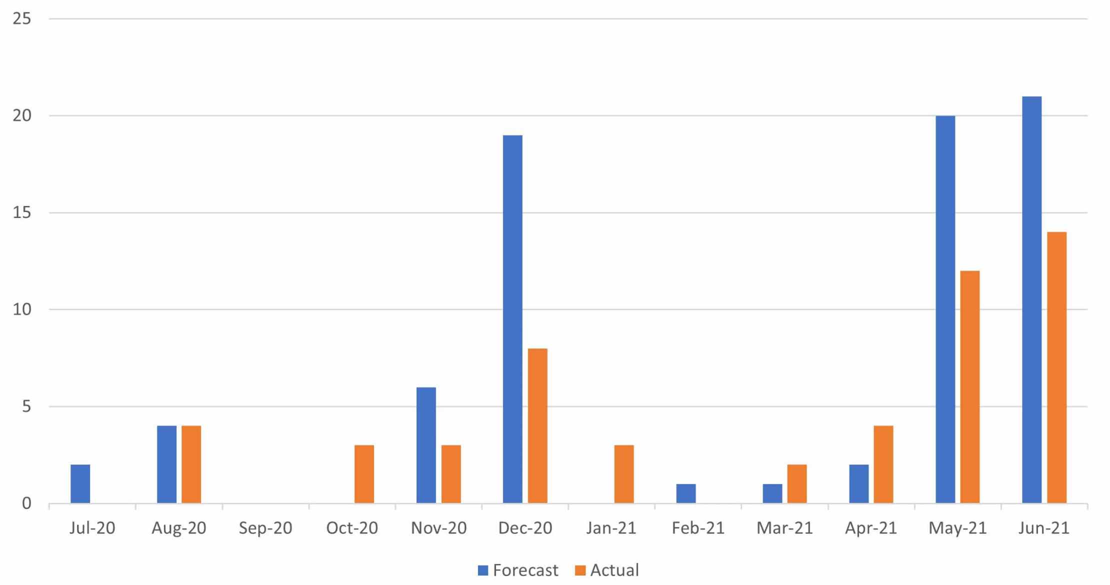
the NEM. This increase was driven by the increase in LOR1 notices, with the number of LOR2 and LOR3 notices similar to previous years. The Panel considers that this indicates a system that is tight but with the reliability frameworks managing these challenges. The distribution of actual LOR notices by state is shown in Table 3.1, and the distribution of forecast and actual LOR notices across the year is shown in Figure 3.5.

Table 3.1: Actual LOR by state

	LOR1	LOR2	LOR3
Qld	3	1	0
NSW	39	2	0
Vic	2	0	0
SA	2	2	0
Tas	2	0	0

Source: AEMO

Figure 3.5: Forecast & actual LOR by month



Source: AEMO

It can be seen in Table 3.1 and Figure 3.5 that most actual LOR notices occurred during Winter, and in NSW. This is due to a combination of concurrent coal unit outages in NSW and works limiting the VIC-NSW and QLD-NSW interconnectors. There was also a significant number of forecast LOR conditions in November and December of 2020. However, the reliability frameworks in place elicited a market response that resolved most of these, evident in the comparatively low number of actual LOR conditions in this period.

3.2.4 Use of the Reliability and Emergency Reserve Trader mechanism

RERT is an intervention mechanism that allows AEMO to contract for additional emergency reserves such as generation or demand response that are not otherwise available in the market when a supply shortfall is forecast. RERT reserves are contracted in addition to the reserve buffer that is already made available by the market as part of the usual operation of the power system. These emergency reserves are used as a safety net to avoid or reduce the need for involuntary load shedding when the market hasn't provided sufficient reserves.[39]

RERT is activated when there is insufficient market reserve to keep the power system in a reliable operating state, or, where practicable, to maintain power system security.[40] In 2020-21, RERT was activated on two occasions when there were insufficient reserves. In NSW, an activation was caused by a combination of increased demand driven by weather and a unit tripping at Liddell power station. The other, in Queensland occurred as a result of the fallout of the Callide Unit C4 failure. The total cost of RERT for 2020-21 was $661,700, which represents a decrease in costs from recent years.

Procurement of RERT reserves

The RERT guidelines specify three types of RERT based on how much time AEMO has in which to procure the RERT prior to the projected reserve shortfall occurring:[41]

- **Long-notice RERT** – At least ten weeks' notice of a projected reserve shortfall.
- **Medium-notice RERT** – Between one and ten weeks' notice of a projected reserve shortfall
- **Short-notice RERT** – Between three hours and seven days' notice of a projected reserve shortfall.

In November 2020, the IRM was introduced. It was introduced due to concerns around reliability in the NEM and represents a lower USE than the reliability standard of 0.0006%. The RERT guidelines were updated by the Reliability Panel in August 2021 to allow AEMO to procure long-notice RERT if a breach of the IRM is forecast to occur.

Under the NER, AEMO may enter reserve contracts to ensure the reliability of supply.[42] Historically, AEMO has set up a RERT panel of providers for both the medium-notice and short-notice RERT and only triggers the procurement contract when it has identified a potential shortfall and after seeking offers from RERT panel members. However, from 2020-21 onwards, AEMO will only set up a panel of providers for short-notice RERT. There is no panel for the long-notice RERT; rather, contracts are signed following the close of a public tender process.

39 AEMO, *Reliability and Emergency Reserve Trader*, https://aemo.com.au/energy-systems/electricity/emergency-management/reliability-and-emergency-reserve-trader-rert

40 Clause 3.20.3 (b) of the NER

41 For the complete RERT guidelines see: https://www.aemc.gov.au/sites/default/files/2020-08/Updated%20Amended%20Panel%20RERT%20Guidelines%20-%2018%20August%202020%20-%20Final%20for%20publication_0.pdf

42 Clause 3.20.2(a) of the NER

In 2020-21 AEMO did not contract any long-notice RERT. This is a decrease from the 72 MW contracted for 2019-20 and the 40 MW for 2018-19. AEMO also contracted a panel of short-notice RERT providers, for up to 1728 MW of potential reserve capacity across the NEM.

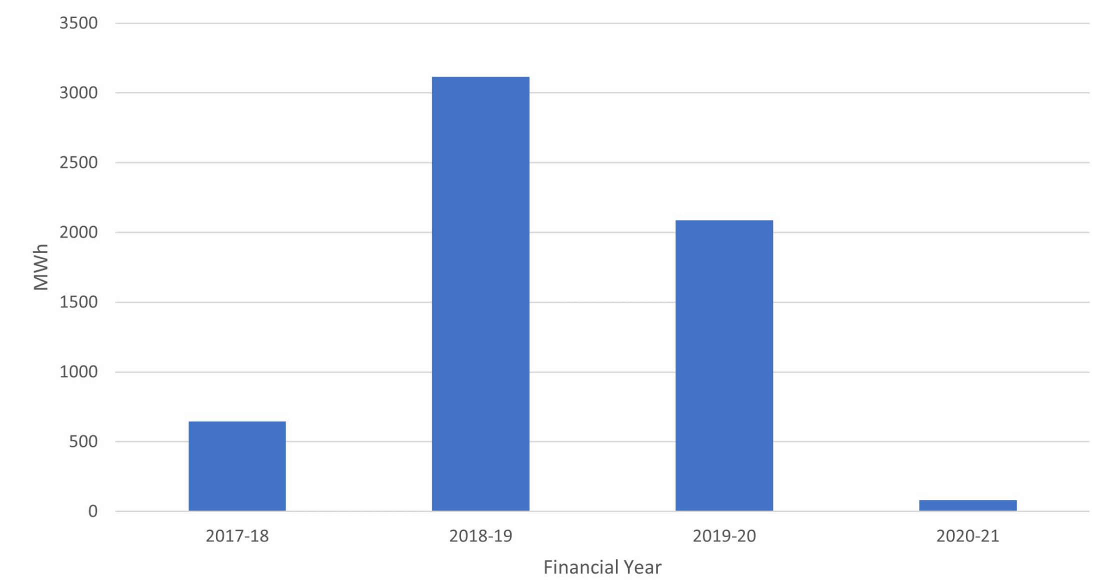
Use of RERT in 2020-21

AEMO activated the RERT mechanism on two occasions in 2020-21.[43] More detail on the circumstances around these activations is provided below:

- **17th December 2020** — Hot, humid weather in NSW resulted in higher-than-expected demand, which was exacerbated by Liddell Unit 3 tripping off. This resulted in a forecast LOR2 condition from 1530 to 1730 hrs. Market response was insufficient, so AEMO tendered for the provision of 398 MW of short-notice RERT. 38 MW of RERT was activated in NSW to ensure adequate reserves.
- **25th May 2021** — following the failure of Callide Unit C4 and the associated trips of other Callide & Gladstone coal-fired units, AEMO declared a forecast LOR2 condition. The forecast available reserve fell 76 MW short of the forecast requirement. AEMO tendered for the provision of 15 MW of short-notice RERT, following which 15 MW was activated in Queensland.

Figure 3.6 shows the volume of RERT activated in the past four financial years. The volume activated is less than all three preceding years, with fewer activations and less volume required per activation.

Figure 3.6: RERT reserves activated



Source: AEMO

43 for more information see: https://aemo.com.au/-/media/files/electricity/nem/emergency_management/rert/2021/rert-end-of-financial-year-report-2020-21.pdf

Costs of RERT use

A necessary consequence of using emergency reserves is that there are associated costs paid for by consumers. The total cost of RERT for 2020-21 was $661,700, which is a significant decrease from $40.6m in the previous period.[44] The breakdown of this cost can be seen in Figure 3.7. The cost can also be broken down into a $/MWh figure per activation, as shown in Table 3.2. In both RERT activations the cost per MWh was less than the MPC of $15,000/MWh and less than the 2021 NEM value of customer reliability of $24,980/MWh.[45] The Panel notes that care should be taken when comparing RERT activation costs with these points of reference. This is because the activation of RERT does not necessarily avoid specific market price outcomes such as MPC events, or system outcomes such as load shedding. Rather, RERT is used to ensure appropriate reserve buffers to reduce the probability that load shedding could result from reliability or security events.

Table 3.2: **Costs of RERT use per megawatt-hour**

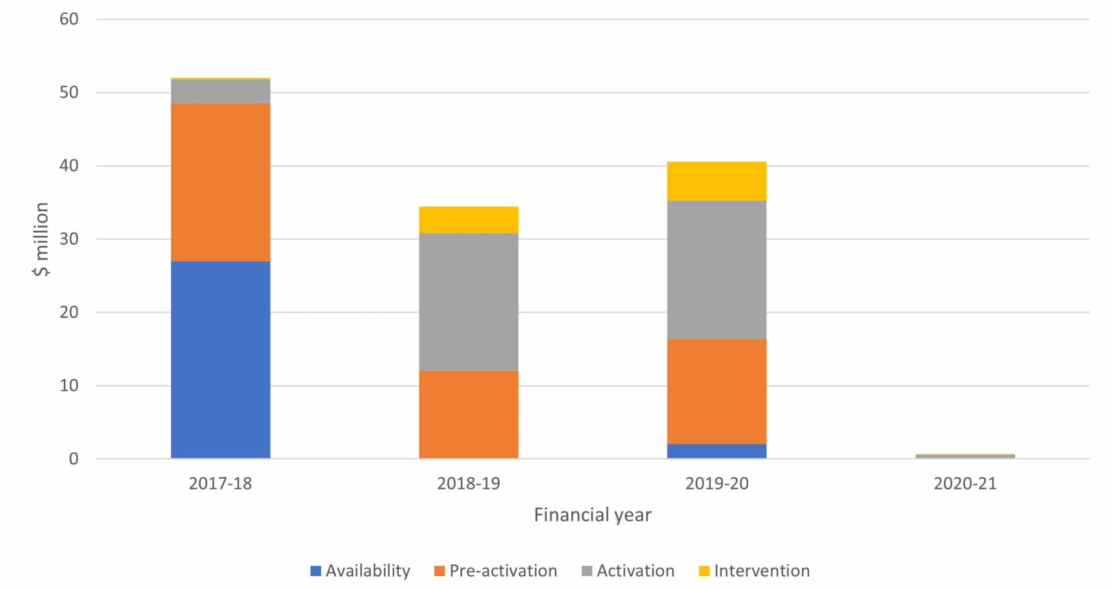
EVENT	REGION	RERT COST ($/MWH)
17 December 2020	NSW	$4,647
25 May 2021	Qld	$10,676

Source: AEMO RERT reporting

44 There is not a downward trend however, with a significant RERT event in Qld on 1 Feb 2022 costing $39.7m on its own.

45 For more information on the value of customer reliability see the AER's *Values of Customer Reliability – Annual adjustment summary – December 2021* – https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20customer%20reliability%20%20update%20summary%20-%20December%202021%2813309497.1%29.pdf

Figure 3.7: Costs of RERT use



Source: AEMO

3.2.5 AEMO interventions

AEMO, as the system operator, can intervene in the market to help maintain and/or re-establish the reliability and security of the power system.

The interventions framework in the NER provides AEMO with the tools to intervene in the market for reliability or for power system security.[46] It is an acknowledged and important feature of the market design, however, the use of such mechanisms requires careful consideration as to the flow-on effects for investment signals, as well as costs to consumers. As such, interventions are used as a last resort.

This section outlines when and how interventions were used in 2020-21 and considers whether the intervention mechanisms available adequately supported the delivery of reliable supply. The Panel has discussed the use of RERT in section 3.2.4, which is one method through which AEMO can intervene in the market. This section will consider the use of other methods of intervention in 2019-20, including:

- reliability directions to generators
- instructions and load shedding
- administered pricing

46 Clause 4.8.9 of the NER

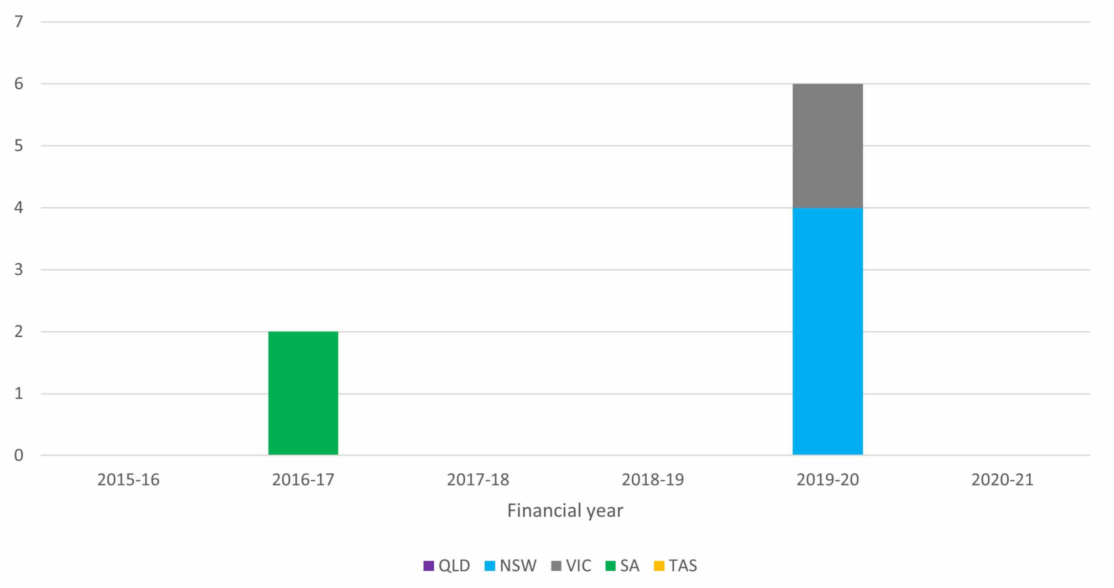
Reliability-related directions

AEMO may issue directions to registered participants where it is necessary to do so to maintain or return the power system to a secure, satisfactory, or reliable operating state.[47] AEMO can issue directions to generators to vary their output or a scheduled load to vary its consumption.

Reliability directions are issued to maintain the power system in a reliable operating state. Historically, AEMO has rarely used directions to manage reliability-related events. Over the last five years, the vast majority (99%) of directions have been issued for security-related events.

In 2020-21, AEMO issued no reliability directions, which is less than 2019-20, but the same as the two years prior. This is shown in Figure 3.8.

Figure 3.8: Reliability directions issued by AEMO



Source: AEMO

Instructions: controlled load shedding

An instruction differs from a direction in the types of market participants that AEMO can require to take action and the nature of the action taken. Instructions often involve AEMO requiring a network service provider or large energy user to shed load.[48]

Controlled load shedding, or involuntary disconnection of customer supply for reliability purposes may be implemented when there is a shortage of electricity supply to meet customer demand, or when demand cannot be satisfied while also keeping the power system

47 Clause 4.8.9(a)(1) of the NER

48 Clause 4.8.9 of the NER

in a secure state. Load shedding for reliability purposes is manually initiated as a last resort response to bring power flows into balance. Under manual load shedding a relatively small amount of load shedding for a short period (generally on a rotational basis) reduces the potential for more widespread and prolonged customer supply interruptions.

AEMO was not required to issue instructions for participants to shed load in 2020-21. It did, however, issue one similar instruction in South Australia to curtail distributed PV. This is discussed in more detail in section 4.2.1.

Administered pricing

The CPT is one of the reliability settings that seeks to maintain the overall integrity of the NEM by limiting market participants' exposure to sustained high prices which could threaten their financial viability. If the CPT is breached, the APC caps the aggregate market price that can occur over seven consecutive days.[49] This is intended to protect market participants, and ultimately customers, from paying excessively high prices. It is also set at a level such that prices over the long term can still incentivise enough new investment in generation, so the reliability standard is expected to be met.

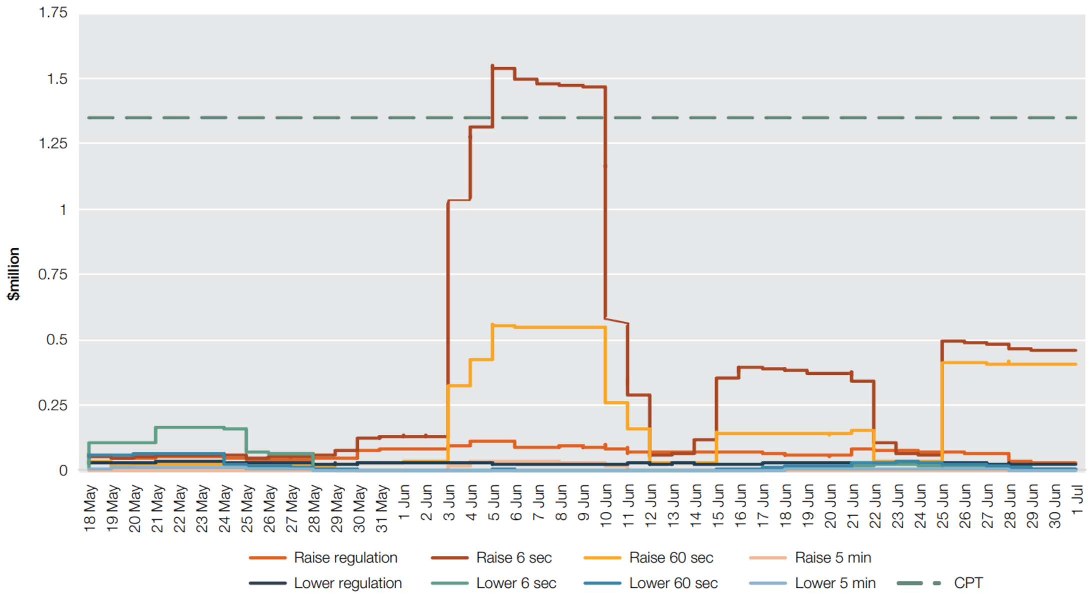
The CPT was not breached for energy during the 2020-21 financial year. Note that market price cap and market floor price events are discussed in section 2.3.

In comparison to energy, the CPT was breached during the 2020-21 financial year for FCAS. On the 3rd, 4th and 5th of June 2021, prices for R6 services in Queensland were sustained at sufficiently high levels to exceed six times the CPT.[50] AEMO capped prices for all FCAS services in Queensland to $300/MW until the cumulative price fell below the CPT on 10 June 2021. This is illustrated in Figure 3.9, below. The high R6 prices were caused by works on the section of QNI between Liddell and Armidale, combined with outages across multiple coal units in Queensland. This resulted in local FCAS requirements being applied in Queensland, and fewer units to fulfil the requirement.

49 For energy this period is 336 trading intervals prior to the commencement of five-minute settlement on 1 October 2021, 2016 trading intervals after its commencement. In FCAS markets, this period is 2016 dispatch intervals.

50 AER, *Wholesale Markets Quarterly Q2 2021*, pp 33-34

Figure 3.9: Queensland CPT - 18 May 2021 - 1 Jul 2021



Source: AER, *Wholesale Markets Quarterly Q2 2021*

The Panel notes that the CPT, as well as the other reliability settings, will be considered during the current RSSR. The review will consider the material changes occurring in the NEM and how these may affect each of the settings.

3.2.6 Forecast accuracy

In this section, the Panel has considered the accuracy of forecasts and has considered AEMO's 2021 forecast accuracy report as well as three different forecasts related to planning for and delivering enough supply to meet demand, i.e. the delivery of reliable supply. This includes:

- Accuracy of ST-PASA
- Accuracy of the wind energy forecasting system and solar energy forecasting system across different time periods and different states.

AEMO's 2021 forecast accuracy summary by region 2020-21

Annually, AEMO publishes an assessment of forecast accuracy.[51] AEMO's report primarily assesses the accuracy of its annual ESOO which provides forecasts over a 10-year period. A summary of AEMO's assessment of its forecast accuracy for 2020-21 is shown in Figure 3.10.

51 https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/forecasting-accuracy-reporting

Figure 3.10: AEMO forecasting accuracy summary by region 2020-21

Forecast Component	NSW	QLD	SA	TAS	VIC	Comments
Energy consumption	Green	Green	Green	Green	Green	All regions within 3%. Tasmania had the largest error, almost entirely explained by lower large industrial load.
Summer maximum demand	Green	Green	Green	Green	Green	All mainland regions within distributions and consistent with forecast drivers. Outcomes in Tasmania and Victoria were in the very low end of the distributions, but driven by very mild weather and, in the case of Tasmania, lower large industrial load at time of the peak.
Winter maximum demand	Amber	Green	Red	Yellow	Red	Winter maximum demand outcomes in New South Wales, South Australia and Victoria above forecast distributions. The distribution of the initial year of the forecast horizon requires review.
Annual minimum demand	Green	Yellow	Yellow	Amber	Yellow	Due to under-forecast PV capacity, actual minimum demands in most regions were below the forecast distribution.
Demand Side Participation	Green	Green	Yellow	Green	Green	Less demand side participation (DSP) than forecast observed in South Australia. This has been adjusted down in the 2021 forecast. Need for monitoring DSP for changes following introduction of 5-Minute Settlement and Wholesale Demand Response.
Installed generation capacity	Yellow	Green	Green	Green	Yellow	New generator installations matched expectation, except in Victoria and New South Wales, where delays impacted availability compared with what was modelled.
Summer supply availability	Yellow	Yellow	Green	Yellow	Green	Planned and unplanned outages in New South Wales, Queensland and Tasmania reduced availability against forecast, however units may simply not have been made available due to low levels of observed supply scarcity.

Source: AEMO forecasting accuracy reporting 2021

AEMO has identified a list of proposed improvements to the ESOO forecasting methodology. Of this comprehensive list, several priority improvements for 2022 were identified:[52]

- **Winter maximum demand forecasts** — noting that three NEM regions observed actual winter maximum demand higher than the 10% probability of exceedance (POE) forecast, AEMO intends to analyse and improve the winter maximum demand forecasting methodology
- **Visibility and understanding of consumption patterns and trends** — in the 2021 *forecast accuracy report* AEMO added an assessment of the accuracy of the large industrial load forecast. This measure points to there being more for AEMO to understand in this area.
- **Additional weather years** — the growth in the proportion of VRE generators in the NEM is increasing the importance of weather when assessing future reliability outcomes. The ten reference weather years used in the 2022 ESOO may prove insufficient in future.

52 For more detail see AEMO's *2021 Forecast accuracy report* – https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/accuracy-report/forecast-accuracy-report-2021.pdf

- **Improved auxiliary load forecast** — the 2020 ESOO forecast auxiliary load was significantly higher than what was observed.
- **Tracking of emerging technologies** — AEMO will be looking for data that will allow tracking of uptake and use of emerging technologies not currently covered in the *forecast accuracy report* — for example behind-the-meter battery storage.

The Panel notes that AEMO's continuing assessments and future work program will improve stakeholder and market participant understanding of the changing supply and demand dynamics. This is a fundamental part of supporting investment, operational and policy decisions that underpin reliability.

Projected assessment of system adequacy

PASA is the principal method of indicating to AEMO and market participants a forecast of the overall balance of supply and demand for electricity. PASA is conducted over short and medium-term horizons. This section considers the forecast accuracy of both.

Short-term projected assessment of system adequacy

ST-PASA provides information to market participants on the expected level of short-term capacity reserve and hence the likelihood of interruptions due to a shortage of power. It can also provide a benchmark for AEMO to intervene in the market. It covers six trading days, from the end of the trading day covered by the most recent pre-dispatch schedule, with a half-hourly resolution. Figure 3.11 illustrates the performance of ST-PASA load forecasts over 2020-21.

Forecasting of small-scale distributed PV systems (less than 100 kW system capacity) commenced on 30 March 2016 and is included as part of dispatch, pre-dispatch and ST PASA. The forecasting system, called ASEFS2, uses the following inputs to produce aggregated regional solar generation forecasts for small-scale PV systems:

- Numerical weather prediction data from multiple weather data providers
- Output measurements and static data from selected household rooftop PV systems from PvOutput.org and Solar Analytics
- Aggregate kilowatt capacity by installed postcode for small-scale solar systems as recorded by the Clean Energy Regulator (CER)
- Imagery from the Himawari-8 satellite

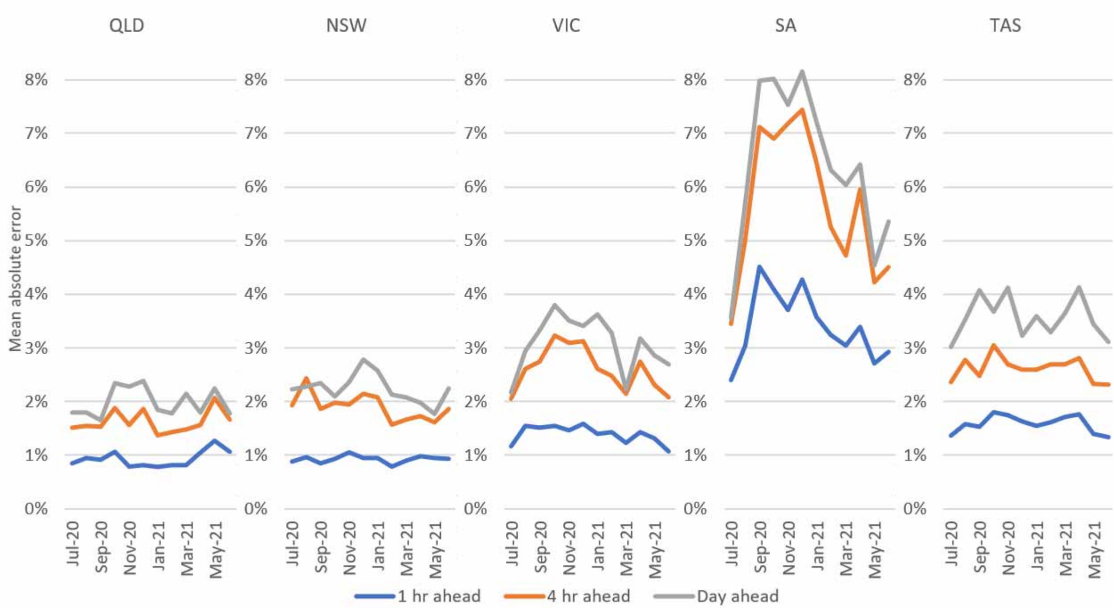
Small scale solar forecasts are used in the pre-dispatch and ST-PASA demand forecasts.

The Panel notes that:

- As expected, forecasting error decreased as the forecasting horizon approached real-time.
- Forecasting performance was marginally worse than the previous reporting period, across all time horizons and regions.
- The accuracy of load forecasts in Queensland, NSW, Victoria and Tasmania was fairly stable across the year.

- In SA, the variability in accuracy of load forecasting is far higher than the other regions. This was also the case in 2018-19 and 2019-20, but not to the same degree as in this reporting period. This can be explained by the impact of Rooftop PV of which SA has a high capacity relative to system load. It has two key impacts on load forecast performance:
  - Low minimum system load caused by rooftop PV generation can result in issues with using percentage calculations. A small absolute forecast error can translate to a large percentage error when the denominator is small.
  - Rooftop PV can be responsible for significant variation in load i.e. rooftop PV errors resulting in load forecast errors.

Figure 3.11: Accuracy of ST-PASA load forecasting



Source: AEMO

Medium-term projected assessment of system adequacy

In addition to ST-PASA reports, AEMO also publishes MT-PASA reports. This process determines if there is sufficient capacity expected to be available to meet forecast demand over the medium term (2-3 year) time horizon. Through the MT PASA process, AEMO collects information on the capacity that each dispatch unit can make available given 24 hours of notice. Participants submit their expected plant availability for the next 36 months and are required to update their PASA submission on an ongoing basis to ensure it matches their current intentions and best estimates. AEMO produces 50% POE and 10% POE demand forecasts for the next 24 months. These two forecasts and other information (outage plans from TNSPs and MNSPs, weather, wind, etc.) are then combined to assess a number of factors including the likelihood of the reliability standard being breached and the probability of lost load on a given day.

Australian wind energy forecasting systems

The Australian wind energy forecasting system (AWEFS) produces wind generation forecasts for all semi-scheduled and non-scheduled wind generators in the NEM.[53] These forecasts cover a forecast horizon of five minutes to seven days and are used for the dispatch, pre-dispatch and ST-PASA processes.

AWEFS produces forecasts from the following inputs:

- Real-time SCADA measurements from the wind farms
- Numerical weather predictions from weather forecasters from around the world
- Standing data from the wind farms
- Availability information provided by the wind farms, including turbines under maintenance and the upper MW limit of the wind farm.

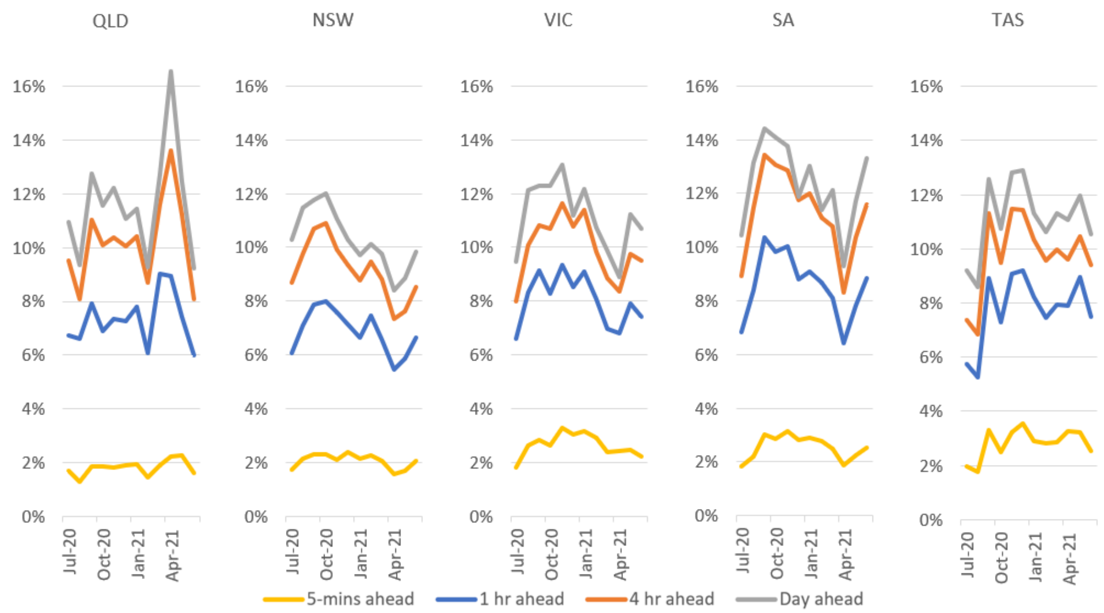
Due to the variable nature of wind and solar, there is potential for material variations in energy availability from these generators which may have implications for power system reliability outcomes. At times of peak demand, even small variations within a tight timeframe can create reliability issues, especially if firming capacity is not available to replace this generation.

The accuracy of forecasting is therefore a key factor in the effective integration of VRE generation into the NEM. Forecasting systems and forecasting improvements, along with the appropriate market structures and operational tools, will be increasingly important tools for promoting efficiencies in NEM dispatch, pricing, system reliability and security, as renewable generation continues to make up a larger share of the generation mix.

The Panel has analysed the normalised mean absolute error in wind energy forecasts over different timeframes. The results for 2020-21 are illustrated in Figure 3.12.

53 AEMO is required to prepare forecasts of the available capacity of semi-scheduled generators such as large scale wind and solar farms in order to schedule sufficient generation in the dispatch process (NER clause 3.7B) and to be used in the PASA processes for reserve assessment purposes (NER clause 3.7.1(c)(2)).

Figure 3.12: Normalised mean absolute error of wind energy forecasts



Source: AEMO

In analysing Figure 3.12 above, the Panel notes that:

- The accuracy of AWEFS forecasts is broadly similar across regions, for each time horizon. This contrasts to 2019-20 which saw greater variability between regions.
- NSW, Victoria, and Tasmania improved from 2019-20 in all forecast horizons besides the five-minute horizon.
- Queensland's forecast accuracy deteriorated from 2019-20 period.
- SA's forecast accuracy was similar to that of 2019-20.

Australian solar energy forecasting system

The Australian solar energy forecasting system (ASEFS) produces solar generation forecasts for large solar power stations, covering forecasting timeframes from five minutes to seven days.

ASEFS produces forecasts for any solar farms greater than or equal to 30 MW registered capacity and any solar farms that AEMO is required to model in network constraints for power system security reasons.

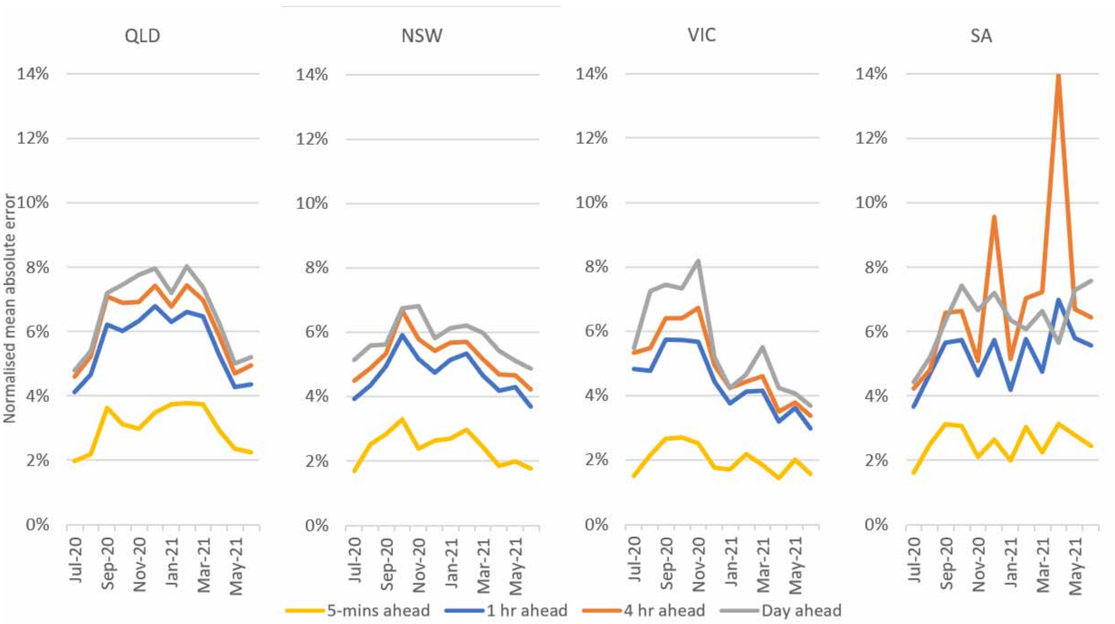
AEMO started forecasting for large scale solar farms on 30 May 2014. It uses the following inputs to produce solar generation forecasts for large scale solar power stations:

- Real-time SCADA measurements from the solar power station
- Numerical weather prediction data from multiple weather data providers

- Standing data from the solar power station as defined in the ASEFS energy conversion model
- Additional information provided by the solar power station, including inverters under maintenance and the upper limit MW on the solar farm
- Imagery from the Himawari-9 satellite

The performance of solar energy forecasting in 2020-21 is illustrated in Figure 3.13 below.

Figure 3.13: Normalised mean absolute error of solar energy forecasts



Source: AEMO

Tasmania was not included in the results due to the low penetration of solar resources in the region. The Panel notes that:

- Unlike other forecasting, there does not appear to be a significant increase in accuracy until the five-minute time horizon, with results from the 24 hours, four hours and one hour ahead horizon relatively similar. This is because the movement, formation, and dissipation of clouds (and dust) is largely chaotic in nature and therefore difficult for meteorologists to predict with precision.
- Queensland is consistently the region where forecasting accuracy is the lowest. This is similar to 2019-20.
- SA saw fluctuations in the performance of the forecast, with the four-hour ahead forecast seeing particularly high variations in performance.
- NSW and Victoria's performance was fairly similar to 2019-20.

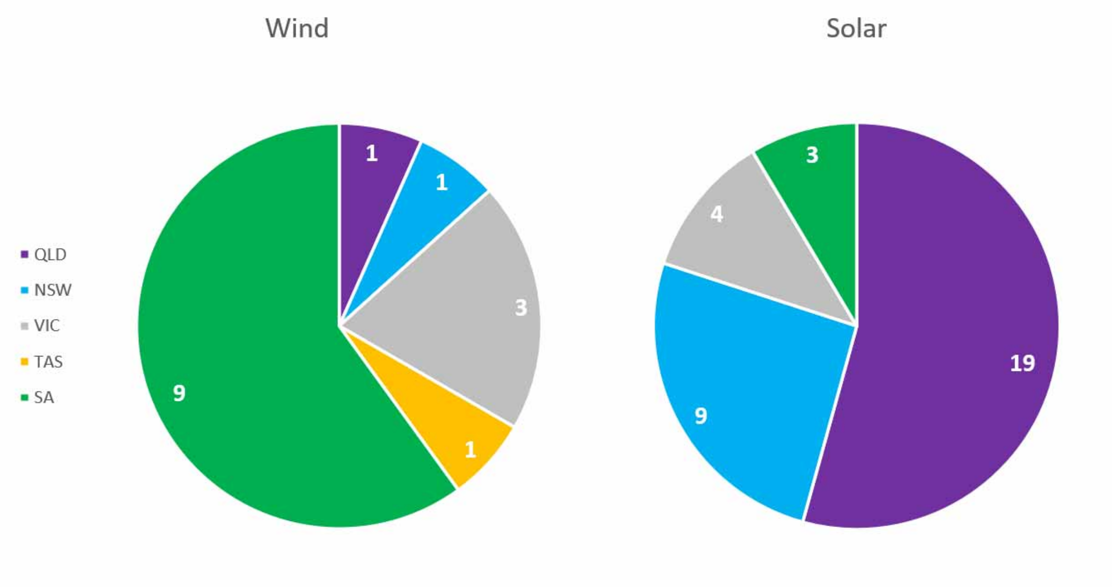
Self-forecasting performance

In 2018, a Market Participant Self-Forecasting trial was initiated as a collaboration between AEMO, the Australian Renewable Energy Agency (ARENA) and industry (forecasting service providers, existing and new wind, and solar generators) to explore the benefits of self-forecasting unconstrained wind and solar generation. The initial focus of the trial is to determine the relative benefits of using the participant's 5-minute ahead dispatch self-forecast in dispatch, in preference to the equivalent forecast from AWEFS or ASEFS.

The trial is ongoing with participants able to apply to participate. There are clear benefits for AEMO — as well as participants — of more accurate forecasts in terms of operating the system, including lower regulation FCAS activation requirements. The corollary of this is that participants can also reduce their causer-pays FCAS costs by improving the accuracy of the pre-dispatch forecast associated with their units. This provides an incentive for self-forecasting participants to invest to improve and optimise their 5-minute ahead self-forecasts.

At the end of 2020-21, there were 15 wind farms, and 35 solar farms employing self-forecasts. The distribution of these participants by state is shown in Figure 3.14.

Figure 3.14: Self-forecasting participants by state



Source: AEMO

The Panel notes that:

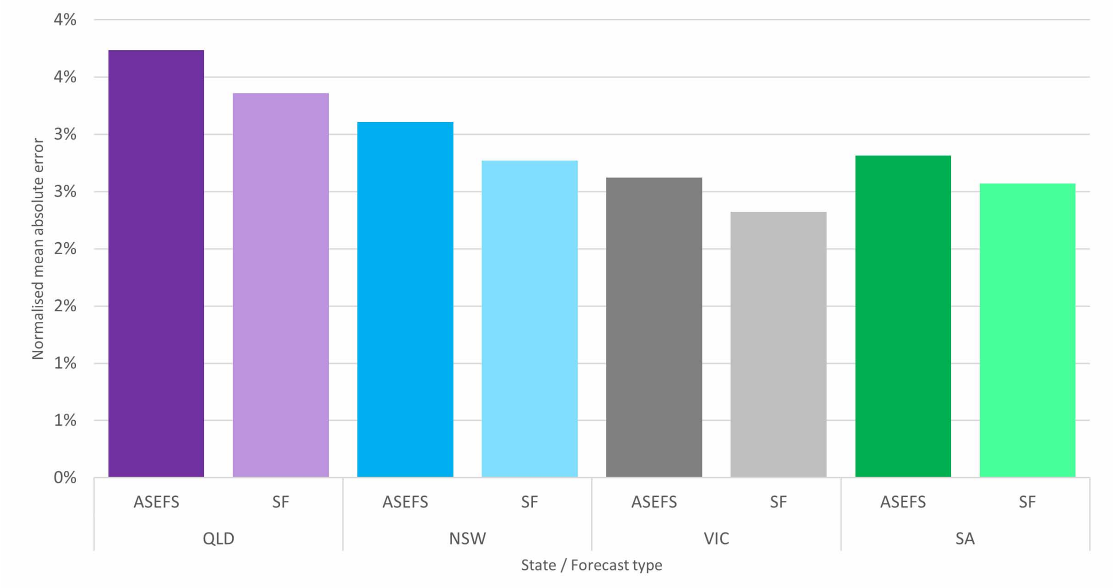
- The number of self-forecasting participants has increased substantially in both solar and wind since 2019-20, from a total of 28 to 50. This indicates the potential FCAS cost reductions from improved forecasting accuracy, as mentioned earlier in this review.
- There are now self-forecasting wind participants in all five NEM regions, up from two regions in the previous period.

In terms of performance against AEMO AWEFS and ASEFS forecasts, self-forecasts exhibit superior accuracy.

Figure 3.15: Wind self-forecasting comparison to AWEFS

Source: AEMO

Figure 3.16: Solar self-forecasting comparison to ASEFS



Source: AEMO

From Figure 3.15 and Figure 3.16, the Panel observes that across all regions in both solar and wind, participant self-forecasts out-perform AEMO's AWEFS and ASEFS systems. This reflects the access to additional data from their assets that participants have, compared to AEMO, resulting in higher forecast accuracy.

3.2.7 Network performance

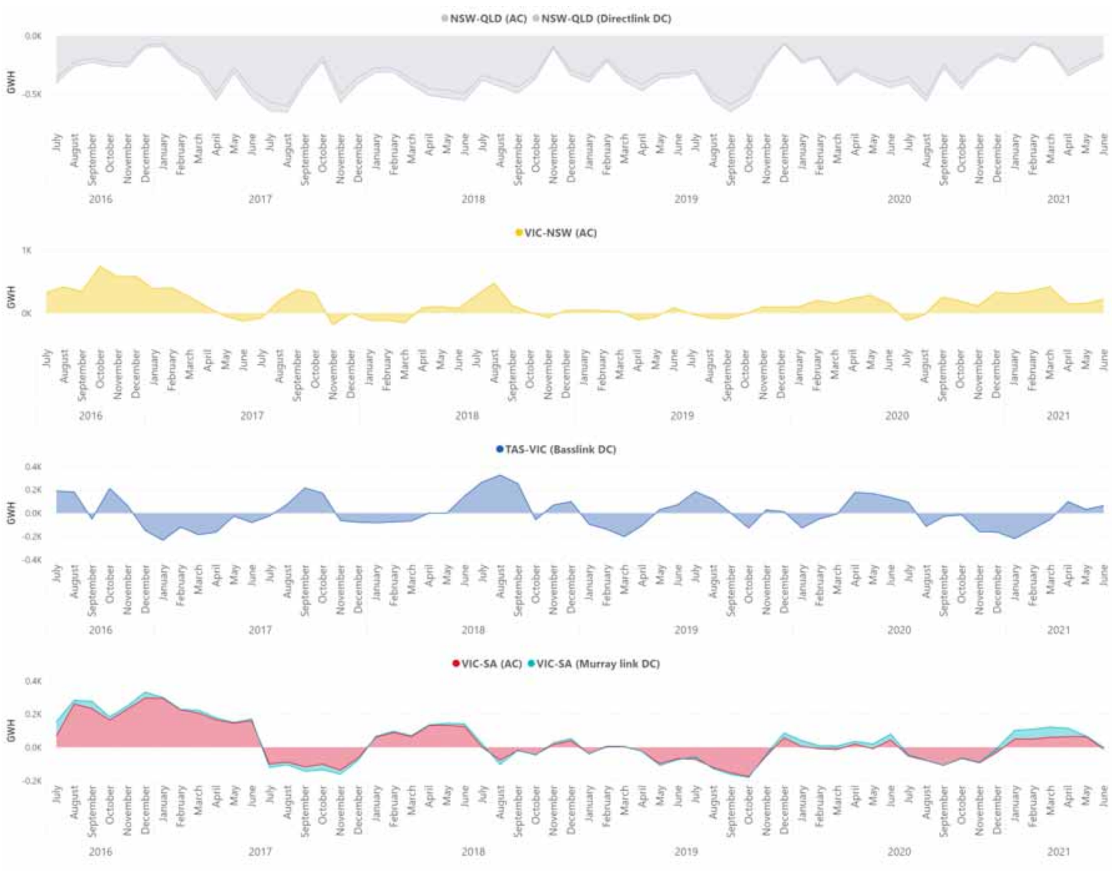
In assessing network performance in the NEM in 2020-21, the Panel has considered the performance of:

- interconnectors
- transmission networks
- distribution networks.

Interconnector performance

In this section, the Panel analyses the performances of the interconnectors in the NEM. These interconnectors allow sharing of generation and reserves between regions. As the geographical and technological diversity of the variable renewable energy generators and batteries in the NEM continues to grow, the role of interconnectors in ensuring each state has adequate energy supply will continue to increase.

Figure 3.17: Inter-regional energy flows by month



Source: Panel analysis of AEMO data

Some key points to note in relation to inter-regional flows include:

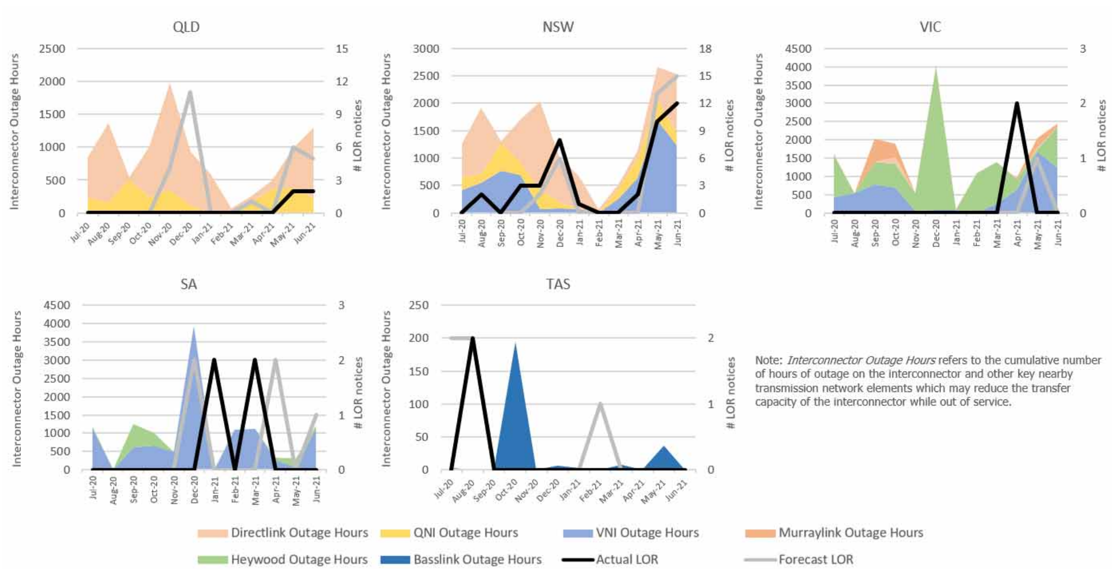
- Queensland-NSW interconnectors continue to have a net Southerly energy flow, as is historically typical. The volume of energy sent South has decreased in 2020-21, compared to 2019-20 and 2018-19. Flow constraints on the interconnector resulting from transmission upgrades may have contributed to this trend.
- Similarly, NSW was a net electricity importer from Victoria for every month in 2020-21 other than July and August 2020. This continues the trend that began in 2019-20 of VIC-NSW energy flows being predominantly in a Northern direction. This may be caused by the trend of decreasing flows from Queensland to NSW.
- Energy flows between Tasmania and Victoria were predominantly Southwards until the Winter period. This pattern is consistent with previous years.
- During the second half of 2020, SA was a net exporter to Victoria, while in the first half of 2021 it was a net importer. This pattern can be seen throughout recent history.

Impact of outages on interconnector infrastructure on reliability

As the geographical and technological diversity of the variable renewable energy generators and batteries in the NEM continues to grow, the role of interconnectors in ensuring each state has adequate energy supply will continue to increase.

The analysis here investigates whether there is any relationship between lack of reserve notices and outages on interconnectors and nearby network elements which could affect their transfer capacity.

Figure 3.18: Correlation between works affecting interconnectors and LOR conditions



Source: Panel analysis of AEMO data

From Figure 3.18, above, it can be noted that there is a moderate correlation between works affecting interconnectors and LOR notices (both forecast and actual) in QLD and NSW, however, there does not appear to be a significant relationship in the other NEM regions. It should be noted that any correlation is especially difficult to identify in the Southern states as they experienced relatively few LOR conditions when compared to QLD and NSW.

The Panel notes that it will continue to monitor this trend.

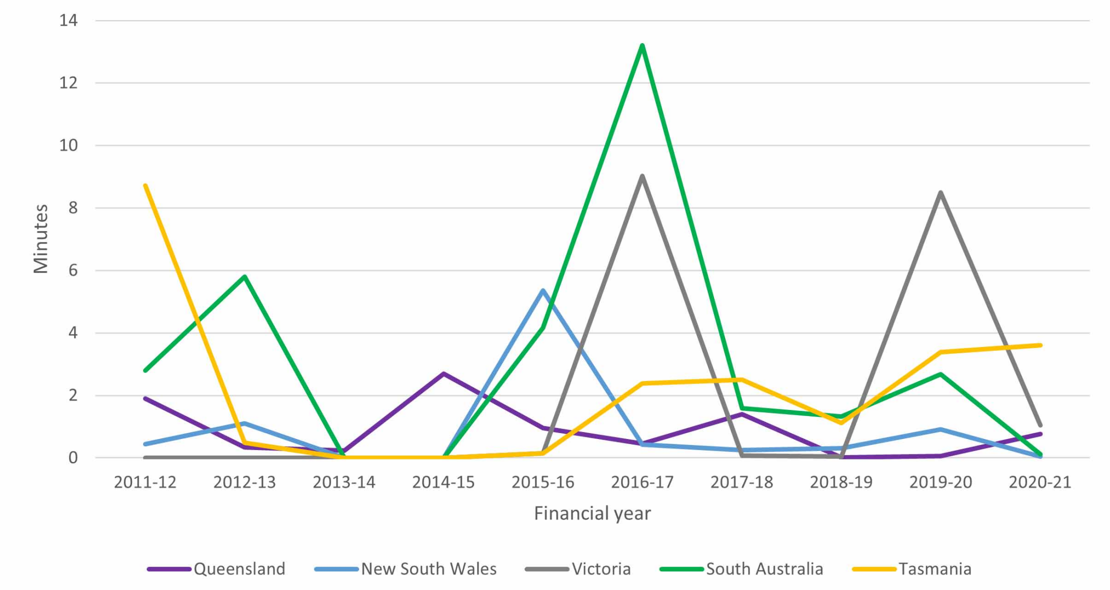
Transmission network performance

This section provides a summary of transmission network performance in 2020-21.

Unplanned network outages result in lost load that is not counted towards USE for the purposes of the reliability standard. This is because USE is only calculated based on demand that is not met due to insufficient generation and bulk transfer, which does not include interruptions to supply caused by disturbances on intra-regional transmission and distribution networks.

For 2020-21, transmission unsupplied minutes was down in all regions besides Queensland and Tasmania, where it rose marginally.

Figure 3.19: Transmission unsupplied minutes



Source: Requested from TNSPs

Distribution network performance

The performance of distribution networks, and the reliability standards that must be met, fall within the responsibility of each jurisdiction. All jurisdictions have their own monitoring and reporting frameworks for the reliability of distribution network service providers (DNSPs).

Two important indicators of distribution network reliability are:

- System average interruption duration index (SAIDI)
- System average interruption frequency index (SAIFI).

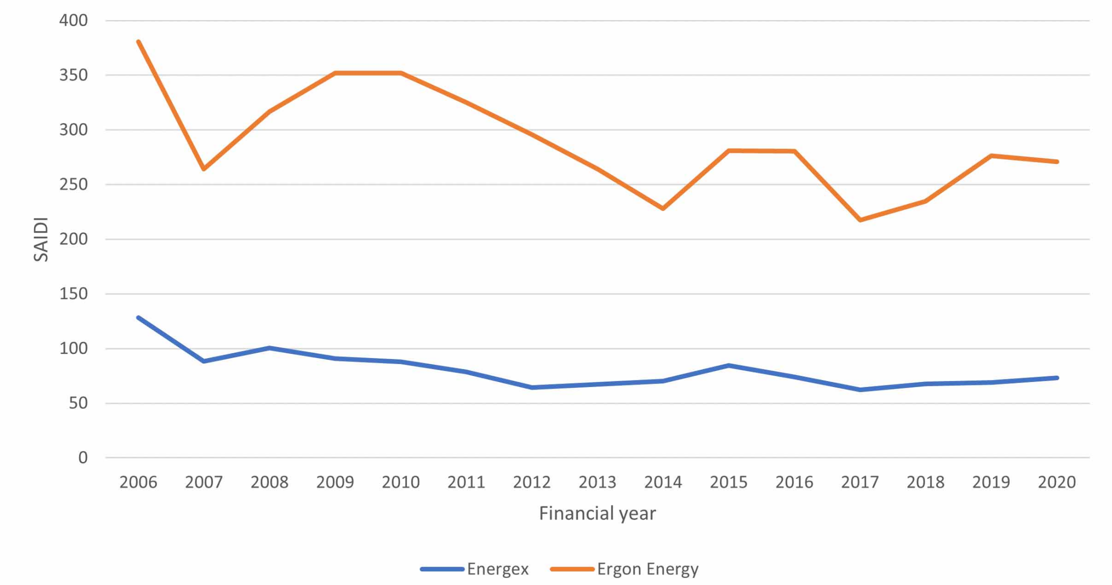
DNSP performance in 2020-21 in relation to each of these is discussed below.

SAIDI indicates the average number of minutes of outages that each customer served by the DNSP experienced. More specifically, it is the sum of the duration of each sustained customer interruption, divided by the number of customers excluding certain events that are not within the control of the distribution network.

Network reliability standards are often measured in terms of the SAIDI. It is calculated for different parts of each DNSP's network, for example, the reliability on long rural lines is calculated differently to the reliability on CBD networks. The reliability targets for these different parts of the network are also different.

The average SAIDI figure for each DNSP is shown in Figures X to Y. As shown in the figures, DNSPs that largely serve urban customers such as Ausgrid, Energex and Citipower have lower SAIDI outcomes compared to DNSPs such as Essential Energy, Power & Water and Ergon Energy that have larger proportions of rural customers.

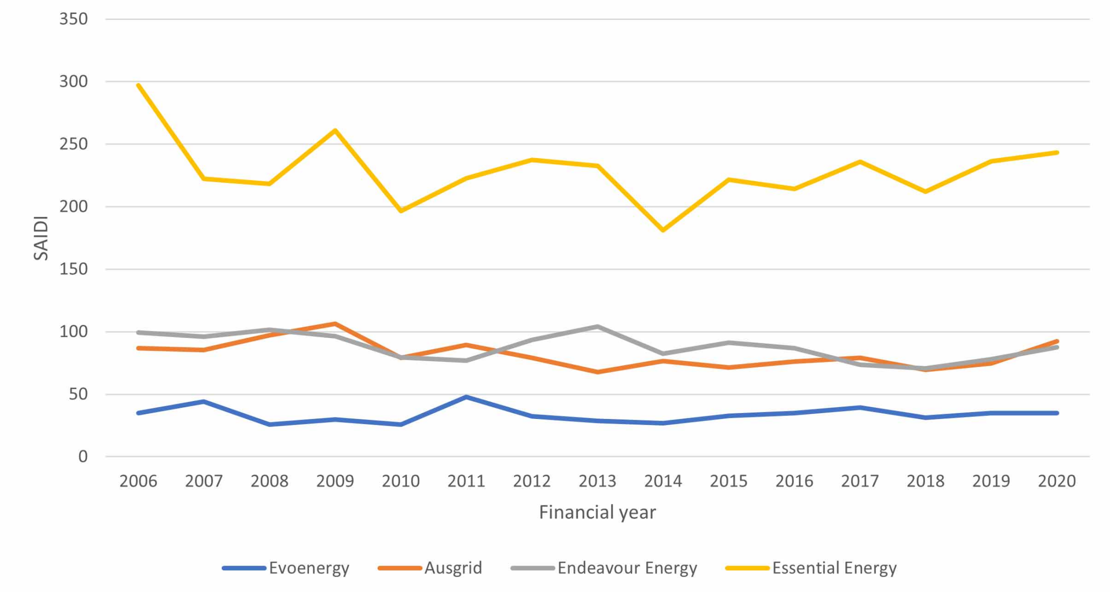
Figure 3.20: SAIDI Queensland



Source: AER, *Electricity network performance report 2021*

In Queensland, the SAIDI results for both Energex and Ergon Energy were consistent with the results from 2019-20.

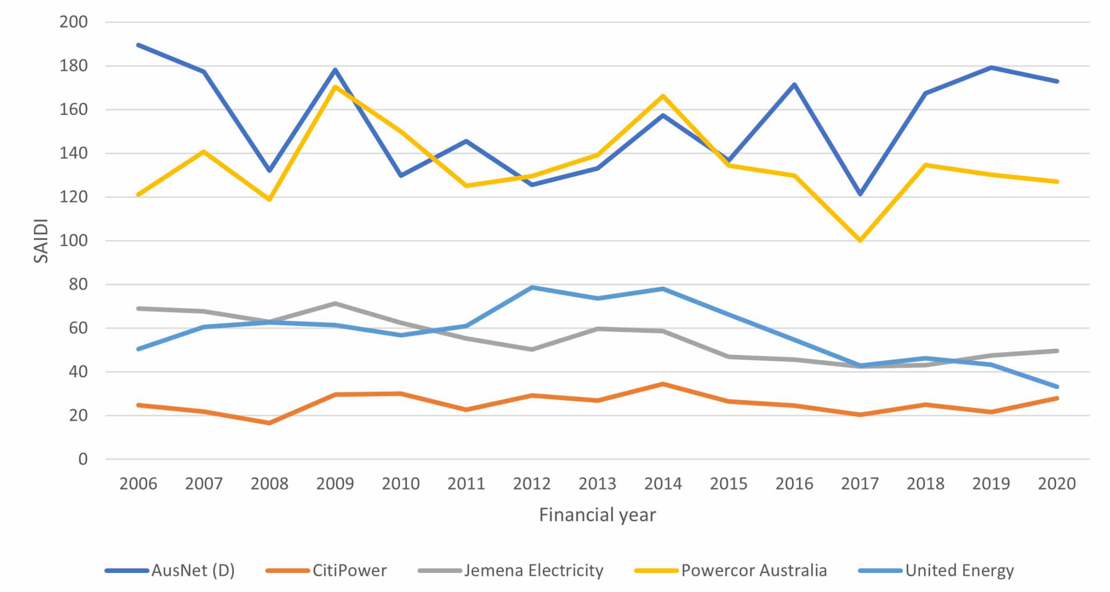
Figure 3.21: SAIDI NSW and ACT



Source: AER, *Electricity network performance report 2021*

In NSW, Ausgrid, Endeavour Energy and Essential Energy all saw moderate increases in their SAIDI results, following the trend of 2019-20. In the ACT, Evoenergy recorded similar results to 2019-20.

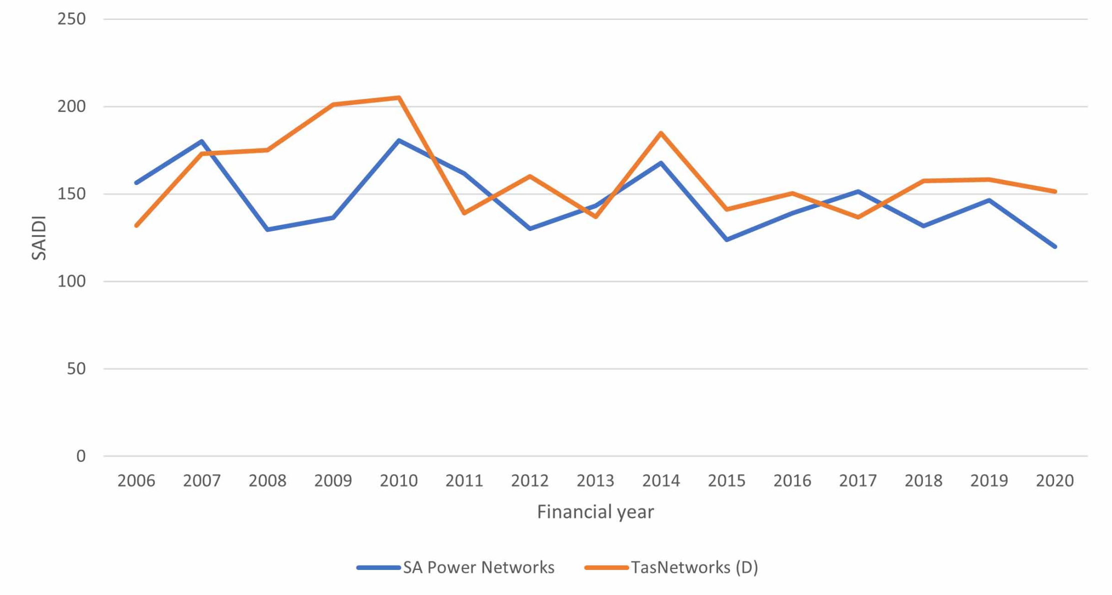
Figure 3.22: SAIDI Victoria



Source: AER, *Electricity network performance report 2021*

In Victoria, Ausnet, Powercor, and United Energy all saw moderate decreases in their SAIDI results from 2019-20. Jemena Electricity and CitiPower by comparison saw moderate increases.

Figure 3.23: SAIDI SA and Tasmania

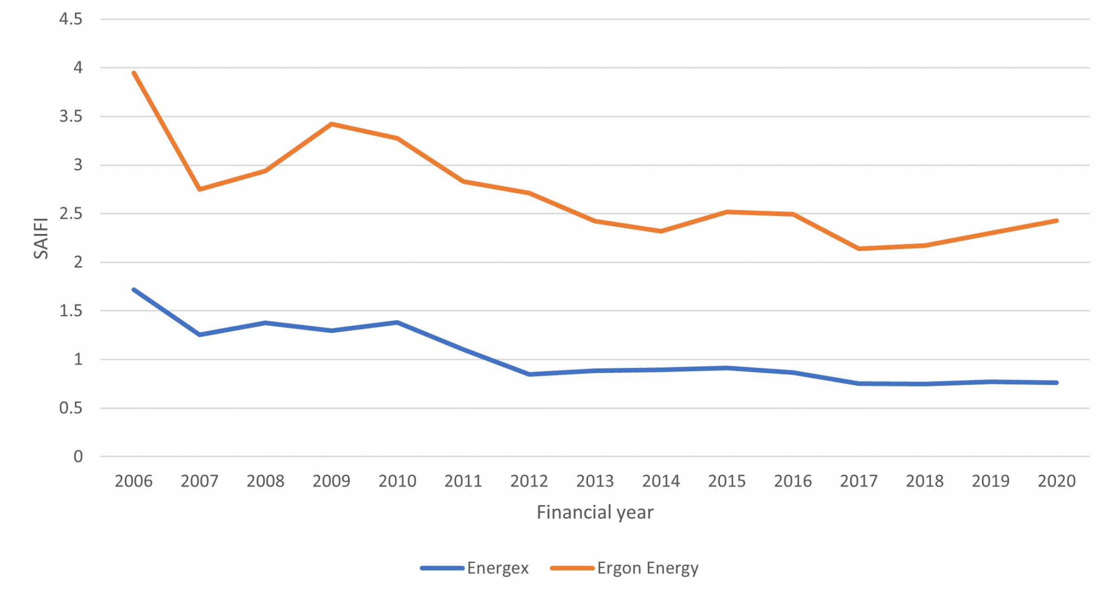


Source: AER, *Electricity network performance report 2021*

In SA, SA Power Networks saw a decrease in its SAIDI result. In Tasmania, TasNetworks saw a moderate decrease in its SAIDI.

SAIFI indicates the average number of outages for each customer served by the DNSP. Figures 3.32 to 3.35 show the SAIFI outcomes for each DNSP.

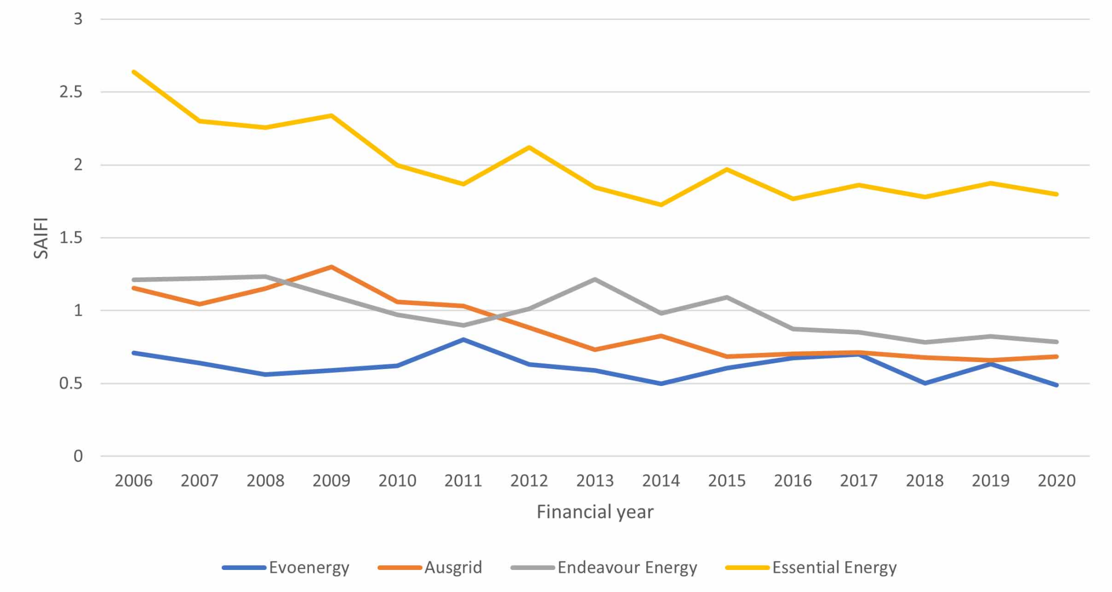
Figure 3.24: SAIFI Queensland



Source: AER, *Electricity network performance report 2021*

In Queensland, the SAIFI results were relatively consistent with 2019-20. Ergon rose moderately, continuing the trend of the previous year, while Energex's results remained stable.

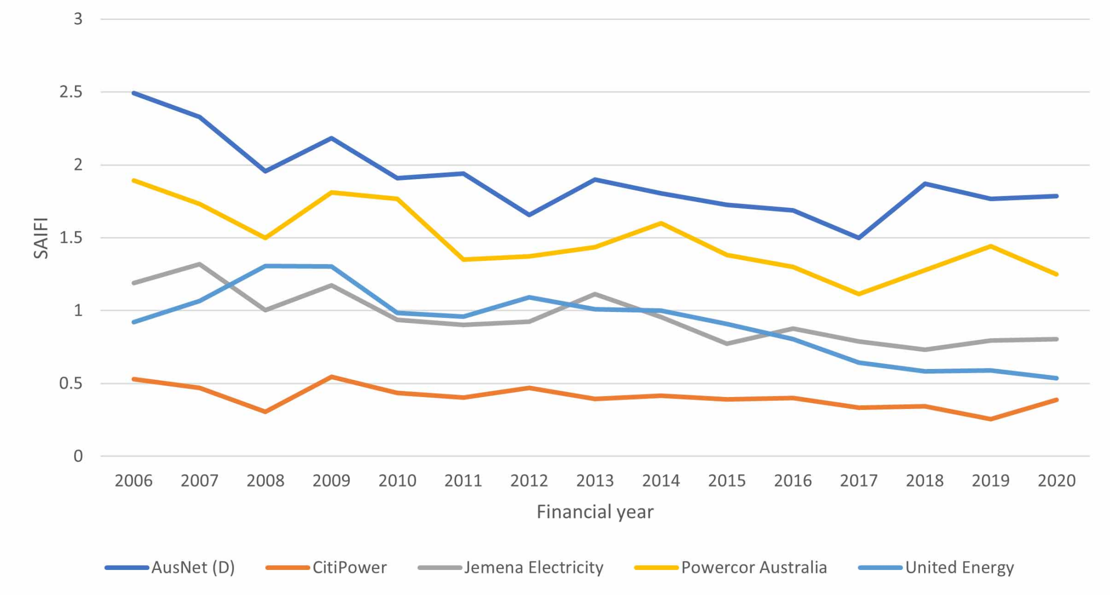
Figure 3.25: SAIFI NSW and ACT



Source: AER, *Electricity network performance report 2021*

In NSW, Endeavour Energy and Essential Energy saw small decreases, while Ausgrid saw a small increase. In the ACT, Evoenergy's SAIFI decreased, offsetting the increase of the prior period.

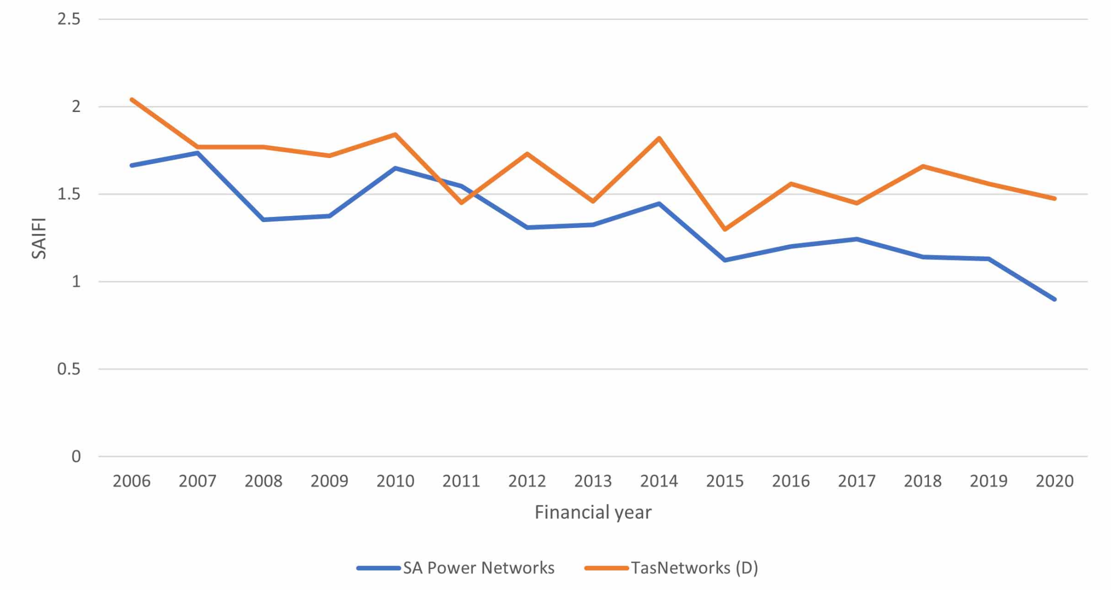
Figure 3.26: : SAIFI Victoria



Source: AER, *Electricity network performance report 2021*

In Victoria, Jemena Electricity and AusNet recorded similar SAIFI results to 2019-20, CitiPower recorded an increase, Powercor a decrease, and United Energy a small decrease.

Figure 3.27: SAIFI SA and Tasmania



Source: AER, *Electricity network performance report 2021*

In SA, SA Power Networks recorded a substantial improvement over their results for 2019-20, continuing a long-term downward trend. TasNetworks also saw an improvement, albeit at a lesser magnitude.

3.3 Key changes to reliability frameworks in FY21

As the power system continues to evolve, so too must the regulatory framework that underpins it. During the 2020-21 financial year, a number of changes were made to improve reliability outcomes in the NEM.

Two key changes were made to reliability frameworks in the NEM in 2020-21:

- introduction of the IRM and associated RERT guideline update
- delay of the implementation of five-minute settlement

A number of other changes were made soon after the end of the reporting period or are currently underway. The following sections describe these changes in more detail.

3.3.1 Interim reliability measure

In July 2020, Energy Ministers amended the NER to include an additional reliability benchmark to the reliability standard — the IRM.[54] The aim of this was to improve reliability during the transition to the ESB's post-2025 market design.

54 More information on the amendments available at https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-electricity-market-reforms/post-2025-market-design/interim-reliability-measures

This:

- established an out-of-market capacity reserve (an 'Interim Reliability Reserve'), triggered to keep unserved energy (USE) to no more than 0.0006% in any region in any year
- amended triggering arrangements for the Retailer Reliability Obligation (RRO) to be based on a breach of 0.0006% USE.

In comparison to the reliability standard, the IRM is not included in the MT-PASA process and is instead used to inform the procurement of out-of-market capacity reserves in a similar timeframe to long-notice RERT.

The AEMC must conduct a review of the interim reliability measure and the procurement of interim reliability reserves by AEMO by 1 July 2023.

3.3.2 Five-minute settlement

The AEMC made a final rule in November 2017 to change the settlement period for the NEM electricity spot market from 30 minutes to five minutes, commencing in July 2021. This was done to align the price signal for resources more accurately with the time in which they are needed. Increasing the granularity of NEM settlement will also provide more incentive for fast technologies such as batteries and demand response. This is particularly important as the NEM continues its transition toward higher penetrations of VRE.

On 9 July 2020, the AEMC made a rule to delay the commencement of five-minute settlement by three months, to 1 October 2021.[55] This was needed due to the impact of COVID-19 on electricity industry capabilities, to give participants and market bodies adequate time to prepare.

The Panel notes that five-minute settlement commenced after the end of the 2021 AMPR's review period, and as such more consideration to the impact of the change will be given by the Panel in the 2022 Annual market performance review.

3.3.3 2022 Reliability standard and settings review

The Panel is currently undertaking its 2022 RSSR, which covers the period 1 July 2025 to 30 June 2028.[56] The reliability standard and settings are key components of the NEM's reliability framework. These elements aim to encourage sufficient investment in generation or demand response capacity to meet consumer demand for energy, while protecting market participants from potential financial risks that threaten the overall stability and integrity of the market.

The reliability standard defines an efficient level of reliability, expressed as the level of USE that represents an efficient economic trade-off between reliability and affordability. The current NEM reliability standard is a maximum expected USE of 0.002% of total electricity demanded. The market price settings are set to achieve market outcomes consistent with the reliability standard by defining a price envelope that provides sufficient revenue to support

55 https://www.aemc.gov.au/rule-changes/delayed-implementation-five-minute-and-global-settlement

56 For more information on the 2022 RSSR, see the project page — https://www.aemc.gov.au/market-reviews-advice/2022-reliability-standard-and-settings-review

investment while also limiting the potential for high, low, and cumulative price impacts. The settings are:

- Market Price Cap
- Market Price Floor
- Cumulative Price Threshold
- Administered Price Cap

The 2022 RSSR will consider both the form and level of the reliability standard and settings. The Panel has a statutory requirement to review the reliability standard and settings every four years. 2024-25 is excluded from this review to allow the team additional time to coordinate with the ESB's capacity market development work.[57] The 2022 RSSR final report is scheduled for publication on 1 September 2022.

3.3.4 Transmission Planning and Investment Review

In August 2021, the AEMC published a consultation paper for the transmission planning and investment review (TPIR).[58] The AEMC self-initiated the review to examine transmission planning and investment frameworks in the context of ensuring the timely and efficient delivery of major transmission projects. The timely development of transfer capacity within and across regions is an important contributor to the reliability of the power system. This is particularly the case in the context of a rapidly transforming power system where transmission is required in new areas and the need to transfer capacity between regions is growing due to the transition to a power system more heavily reliant on VRE to provide bulk energy.

The review is being progressed in stages to support the timely implementation of initial reforms while allowing time for adequate consideration of longer-term term strategic reforms. Stage two of the review, a draft report on near term reforms, is expected to be published by the end of May. Stage three of the review, a draft report on longer term overarching reforms, is expected to be published in early July.

3.3.5 Updating short-term PASA

In December 2021 the AEMC published a draft determination in response to a rule change request from AEMO to overhaul the current ST PASA framework for more flexibility and to better align with industry practices.[59] The draft rule determination :

- introduces a principles-based approach to ST PASA
- requires AEMO to develop and consult on ST PASA procedures to describe how it will administer ST PASA

57 For more information on this change, see *Extension of time and reduction in scope of the 2022 reliability standard and settings review* rule change project page — https://www.aemc.gov.au/rule-changes/extension-time-and-reduction-scope-2022-reliability-standard-and-settings-review

58 For more information, see the *Transmission planning and investment review* project page — https://www.aemc.gov.au/market-reviews-advice/transmission-planning-and-investment-review

59 For more information, see the *Updating short-term PASA* project page — *https://www.aemc.gov.au/rule-changes/updating-short-term-pasa*

- requires AEMO to publish generator availability information at a unit level
- changes the PASA availability definition to gather more accurate information on plant recall time
- changes the definition of energy constraint to a more technologically neutral definition.

A final determination is due to be published by 5 May 2022.

3.3.6 Enhancing information on generator availability in MT PASA

The AEMC is currently considering a rule change request on *Enhancing information on generator availability in MT PASA*.[60] The rule was recommended as part of the ESB's resource adequacy workstream and aims to improve transparency in the market around intermittent and seasonal operating regimes. The request proposes to do so by requiring generators to submit a reason for and recall time from any unavailability they submit through MT PASA.

The additional information to be gathered through the proposal will be particularly important as thermal generators near their retirement and move to cyclical operating regimes to maintain profitability. A draft determination is due to be released on 26 May 2022.

3.3.7 ESB capacity mechanism design work

One of the recommendations of the ESB's post-2025 reform package advice to ministers was the development of a capacity mechanism. This refers to an instrument that creates a market for capacity, with the aim of creating a clear, technology-neutral, long-term price signal for investment in dispatchable capacity.

The ESB published an initiation paper for consultation in December 2021, with the consultation closing in February 2021. A paper detailing the design of the mechanism is expected to be published in mid-2022.

The Panel is working closely with the ESB so that the 2022 RSSR and capacity market design work can be appropriately aligned and dovetail where necessary. This includes ensuring that the assumptions in the RSSR and those used in the development of the capacity mechanism are aligned. This is necessary due to the amount of overlap between the reliability settings and any potential capacity mechanism. The assumptions for each mechanism underpin pricing and incentive-based approaches that need to work together to meet a common level of reliability desired by consumers.

60 For more information, see the *Enhancing information on generator availability in MT PASA* rule change project page — https://www.aemc.gov.au/rule-changes/enhancing-information-generator-availability-mt-pasa

4 SECURITY

One of the Panel's key responsibilities, as set out in the National Electricity Law, is to monitor, review and report on the security of the national power system, at the request of the AEMC. This chapter considers the security performance of the NEM over the 2020-21 financial year in line with the Panel's NEL obligations and the review's terms of reference.[61]

This chapter outlines:

- what power system security is and how it is delivered
- the security performance of the NEM in 2020-21
- panel insights, challenges to security and work underway to address these

In assessing the system security performance of the NEM, the Panel has considered several indicators. Power system security involves keeping the power system within a technical envelope across a range of characteristics. The Panel plays an important role in determining standards that are required to deliver a secure, reliable, and safe power system in the most efficient way in order to minimise costs for consumers. The Panel will use its assessment of system security to inform its future work plan.

4.1 What power system security is and how it is delivered

The NEM is a large-scale, complex machine made up of thousands of elements, each with specific technical characteristics and operating requirements. Power system security involves:

- maintaining components within their allowable equipment ratings
- maintaining the system in a stable condition within defined technical limits
- returning the power system to operate within normal conditions following a disturbance.

In a secure power system, technical parameters such as power flows, voltage and frequency remain stable during normal operations and are returned even after a significant change in power system conditions, such as the loss of a major transmission line or large generator. A secure power system is one that, among other things:

- Can maintain a satisfactory operating state following the occurrence of a credible contingency event[62]
- Maintains power system frequency, voltage, current and plant operation within appropriate limits as specified by the power system security standards.[63]

In practice, a power system is in a secure state if it would remain within the technical operating parameters in the event of a credible contingency. More information on power system security can be found on the AEMC website.[64]

61 For the complete standing terms of reference see appendix A.

62 A credible contingency event is a contingency event whose occurrence is considered "reasonably possible" in the circumstances. For example the unexpected disconnection or unplanned reduction in capacity of one operating generating unit; or the unexpected disconnection of one major item of transmission plant.

63 Clause 4.2.2 of the NER

64 https://www.aemc.gov.au/energy-system/electricity/electricity-system/security

BOX 2: SUMMARY OF SECURITY OUTCOMES IN 2020-21

- While overall security outcomes were good in 2020-21, security continues to remain a challenge for the sector. This reinforces the need to focus on the progression of the ESB's post-2025 market design project recommendations on essential system services. This is particularly driven by the effects of climate change as well as the ageing of thermal generators.
- There were no events where the power system, was not in a secure operating state for more than 30 minutes, down from three in 2019-20.
- Reviewable operating incident numbers were similar to 2019-20. These are 'unusual power system events' and are set out in the Panel's *Guidelines for identifying reviewable operating incidents*.
- The upward trend in the number of power system directions continued. These directions were almost exclusively used to manage system strength in South Australia where there is a high penetration of IBR.
- Frequency performance improved notably in both the mainland and Tasmania following the mandatory primary frequency response implementation rollout beginning in September 2020.
- FCAS costs are trending down, however, localised FCAS requirements in Queensland and concurrent coal unit outages resulted in higher costs in the second quarter of 2021.
- The number of changes to constraints in NEMDE was more than 2019-20 but less than 2018-19.
- There was a large increase in the number of market notices issued by AEMO in 2020-21, driven by automated dispatch price reviews and lack of reserve notices.

4.2 Security outcomes

4.2.1 Reviewable operating incidents

One indicator of power system security performance in the NEM is the number of system security-related operating incidents that occurred during the year.

AEMO has the responsibility to investigate and review all major power system operational incidents and publish detailed incident reports. This allows them to assess the adequacy of the provision and response of facilities or services, and the appropriateness of actions taken to restore or maintain power system security.[65] A reviewable operating incident is an incident identified, in accordance with guidelines determined by the Reliability Panel under the NER, to be of significance in the operation of the power system or a significant deviation from normal operating conditions.[66]

65 Clause 4.8.15(b) of the NER
66 Clause 4.8.15(a) of the NER

The Panel notes it will be reviewing the guidelines for identifying reviewable operating incidents later this year to update them to be fit for purpose given the changing power system.

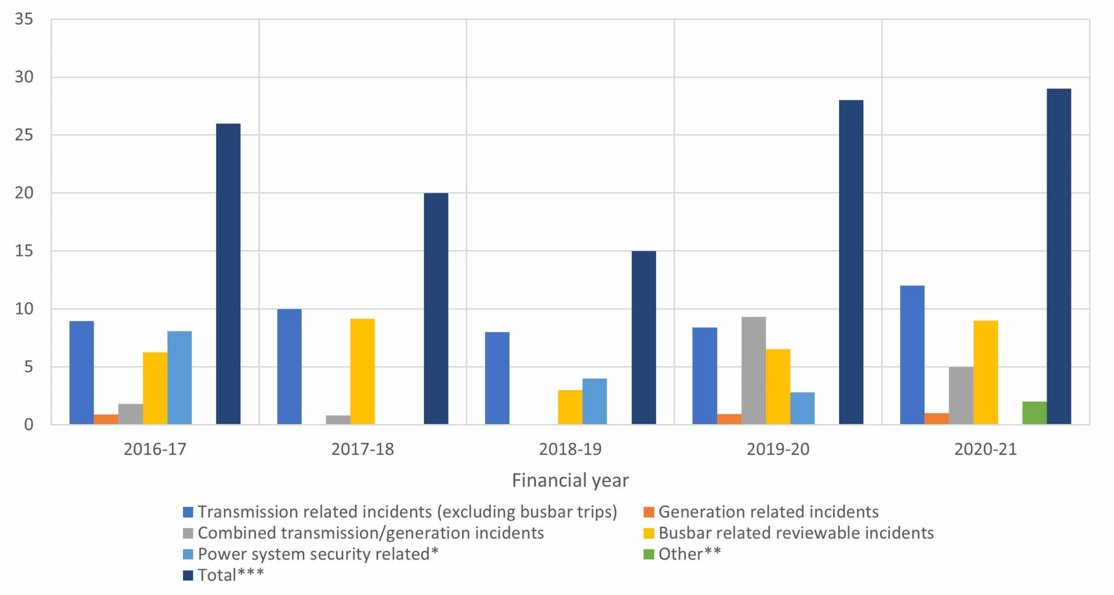
AEMO is currently required to report on the following categories of incidents as reviewable operating incidents:

- A non-credible contingency event or multiple contingency events on the transmission system
- A black system condition
- An event where the frequency of the power system is outside limits specified in the power system security standards
- An event where the power system is not in a secure operating state for more than 30 minutes
- An event where AEMO issues a clause 4.8.9 instruction for load shedding.
- An event where AEMO's oscillatory and transient stability monitoring systems detect potential generator instability for more than 30 minutes.
- Incidents that result in the operation of under frequency or over-frequency protection and control schemes
- Incidents where the power system is not in a satisfactory state for more than five minutes.

AEMO may also report on other significant events or systemic issues at its discretion or be requested to review particular events by the Panel.

Figure 4.1 shows the number and type of reviewable incidents that have occurred across recent reporting periods.

Figure 4.1: Number of reviewable operating incidents



Source: AEMO
Note: * Power system security refers to the power system not being in a secure state for more than 30 minutes, ** Multiple categories of incident can occur during the same event and are double-counted, so the sum of all categories does not necessarily equal the total.

There were 29 reviewable operating incidents in 2020-21, slightly up from 28 in 2019-20. While the volume of incidents was similar, the distribution varied, with 2020-21 recording more transmission and busbar related incidents. Combined transmission/generation incidents were down on the other hand, while a similar volume of generation related incidents was recorded. The number of incidents is higher than in previous reporting periods, but not significantly so.

In 2020-21 there were no instances where the power system was not in a secure state for more than 30 minutes. This is down from three instances in 2019-20.

Notably, in an event not seen in the NEM before, on 14 March 2021, AEMO issued a direction under NER section 4.8.9 to curtail distributed solar PV to maintain the system in a secure state. In total 67 MW of solar PV was curtailed. This was necessitated by works restoring damaged towers on the Heywood interconnector, resulting in a risk of islanding the SA region. When such a risk is present, AEMO studies have identified that the secure system load threshold is 400 MW. Due to the mild shoulder-season weather and the 14th of March being a Sunday, AEMO forecast system load to fall below 400 MW, and as such directed ElectraNet to take steps to maintain system load above 400 MW for about an hour from 3:00pm (ACDT). This resulted in curtailing larger distribution-connected solar generation and residential solar systems, including more than 10 MW for the first time through the South Australian government's 'Smarter Homes' initiatives.[67]

4.2.2 Power system directions

AEMO may issue directions to participants to maintain or re-establish the power system to a secure operating state. It can direct participants to manage voltage and system strength.

System strength reflects the sensitivity of power system variables to disturbances. It indicates inherent local system robustness with respect to properties other than inertia. System strength affects the stability and dynamics of generating systems' control systems, and the ability of the power system to both:

- Remain stable under normal conditions
- Return to steady-state conditions following a disturbance, such as a fault.

Large synchronous machines, such as hydro, gas and coal generation, as well as synchronous condensers, inherently contribute to system strength. Non-synchronous generators, such as batteries, wind, and solar generation, do not presently provide an inherent contribution to system strength.[68]

Currently, most directions given by AEMO are to synchronous gas-fired generators to ensure that that the power system is secure in South Australia. For secure operation of the South Australian power system, certain combinations of synchronous generating units must be in service at all times. This was stipulated in early December 2016, when AEMO announced that at least two large synchronous generating units should be online at all times to maintain system strength in South Australia.[69] Directions in South Australia are needed to maintain system strength when low spot prices incentivise gas-powered generators to de-commit from the market to avoid generating unprofitably. This usually occurs during periods of high wind and solar output with low to moderate demand.

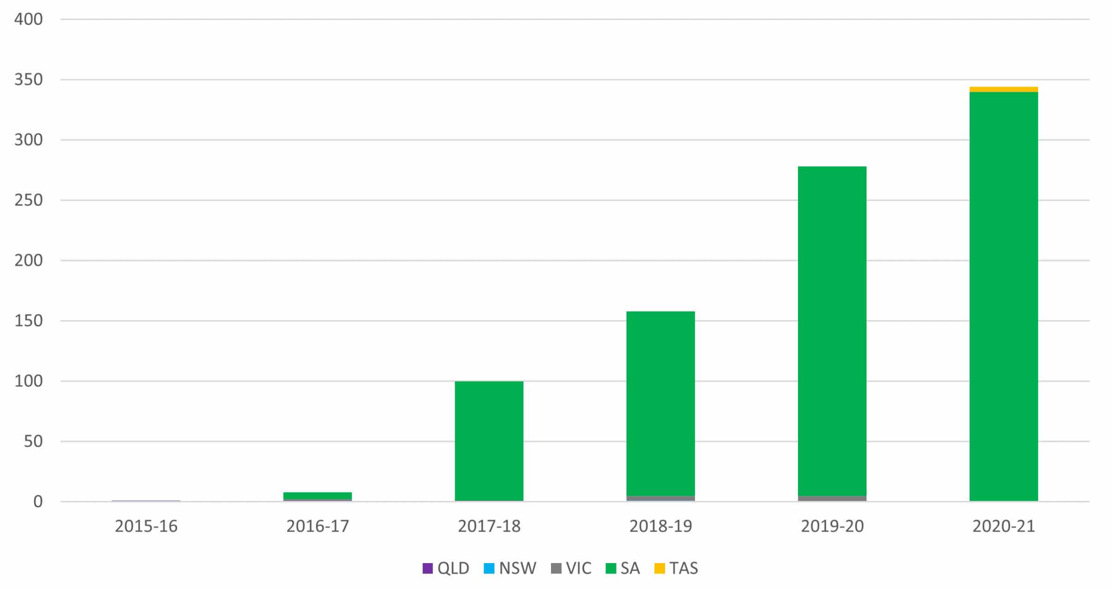
In 2020-21, AEMO issued 344 power system directions. Of these, 340 were issued in South Australia, with the remaining four issued in Tasmania. This continues the upward trend in directions in South Australia that emerged in 2016-17. This can be seen in Figure 4.2, below.

67 For more information on this event, see *Solar PV curtailment initiative by SA Government supports the NEM* — https://aemo.com.au/en/newsroom/media-release/solar-pv-curtailment-initiative-by-sa-government-supports-the-nem

68 This may change in the future, with small scale tests of advanced 'grid-forming' inverters shown to supply system strength. More information available in AEMO's *Application of advanced grid-scale inverters in the NEM* whitepaper, https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/application-of-advanced-grid-scale-inverters-in-the-nem.pdf

69 AEMO, *Second update to the 2016 National Transmission Network Development Plan*, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2017/Second_Update_to_the_2016_NTNDP.pdf

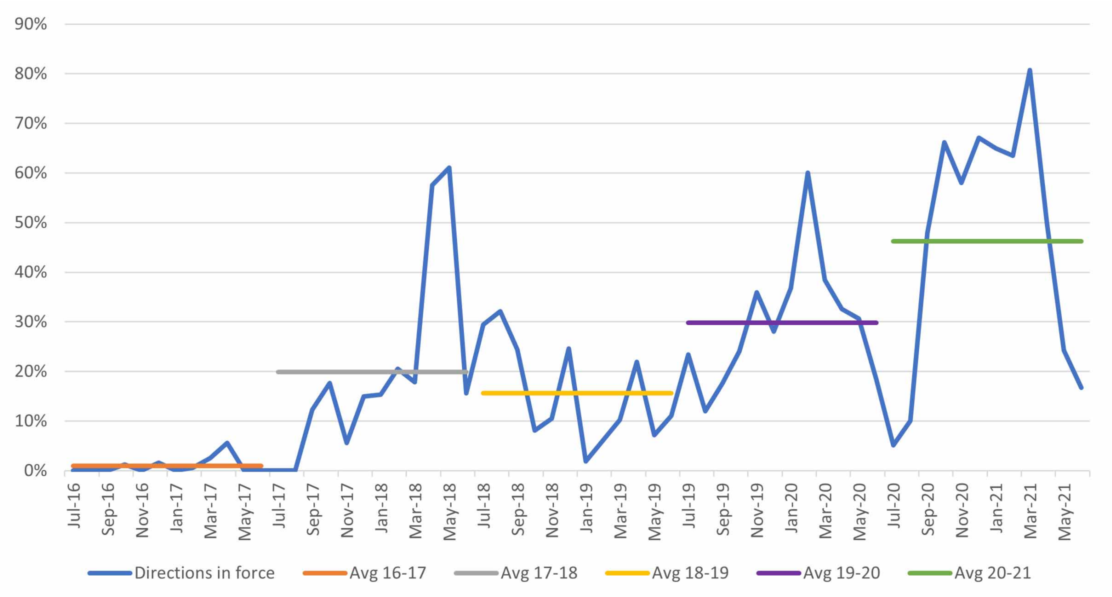
Figure 4.2: Number of directions issued by AEMO for security



Source: AEMO

The Panel notes that this trend is likely to continue in the near future, until it is clearer how to operate the system with a high proportion of non-synchronous machines. Additionally, the four synchronous condensers in the ElectraNet network that have recently been commissioned are expected to alleviate South Australia's system strength shortfalls. This should reduce the number of units directed, however may not materially reduce the number of directions issued given AEMO still needs to make sure that there are certain combinations of units online at any point in time.

Figure 4.3: Percentage of time NEM under direction



Source: AEMO

The proportion of time that the NEM is operating under security directions continues to increase with directions in force 46% of the time in 2020-21. This marks a sizeable increase from 30% in 2019-20 and 16% in 2018-19. This is shown in Figure 4.3.

The time under directions was lowest in 2020-21 during Winter, which reflects that the IBR penetration tends to be lower during this period, alleviating security issues.

4.2.3 Constraint changes

AEMO operates the power system to balance supply and demand for power using the most economic resources available, while also maintaining a secure and reliable system. To do so, the NEM is operated within a technical envelope of constraints that aim to prevent the power system from operating in a state that is vulnerable to supply disruptions in response to a credible contingency event.

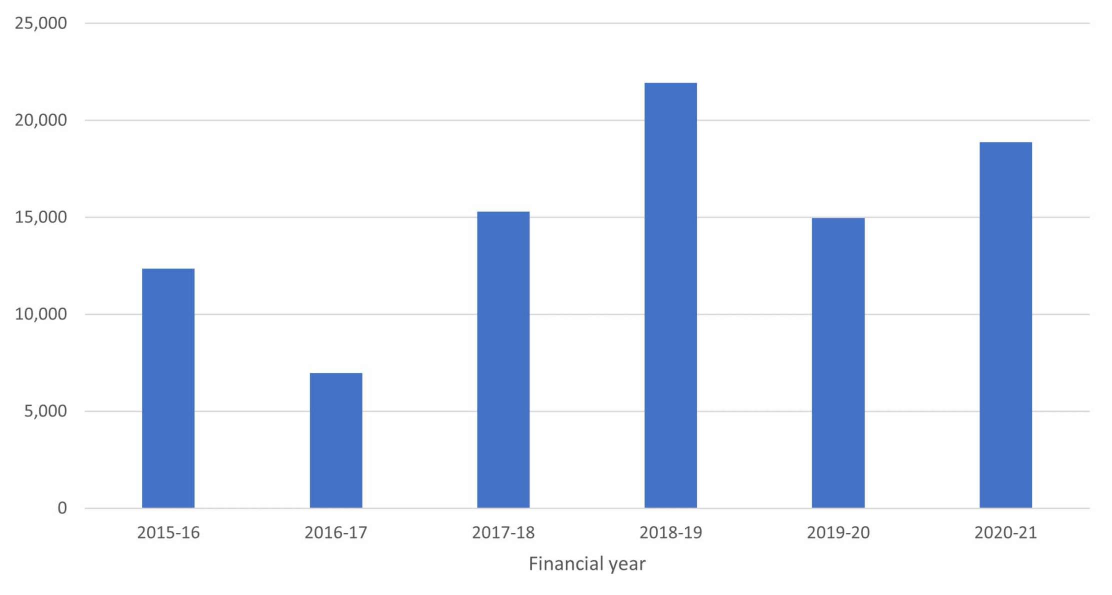
Network constraints are derived from TNSP advice to AEMO about the technical limits of plant and are used by AEMO in the NEM dispatch process. This is done to ensure that plant remains within its technical rating, and power transfers remain within stability limits, ensuring the power system is in a secure operating state.

As the power system transitions from one dominated by a small number of large synchronous generating systems, located in areas with strong transmission connections, to a system dominated by inverter-connected renewable generators connecting in weaker parts of the network, the number of constraint changes is likely to increase to reflect this complexity. Constraint equations are changed or added to for a number of reasons including:

- New advice from the TNSP
- An item of plant (such as a generator) was commissioned or decommissioned
- Adjustments were made to improve the performance of the constraint equation
- Power system studies identified a new condition that needs to be managed by a constraint equation
- A new FCAS requirement was identified.

In 2020-21, there were 18,870 constraint changes. This is an increase from 2019-20, however, it is typical of recent years. The large amounts of constraint changes occurring each year are symptomatic of the increasing complexity of operating the NEM power system.

Figure 4.4: Number of constraint changes



Source: AEMO

4.2.4 Frequency performance

Controlling or maintaining frequency is a key element of power system security. All generation, transmission, distribution, and load components connected to the power system are standardised to operate at a normal system frequency of 50 Hz. The power system must therefore stay at or close to this level for equipment to stay connected to the system and continue to operate within technical bounds.

To maintain a stable system frequency at or close to 50 Hz, AEMO must balance the supply of electricity with demand at all times. When there is more generation than load, the frequency will increase. When there is more load than generation, the frequency will fall. AEMO relies on a number of processes and factors to ensure that frequency remains within the acceptable window, including:

- **The dispatch process** — balances forecast supply and demand on a five-minute basis
- **FCAS regulation services** — balances supply and demand on a four-second basis, accounting for changes that occur within a dispatch interval
- **FCAS contingency services** — response that is on standby in case of a credible contingency event
- **Local generator frequency responses** — generators vary their output within a defined envelope, to correct deviations in frequency in real-time, as measured by the generators

Frequency performance in the NEM is assessed against the frequency operating standard (FOS). It defines the range of allowable frequencies for the power system under different conditions, including normal operation and following contingencies, and is reviewed and updated periodically by the Panel.

Uncontrolled changes in frequency can cause cascading failures leading to major supply disruptions or black system events. To protect against this, it is important there are sufficient measures in place to provide frequency control.

Under the NER, AEMO must keep the power system stable and securely operating at a frequency in line with the NER's power system security requirements set out in the FOS.[70] Where frequency deviates from 50 Hz, there are acceptable limits defined for different scenarios.

Figure 4.5: NEM frequency bands

COLUMN 1	COLUMN 2		COLUMN 3		COLUMN 4
	NORMAL (HZ)		ISLAND (HZ)		SUPPLY SCARCITY (HZ)
	MAINLAND	TASMANIA	MAINLAND	TASMANIA	MAINLAND[1]
normal operating frequency band	49.85 – 50.15		49.5 – 50.5	49.0 – 51.0	49.5 – 50.5
normal operating frequency excursion band	49.75 – 50.25		49.5 – 50.5	49.0 – 51.0	49.5 – 50.5
operational frequency tolerance band	49.0 – 51.0	48.0 – 52.0	49.0 – 51.0	48.0 – 52.0	48.0 – 52.0
extreme frequency excursion tolerance limit	47.0 – 52.0	47.0 – 55.0	47.0 – 52.0	47.0 – 55.0	47.0 – 52.0

Source: Reliability Panel, *Frequency Operating Standard*

Note: The Reliability Panel has not determined separate frequency bands for periods of supply scarcity in Tasmania. Where a state of supply scarcity exists for the Tasmanian power system, the frequency bands set out in the 'normal' column apply for an intact power system, and the frequency bands set out in the 'island' column apply for an island with the Tasmanian power system.

The FOS also provides that in the absence of a contingency event, AEMO should maintain system frequency within the applicable normal operating excursion band and should not exceed the applicable normal operating band for more than five minutes on any occasion, and not for more than 1% of the time over any 30-day period. AEMO calculates the

70 NER clause 4.4.1

percentage of time spent inside the normal operating frequency band on a daily rolling average.

Mandatory primary frequency response introduced

On 26 March 2020, the AEMC made a final rule to require all scheduled and semi-scheduled generators in the NEM to support the secure operation of the power system by responding automatically to changes in power system frequency.[71]

Following the AEMC's determination, mandatory primary frequency response (PFR) was rolled out across NEM generators in three tranches. This is detailed in Table 4.1, below.

Table 4.1: Mandatory primary frequency response implementation timeline

TRANCHE	MEMBERS	CAPACITY (APPROX.)	IMPLEMENTATION
1	DUIDs > 200 MW	35.6 GW	Sep-20
2	DUIDs 80 - 200 MW	17.4 GW	Mar-21
3	DUIDs < 80 MW	5.1 GW	Jun-21

The implementation roll-out of mandatory PFR is ongoing, but the majority of the NEM generation fleet implemented PFR in the second quarter of 2020. The result of this change was a vast improvement in the frequency performance of the NEM across regions. This is discussed in the following section.

The AEMC also noted in its final determination that mandatory PFR in and of itself will not be sufficient to ensure adequate frequency outcomes. Therefore, the Commission is considering a rule change request that will put in place incentives to further reward and encourage PFR.[72] The draft rule specifies that mandatory PFR will be enduring for all scheduled and semi-scheduled generators and introduces frequency performance payments to incentive generators to operate their plant in a way that helps control power system frequency. The final determination for this rule change is currently due to be published in July 2022.

Performance against the Frequency Operating Standard in 2020-21

Frequency performance in the NEM saw a marked improvement in both the mainland and Tasmania in 2020-21. This improvement occurred in the September – October 2020 period and coincided with the implementation of mandatory PFR to the first tranche of generating units.

Prior to the rollout frequency performance was typical of recent years, being noticeably worse during the shoulder period due to the smaller number of units in operation.

71 For more detail on the rule change see the project page — https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response

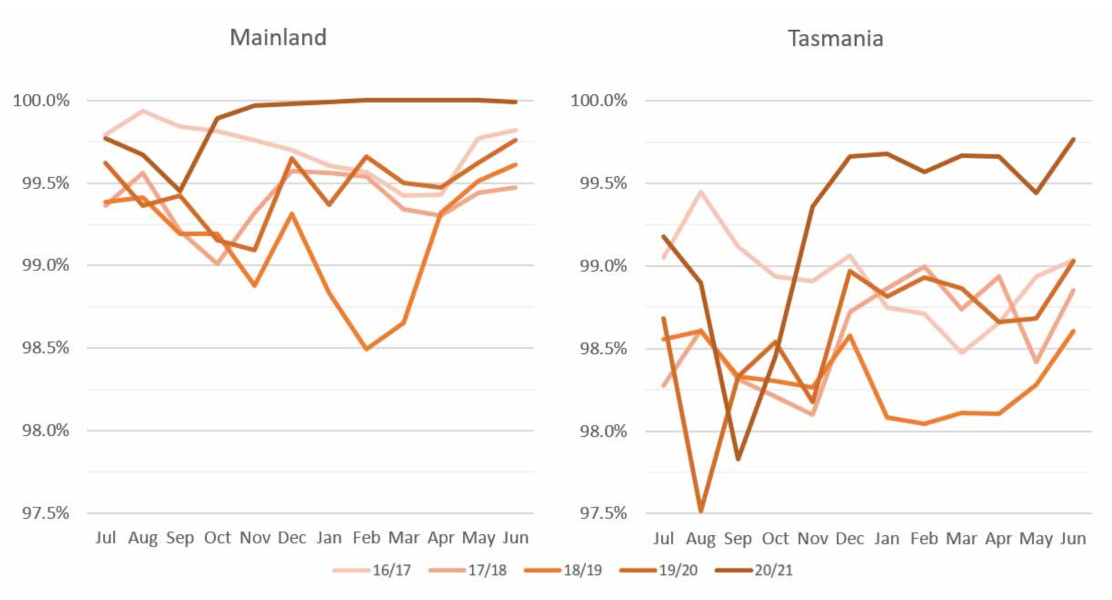
72 For more information see the *Primary frequency response incentive arrangements* project page — https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements

Following the rollout:

- Mainland frequency remained in the normal operating frequency band (NOFB) almost 100% of the time
- Frequency in Tasmania remained in the NOFB around 99.5% of time, an improvement from less than 99% the period before

As evident in Figure 4.6 below, the improvement in frequency control in 2020-21 far exceeded any other improvement from the last five years. Notably, Q1 2021 was the first time since Q4 2015 that frequency remained in the NOFB more than 99% of the time in both the mainland and Tasmania.

Figure 4.6: Proportion of time in the normal operating frequency band



Source: AEMO

Additional to the time spent outside the NOFB, AEMO also reports on the number of times the FOS is exceeded. The results for 2020-21 are shown in Table 4.1.

Table 4.2: Frequency operating standard exceedance 2020-21

QUARTER	TIMES FOS EXCEEDED	
	Mainland	Tasmania
2020 Q3	5	55
2020 Q4	0	38
2021 Q1	0	28
2021 Q2	0	14

Source: AEMO Frequency and time error monitoring

The Panel notes:

- The FOS was exceeded five times on the mainland in Q3 2020, but not again for the remainder of 2020-21.
- The FOS was exceeded 135 times in Tasmania through 2020-21, however, the exceedances per quarter trended down through the year.
- The higher number of FOS exceedances in Tasmania highlights the inherent nature of the smaller power system that is not AC-interconnected.
- The general improvement in FOS exceedance is due to the implementation rollout of mandatory PFR.

4.2.5 System services

System ancillary services are used by AEMO to manage the power system safely, securely, and reliably. These services maintain key technical characteristics of the system, including standards for frequency, voltage, network loading and system restart processes.

AEMO operates eight separate markets for the delivery of FCAS, and purchases network support control ancillary services (NSCAS) and SRAS under agreements with service providers. Payments for ancillary services include payments for availability and delivery of these services.

As the system continues its transition toward higher penetrations of IBR, the challenge of defining some services that contribute to grid security has emerged. Historically, these services have been provided by synchronous generators as a by-product of energy production and are currently unable to be defined in a discrete manner. Instead, AEMO has been able to identify and develop specific configurations of network and generating assets in the power system that are known to result in secure dispatch that must be maintained at all times. At present this is accomplished using directions during periods when some of the units in these secure configurations would otherwise de-commit for economic reasons. There is currently a rule change under consideration that is looking at alternative approaches to ensuring these services are efficiently valued.[73]

FCAS Markets

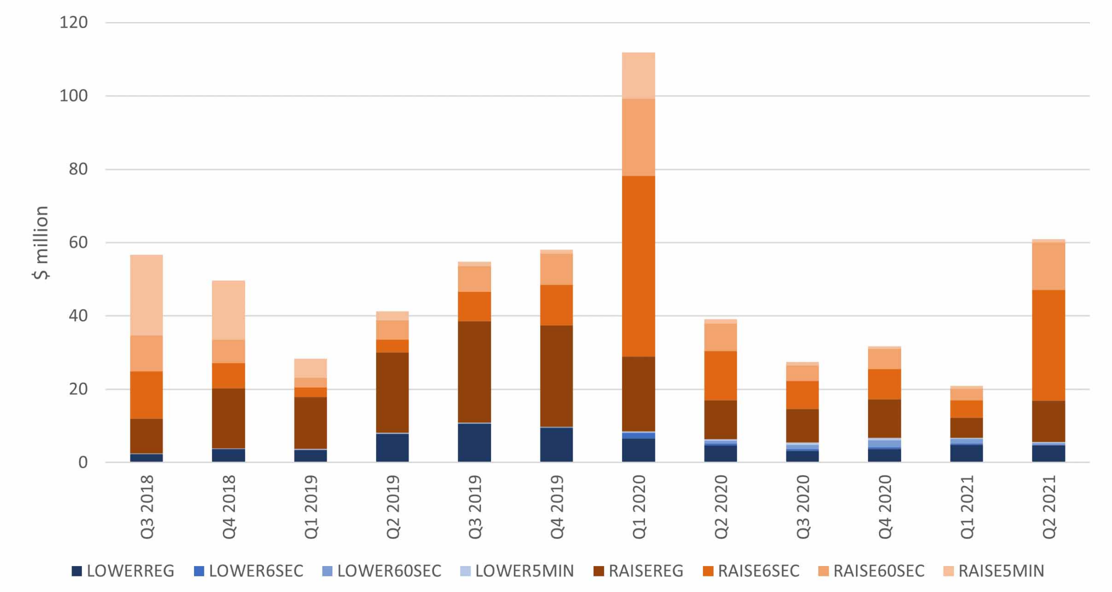
FCAS services are used to raise system frequency if it has fallen (by increasing generation or reducing load) and to lower system frequency if it has risen (by decreasing generation or increasing load). FCAS are intended to work together to maintain a steady frequency during normal operation, and to stabilise and restore the frequency by reacting quickly and smoothly to contingency events that cause frequency deviations.

The AER monitors FCAS prices to understand the impact that the use of these services has on the total cost of running the power system. Overall, FCAS costs were $140.9 million in 2020-21, down from $263.8 million in 2019-20. Raise services continued to represent the majority of FCAS costs in 2020-21, which has historically been the case. Q2 2021 saw the

73 For more information see the *Operational security mechanism project page* — https://www.aemc.gov.au/rule-changes/operational-security-mechanism

highest costs for 2020-21 resulting from local FCAS requirements in Queensland due to upgrades on the QNI interconnector. This can be seen in Figure 4.7, below.

Figure 4.7: Global NEM FCAS costs by quarter

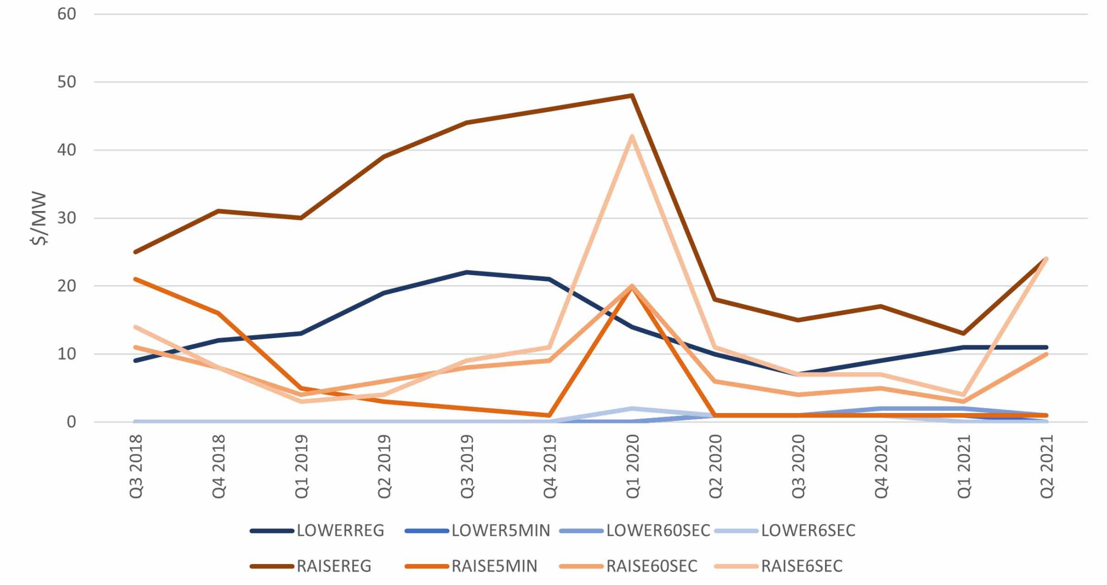


Source: AER

Upon analysis of FCAS prices in Figure 4.7 for 2020-21, the Panel notes that:

- Raise regulation FCAS prices are down significantly from 2019-20, averaging $17.25/MW through 2020-21, down from $39/MW in the previous period
- Lower regulation prices are down, averaging $9.50/MW in 2020-21, compared to $16.75/MW in 2019-20
- Contingency raise prices are similar for 2020-21 to the previous period, excluding Q1 2020 and Q2 2021 as outlier quarters with outside factors influencing FCAS prices.
- In Q2 2021 contingency raise prices were significantly higher than other quarters. This was driven by a combination of low coal unit availability and localised requirements in Queensland, mentioned above.
- Contingency lower prices remain near zero, reflecting the low cost of supplying it for most generating units

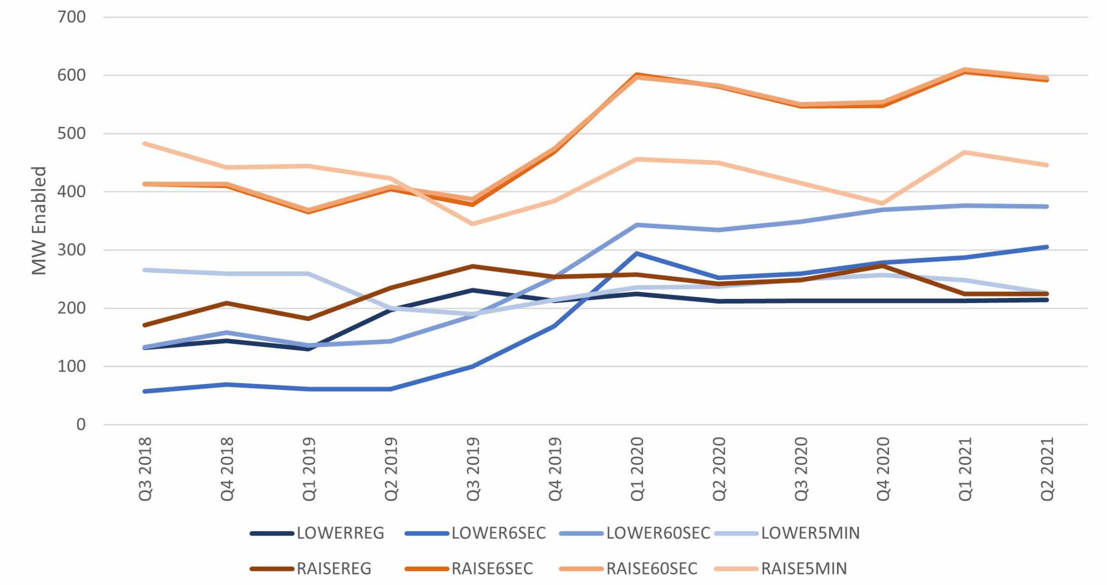
Figure 4.8: NEM FCAS prices by quarter



Source: AER

While there were some changes throughout 2020-21 in the volume of FCAS services procured due to varying power system operating conditions, the variation in most services was relatively small. This is illustrated in Figure 4.9, below.

Figure 4.9: NEM FCAS enablement



Source: AER

System restart ancillary services

SRAS enable the recovery of the power system following a major disturbance, where large parts of the power system have collapsed to a "black system" condition. SRAS is currently provided by generators with the capability to start or remain in service without electricity being provided from the grid. Once an SRAS provider has restarted its own plant, it provides energy to restart other generators and commence the processes required for system restoration. There is an additional cost involved to equip generating plant with this capability and not all generators have it.

The Panel is responsible for determining the system restart standard, which specifies the level of supply restoration for which AEMO is to procure system restart services. The system restart standard specifies the parameters for restoring generation and transmission system operations after a major supply disruption including a black system event. The parameters included in this standard are:

- The maximum time in which a specified level of generation capability must be restored in each sub-network.
- The aggregate level of reliability of restart services in each sub-network, that is, the overall reliability of the SRAS procured for the sub-network rather than for any individual source of SRAS.

AEMO must use reasonable endeavours to acquire sufficient SRAS for each defined electrical sub-network to meet the requirements of the system restart standard. The NER sets out a framework for how the restoration of the system should be managed. Careful planning and clear communication between these various parties is critical to the effective restoration of supply to customers.

The system restart standard applicable to the reporting period was determined by the Panel in January 2021 following consultation with energy users, industry, jurisdictional system security coordinators and state and territory governments, and came into effect on 28 January 2021. The standard was updated following AEMO's decision to combine the existing North and South Queensland sub-networks into a single sub-network for the entire Queensland region. The Panel's final determination includes revised Standard settings for restoration level, restoration timeframe, and aggregate reliability for a combined Queensland sub-network.

Under the standard:

- The level and time components are tailored for each electrical sub-network to reflect the speed at which the generation can be restored, the characteristics of the transmission network and the economic circumstances that apply to the sub-network
- Costs of SRAS are minimised by specifying the minimum level of generation and transmission capacity to be restored by SRAS in each sub-network in accordance with a detailed economic assessment of procuring different levels of SRAS
- The aggregate reliability of the SRAS procured for each electrical sub-network is included. This requirement better specifies the performance of the procured SRAS, and includes a

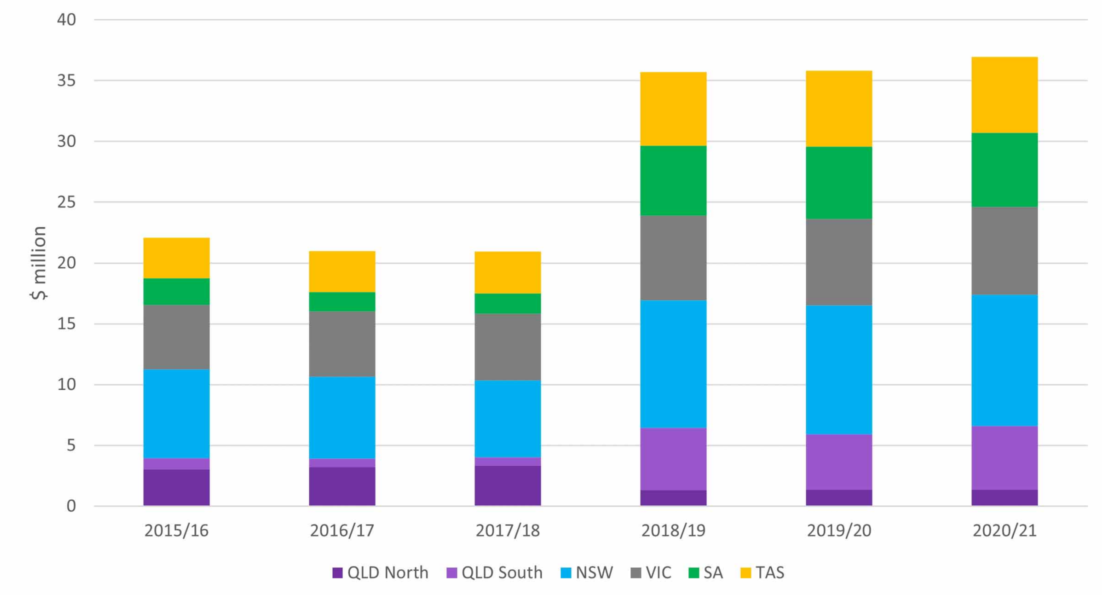
requirement for AEMO to consider the reliability and damage to the transmission network following a major supply disruption when it calculates aggregate reliability.

For 2020-21, AEMO procured two SRAS contracts per sub-network, for a total of 12 contracts. The sub-networks are:

- Queensland North
- Queensland South
- NSW
- Victoria
- SA
- Tasmania

The total cost of SRAS in 2020-21 was $36.9 million, a small increase from the previous period resulting from inflation. Costs are expected to decrease in the 2021-22 period due to the restructuring of SRAS regions and a new set of contracts beginning 1 Jul 2021.[74]

Figure 4.10: SRAS costs by sub-network



Source: AEMO

The Panel notes that in April 2020, the AEMC made a final rule to enhance the frameworks for system restart and restoration.[75] These changes:

- expanded the definitions of SRAS and black start capability to allow AEMO to procure the services needed to effectively and promptly restore supply to consumers

74 For more information see AEMO NMAS annual summary — https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/ancillary-services-data/non-market-ancillary-services-annual-summary

75 For more information see the rule change project page — https://www.aemc.gov.au/rule-changes/system-restart-services-standards-and-testing

- clarify that AEMO can take overall costs into account when procuring SRAS (including both short-term and long-term costs)
- establish a transparent framework for the physical testing of system restart paths
- clarify the roles of the different parties involved in system restoration and the communication processes they must follow with respect to SRAS

Following this rule change, the Panel determined an updated system restart standard. The updated framework is expected to improve the security and resilience of the power system and reduce costs for consumers over the long term.

Network support and control ancillary services

NSCAS are non-market ancillary services that may be procured by AEMO or TNSPs to maintain power system security and reliability and to maintain or increase the power transfer capability of the transmission network. AEMO is required to assess NSCAS needs in the NEM for the upcoming five-year period. When AEMO identifies an NSCAS gap, the National Electricity Rules give TNSPs the primary responsibility for having arrangements in place to address the gap. AEMO will be required to acquire NSCAS only to ensure power system security and reliability if the NSCAS gaps remain unmet after TNSP's attempt to procure services.

AEMO did not procure any NSCAS contracts in its role as the market operator in 2020-21. NSCAS costs for AEMO as the market operator were accordingly $0 in 2020-21. AEMO has not forecast the need to procure NSCAS contracts in its role as the market operator in 2021-22.

The Panel notes that AEMO updated its NSCAS procedures in September 2020.[76] This update amended the NSCAS description and quantity procedure. The NSCAS description was updated to change the types of NSCAS to reflect the NSCAS needs. Previously, NSCAS types are classified according to electrical phenomena. The procedures will now classify NSCAS types according to which of the two NSCAS needs the service would primarily address. The new types are:

- **Reliability and Security Ancillary Services (RSAS)** – procured to assist AEMO to operate the NEM within a secure state and the Reliability Standards. This service will exclude any services excluded by the rules that have existing frameworks.
- **Market Benefit Ancillary Services (MBAS)** – acquired to increase the power transfer capability of the transmission network, to maximise the present value of economic benefit to all those who produce, consumer or transport electricity in the market. The identification of the top binding constraint and/or projected top binding future constraints would be assessed to determine if there is an identified need to alleviate these constraints.

The NSCAS quantity procedure updates included:

76 https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/ncas/nscas-final-report-and-determination.pdf

- The ability to restore the network to a secure operating state within 30 minutes in RSAS assessments
- The assessment of forward-looking constraints in MBAS studies, which can be proposed by participants along with viable, technology agnostic solutions
- Improved collaboration with TNSPs at the start and finish of the quantity determination process, to discuss inputs and assumptions and later study results.

These changes became effective on 1 October 2020. The Panel notes that these changes may have an impact on NSCAS procurement in the future.

4.2.6 Market notices

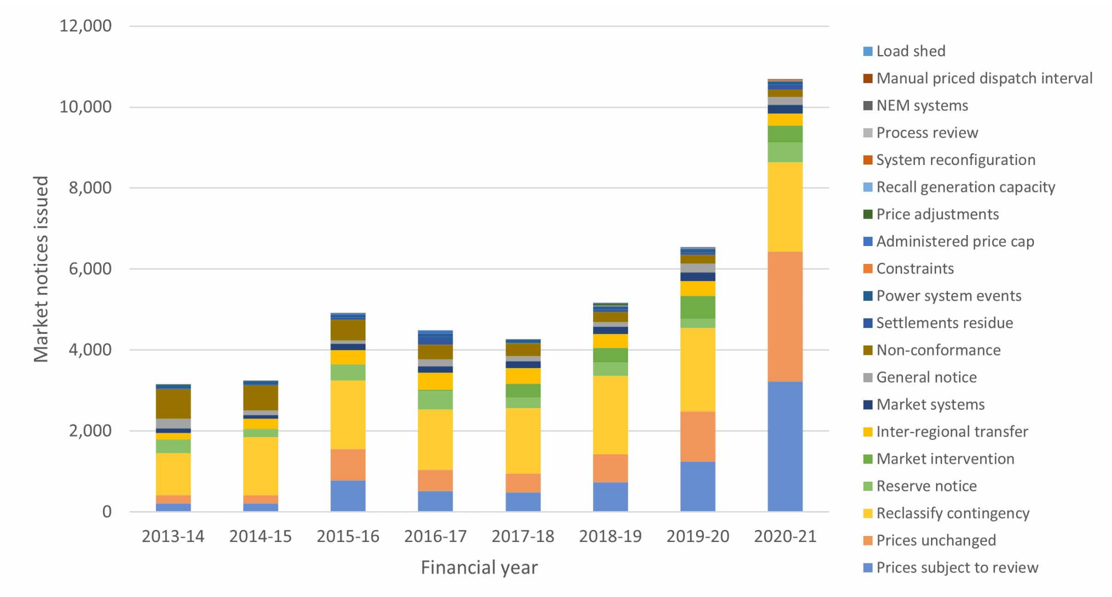
AEMO issues market notices to communicate to participants events that impact the market, including interventions, reserves notices and power system events.

The upward trend in market notices issued by AEMO continued in 2020-21 with 10,681, an increase from 6,539 in 2019-20. This was driven by a large increase in prices subject to review (+1,973) and prices unchanged (+1,978). These notices are generated when AEMO is required to review the prices of a dispatch interval, which occurs when interconnector flows change by an amount greater than a defined threshold between two dispatch intervals.[77] Another driver of this increase was an increase in reserve notices (+253), which are issued for forecast and actual lack of reserve events.

These increases reflect the continuing increase in complexity of managing the NEM in a secure state.

77 AEMO, *Automated procedures for identifying intervals subject to review*, https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Policy_and_Process/2017/Automated-Procedures-For-Identifying-Dispatch-Intervals-Subject-to-Review.docx

Figure 4.11: Market notices issued



Source: AEMO

4.3 Key changes to security frameworks in 2020-21

As the way energy is generated and consumed in the NEM continues to evolve, the security frameworks must also evolve to ensure a secure system now, and into the future. The two changes to NEM security frameworks in 2020-21 were:

- *Implementing a general power system risk review* final rule
- *Prioritising arrangements for system security during market suspension* final determination

Several other changes were made soon after the end of the reporting period or are currently underway. The following sections describe these changes in more detail.

4.3.1 Implementing a general power system risk review

On 3 June 2021 the AEMC made a final rule on *Implementing a general power system risk review*.[78] This rule change replaces AEMO's existing power system frequency risk review (PSFRR) with a broader general power system risk review (GPSRR). The final rule requires AEMO to review, in respect of a prioritised set of risks determined by AEMO:

- non-credible contingency events, the occurrence of which AEMO expects would be likely to involve uncontrolled increases or decreases in frequency, alone or in combination, leading to cascading outages, or major supply disruptions

78 For more information on the *Implementing a general power system risk review* rule change, see project page — https://www.aemc.gov.au/rule-changes/implementing-general-power-system-risk-review

- other events and conditions (including contingency events) the occurrence of which AEMO expects, alone or in combination, would be likely to lead to cascading outages, or major supply disruptions.

This change is expected to increase the transparency of emerging system security risks that may need to be managed. It will help AEMO, NSPs and market participants better understand the nature of new risks and monitor these over time.

AEMO is to complete the first GPSRR by 31 July 2023, while the new obligations on NSPs to consider emergency control schemes and protection systems in their annual planning review come into force on 10 January 2022.

4.3.2 Prioritising arrangements for system security during market suspension

On 17 June 2021, the AEMC made a final determination to make no rule in response to a proposal seeking to explicitly set out the applicability of the Rules during periods of market suspension with the aim of providing AEMO with the appropriate flexibility to prioritise arrangements for system security during such periods.

No rule was made as the Commission considered that the Rules currently set out clearly what arrangements apply during a period of market suspension, and that attempting to further clarify this may create uncertainty or confusion in relation to the interpretation of the Rules.

4.3.3 Fast frequency response market ancillary service

On 15 July 2021, the Commission made a final rule on the *Fast frequency response market ancillary service* rule change request.[79] The transition away from a system dominated by large, synchronous, thermal generation units is resulting in a reduction in inertia in the system. At lower operating levels of inertia, increased volumes or faster-acting frequency control services are required to arrest and stabilise the system frequency within the existing system operating standards. This rule introduces two new ancillary service categories to address this need: *very fast raise* and *very fast lower*. The rule commences in two stages:

- 19 December 2022 — AEMO must revise the market ancillary services specification to set out the description and performance parameters for the very fast raise and lower services
- 9 October 2023 — the fast frequency response market ancillary service arrangements commence

4.3.4 Efficient management of system strength on the power system

On 21 October 2021, the AEMC made a final rule on *Efficient management of system strength on the power system*.[80] This rule evolves the existing system strength provision framework, that was reactive in nature, to a more proactive framework. The evolved framework requires TNSPs to procure system strength services to meet a forecast produced by AEMO. To coordinate demand with supply, connecting generators can choose to pay a

79 For more information on the *Fast frequency response market ancillary service* rule change, see project page — https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service

80 For more information on the *Efficient management of system strength on the power system* rule change, see project page — https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system

charge representing the marginal cost of system strength they demand, or to remediate their own impact. The rule commences in two stages:

- 1 Dec 2022 — The TNSP system strength planning and procurement (supply side) provisions commence.
- 15 March 2023 — The system strength mitigation requirement (coordination) and new access standards (demand side) for connecting generators commence.

4.3.5 Enhancing operational resilience in relation to indistinct events

On 3 March 2021 the AEMC made a final rule to expand the contingency event framework to allow AEMO to manage the risk of events that are uncertain, unpredictable and can impact multiple power system elements (indistinct events).[81]

The final rule provides AEMO with the flexibility to manage threats to power system security which are unpredictable and uncertain and can impact multiple power system elements (indistinct events), while minimising costs to consumers. It is important that AEMO can keep the system secure as abnormal conditions become increasingly frequent as the sector transitions and the climate changes. The Panel has been staying updated on the progress of this rule change, given the relevance to its work program.

4.3.6 Operational security mechanism

The *Operational security mechanism* (OSM) rule change is considering options to implement a mechanism to value, procure, and schedule system security services, which are critical to maintaining overall power system security and reliability but are not valued in current market arrangements.[82]

The draft determination for this rule change is currently scheduled for publication on 30 June 2022.

4.3.7 Operating reserves and ramping services

The AEMC is currently considering two rule change requests that propose additional services in the NEM to help respond to rapid, unexpected changes in supply and demand caused by the increasing penetration of VRE. A draft determination for each rule change is scheduled for publication on 30 June 2023.[83] The publication date was extended to allow the Commission to take into account further information as the energy system and the frameworks that govern it rapidly evolve, including technical design information from AEMO, data on the impacts of five-minute settlement on the market and the development and detailed design of various post-2025 market design reforms by the ESB.

81 For more information on the *Enhancing operational resilience in relation to indistinct events* rule change, see project page — https://www.aemc.gov.au/rule-changes/enhancing-operational-resilience-relation-indistinct-events

82 For more information on the *Operational security mechanism* rule change, see project page – https://www.aemc.gov.au/rule-changes/operational-security-mechanism

83 For more information on the reserve services rule changes and the draft determination extension, see https://www.aemc.gov.au/news-centre/media-releases/extension-two-reserve-services-rule-changes

4.3.8 2022 Frequency operating standard review

On 28 April 2022 the Panel published an issues paper to initiate its 2022 FOS review.[84] The frequency requirements that AEMO must meet are set out in the FOS, which is defined in the NER and determined by the Reliability Panel.[85] One of AEMO's key obligations under the NER is to maintain the power system in a secure operating state. This includes keeping system frequency within the normal operating frequency band that is set out in the FOS. Several key changes have occurred recently in the way frequency is managed in the NEM, necessitating a review of both the form and level of the FOS. The issues paper includes a discussion of the following issues:

- Frequency performance during normal operation
- A system standard for rate of change of frequency
- Settings in the FOS that apply for contingency events
- The limit in the FOS for accumulated time error

The FOS review draft determination is scheduled for publication at the end of 2022.

4.3.9 Primary frequency response incentive arrangements

On 16 September 2021 the AEMC made a draft rule on *Primary frequency response incentive arrangements* for enduring arrangements to support the control of power system frequency and to incentivise plant behaviour that reduces the overall costs to consumers of frequency control. The draft rule confirms the mandatory PFR arrangements as enduring beyond the sunset date on 4 June 2023, while also introducing incentive payments for market participants to operate their plant in a way that helps control power system frequency. It also makes improvements to regulation FCAS cost recovery and imposes additional reporting requirements on AEMO and the AER in relation to frequency performance and the costs of frequency performance payments.

A final determination for this project is currently scheduled for July 2022.

84 For more information on the 2022 FOS review, see the project page

85 NER clause 8.8.3

5 SAFETY

This section covers the Panel's assessment of safety of the power system in 2020-21. The Panel notes that its role regarding safety for the purposes of this report relates primarily to the operation of assets and equipment within their technical limits.

This chapter sets out:

- Outline and definition of power safety for the purposes of this review,
- Safety performance in 2019-20
- Developments around system safety.

5.1 What power system safety is in the context of this review

The safety of the national electricity system can be understood to mean that:

- The transmission and distribution systems and the generation and other facilities connected to them are safe from damage
- The transmission and distributions and generation and other facilities connected to them are not a source of injury and danger.

5.2 Safety in the power system

The National Electricity Law and NER set out the functions and power of the Reliability Panel, which include a function to monitor, review, and report on safety in accordance with the rules. However, the NER do not specify additional requirements in relation to safety performance reporting.[86] The Panel also has the function of advising in relation to the safety of the national electricity system at the request of the AEMC. The terms of reference provided by the AEMC request that the Panel provide advice in relation to the safety, security, and reliability of the power system. In accordance with the terms of reference issued by the AEMC, for the purposes of the safety assessment, the Panel has considered the maintenance of power system security within the relevant standards and technical limits.

5.3 How a safe power system is delivered

The safety of the power system, and associated equipment, power system personnel and the public is covered in general terms under the NEL.[87] There is no national safety regulator specifically for electricity. Instead, state and territory legislation governs safety generally, including the safe supply of electricity and broader safety requirements associated with electricity use in households and businesses. Each jurisdiction has its own approach to setting out obligations relating to safety in the power system and enforcing these obligations. These arrangements provide the specific health and safety obligations and responsibilities relating

86 Instead, the functions of the Reliability Panel under clause 8.8.1 of the NER provide that the functions of the Panel is to, among other things, monitor, review and report on the performance of the market in terms of reliability of the power system, report to the AEMC and jurisdictions on overall power system reliability matters and undertake a number of functions relating to the security of the power system. The reliability and security focus of the Panel under the NER is reflected in the scope of the annual market performance review that the Panel is required to undertake under clause 8.8.3(b) of the NER.

87 Section 38(2)(b) of the NEL.

to the safety of personnel and the public that network service providers and other market participants must comply with. The power system is also designed with extensive safety systems to provide the protection of the system itself, workers, and the public. Network constraints, developed from TNSP limit advice, are used by AEMO in the NEM dispatch process to make sure that plant remains within rating and power transfers remain within stability limits so that the power system is in a secure operating state. Should AEMO not be able to manage secure and satisfactory limits through the use of network constraints, the following options can be used, potentially in combination. These options are listed in AEMO's suggested priority order and may not all be available under all circumstances:

- Revision to generator thermal ratings.
- Revision to power system limits.
- Implement plan agreed between AEMO and relevant registered participants (e.g. Contingency plan, Network Support Agreement (NSA)).
- Reconfigure network.
- Dispatch or activation of reserve contracts to address a power system security event.
- System security direction or instruction issued under clause 4.8.9 of the rules
- If sufficient raise FCAS are unavailable, use system security constraints to reduce the size of the largest generation at risk. If sufficient lower FCAS are unavailable, issue a direction under section 116 of the NEL for a reduction in the size of the largest load at risk.
- Instruct involuntary load shedding.

5.4 Safety performance of the power system in 2020-21

The Panel has reviewed AEMO's power system incident reports and consulted with AEMO to understand if there were any instances where actions to maintain the power system within relevant standards and technical limits resulted in technical safety issues. The Panel is not aware of any incidents during the 2020-21 reporting period where AEMO's management of power system security has resulted in a safety issue with respect to maintaining the system within relevant standards and technical limits.

The Panel also notes that there were no instances in 2020-21 where AEMO issued a direction and the directed participant did not comply on the grounds that complying with the direction would be a hazard to public safety, or materially risk damaging equipment or contravene any other law.

While AEMO's management of the power system did not result in any technical safety issues, the incident report it produced in response to the Callide C Unit 4 incident on 25 May 2021 identified a number of potential opportunities to improve operation and processes with respect to power system safety.[88]

88 For more detail on these opportunities, see AEMO's report *Trip of multiple generators and lines in Central Queensland and associated under-frequency load shedding on 25 May 2021* - https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2021/final-report-trip-of-multiple-generators-and-lines-in-qld-and-under-frequency-load-shedding.pdf

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

GLOSSARY

Available capacity	The total MW capacity available for dispatch by a scheduled generating unit or scheduled load (i.e. maximum plant availability) or, in relation to a specified price band, the MW capacity within that price band available for dispatch (i.e. availability at each price band).
Busbar	A busbar is an electrical conductor in the transmission system that is maintained at a specific voltage. It is capable of carrying a high current and is normally used to make a common connection between several circuits within the transmission system. The rules define busbar as 'a common connection point in a power station switchyard or a transmission network substation'.
Cascading outage	The occurrence of a succession of outages, each of which is initiated by conditions (e.g. instability or overloading) arising or made worse as a result of the event preceding it.
Contingency events	These are events that affect the power system's operation, such as the failure or removal from operational service of a generating unit or transmission element. There are several categories of contingency event, as described below: • credible contingency event is a contingency event whose occurrence is considered "reasonably possible" in the circumstances. For example: the unexpected disconnection or unplanned reduction in capacity of one operating generating unit; or the unexpected disconnection of one major item of transmission plant • non-credible contingency event is a contingency event whose occurrence is not considered "reasonably possible" in the circumstances. Typically a non-credible contingency event involves simultaneous multiple disruptions, such

	as the failure of several generating units at the same time.
Customer average interruption duration index (CAIDI)	The sum of the duration of each sustained customer interruption (in minutes) divided by the total number of sustained customer interruptions (SAIDI divided by SAIFI). CAIDI excludes momentary interruptions (one minute or less duration).
Directions	Under s. 116 of the NEL, AEMO may issue directions. Section 116 directions may include directions as issued under clause 4.8.9 of the NER (e.g. directing a scheduled generator to increase output) or clause 4.8.9 instructions (e.g. instructing a network service provider to load shed). AEMO directs or instructs participants to take action to maintain or re-establish the power system to a secure operating state, a satisfactory operating state, or a reliable operating state.
Dispatch	The act of initiating or enabling all or part of the response specified in a dispatch bid, dispatch offer or market ancillary service offer in respect of a scheduled generating unit, a scheduled load, a scheduled network service, an ancillary service generating unit or an ancillary service load in accordance with NER rule 3.8, or a direction or operation of capacity the subject of a reserve contract as appropriate.
Distribution network	The apparatus, equipment, plant and buildings (including the connection assets) used to convey and control the conveyance of electricity to consumers from the network and which is not a transmission network.
Distribution network service provider (DNSP)	A person who engages in the activity of owning, controlling, or operating a distribution network.
Frequency control ancillary services (FCAS)	Those ancillary services concerned with balancing, over short intervals, the power supplied by generators with the power consumed by loads (throughout the power system). Imbalances cause the frequency to deviate from 50 Hz.

Interconnector	A transmission line or group of transmission lines that connect the transmission networks in adjacent regions.
Jurisdictional planning body	The transmission network service provider responsible for planning a NEM jurisdiction's transmission network.
Lack of reserve	This is when reserves are below specified reporting levels.
Load	A connection point (or defined set of connection points) at which electrical power is delivered, or the amount of electrical power delivered at a defined instant at a connection point (or aggregated over a defined set of connection points).
Load event	In the context of frequency control ancillary services, a load event: involves a disconnection or a sudden reduction in the amount of power consumed at a connection point and results in an overall excess of supply.
Load shedding	Reducing or disconnecting load from the power system either by automatic control systems or under instructions from AEMO. Load shedding will cause interruptions to some energy consumers' supplies.
Low reserve condition (LRC)	This is when reserves are below the minimum reserve level.
Momentary average interruption frequency index (MAIFI)	The total number of customer interruptions of one minute or less duration, divided by the total number of distribution customers.
Medium term projected assessment of system (MT PASA) (also see ST PASA)	A comprehensive programme of information collection, analysis and disclosure of medium-term power system reliability prospects. This assessment covers a period of 24 months and enables market participants to make decisions concerning supply, demand and outages. It must be issued weekly by AEMO.
Minimum reserve level (MRL)	The minimum reserve margin calculated by AEMO to meet the reliability standard.
Ministerial Council on Energy (MCE)	The MCE is the national policy and governance body for the Australian energy market, including for electricity and gas, as

	outlined in the COAG Australian Energy Market Agreement of 30 June 2004.
National Electricity Code	The National Electricity Code was replaced by the National Electricity Rules on 1 July 2005.
National electricity market (NEM)	The NEM is a wholesale exchange for the supply of electricity to retailers and consumers. It commenced on 13 December 1998, and now includes Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia, and Tasmania.
National Electricity Law (NEL)	The NEL is contained in a schedule to the National Electricity (South Australia) Act 1996. The NEL is applied as law in each participating jurisdiction of the NEM by the application statutes.
National Electricity Rules (NER)	The NER came into effect on 1 July 2005, replacing the National Electricity Code.
Network	The apparatus, equipment and buildings used to convey and control the conveyance of electricity. This applies to both transmission and distribution networks.
Network capability	The capability of a network or part of a network to transfer electricity from one location to another.
Network control ancillary services (NCAS)	Ancillary services concerned with maintaining and extending the operational efficiency and capability of the network within secure operating limits.
Network event	In the context of frequency control ancillary services, the tripping of a network resulting in a generation event or load event.
Network service providers	An entity that operates as either a transmission network service provider (TNSP) or a distribution network service provider (DNSP).
Network services	The services (provided by a TNSP or DNSP) associated with conveying electricity and which also include entry, exit, and use-of-system services.
Operating state	The operating state of the power system is defined as satisfactory, secure or reliable, as described below.

	The power system is in a **satisfactory** operating state when: • it is operating within its technical limits (i.e. frequency, voltage, current etc are within the relevant standards and ratings) • the severity of any potential fault is within the capability of circuit breakers to disconnect the faulted circuit or equipment. The power system is in a **secure** operating state when: • it is in a satisfactory operating state • it will return to a satisfactory operating state following a single credible contingency event. The power system is in a **reliable** operating state when: • AEMO has not disconnected, and does not expect to disconnect, any points of load connection under NER clause 4.8.9 • no load shedding is occurring or expected to occur anywhere on the power system under NER clause 4.8.9 • in AEMO's reasonable opinion the levels of short term and medium term capacity reserves available to the power system are at least equal to the required levels determined in accordance with the power system security and reliability standards.
Participant	An entity that participates in the national electricity market.
Plant capability	The maximum MW output which an item of electrical equipment is capable of achieving for a given period.
Power system reliability	The measure of the power system's ability to supply adequate power to satisfy demand, allowing for unplanned losses of generation capacity.
Power system security	The safe scheduling, operation and control of the power system on a continuous basis.

Probability of exceedance (POE)	POE relates to the weather/temperature dependence of the maximum demand in a region. A detailed description is given in the AEMO ESOO.
Reliable operating state	Refer to operating state.
Reliability of supply	The likelihood of having sufficient capacity (generation or demand-side response) to meet demand (the consumer load).
Reliability standard	The Reliability Panel's current standard for reliability is that there should be sufficient generation and bulk transmission capacity so that the maximum expected unserved energy is 0.002 per cent.
Reserve	The amount of supply (including available generation capability, demand side participation and interconnector capability) in excess of the demand forecast for a particular period.
Reserve margin	The difference between reserve and the projected demand for electricity, where: Reserve margin = (generation capability + interconnection reserve sharing) – peak demand + demand-side participation.
System average interruption duration index (SAIDI)	The sum of the duration of each sustained customer interruption (in minutes), divided by the total number of distribution customers. SAIDI excludes momentary interruptions (one minute or less duration).
System average interruption frequency index (SAIFI)	The total number of sustained customer interruptions, divided by the total number of distribution customers. SAIFI excludes momentary interruptions (one minute or less duration).
Satisfactory operating state	Refer to operating state.
Scheduled load	A market load which has been classified by AEMO as a scheduled load at the market customer's request. A market customer may submit dispatch bids in relation to scheduled loads.
Secure operating state	Refer to operating state.
Separation event	In the context of frequency control ancillary services, this describes the electrical

	separation of one or more NEM regions from the others, thereby preventing frequency control ancillary services being transferred from one region to another.
Short term projected assessment of system adequacy (ST PASA) (also see MT PASA)	The PASA in respect of the period from two days after the current trading day to the end of the seventh day after the current trading day inclusive in respect of each trading interval in that period.
Spot market	Wholesale trading in electricity is conducted as a spot market. The spot market allows instantaneous matching of supply against demand. The spot market trades from an electricity pool, and is effectively a set of rules and procedures (not a physical location) managed by AEMO (in conjunction with market participants and regulatory agencies) that are set out in the NER.
Supply-demand balance	A calculation of the reserve margin for a given set of demand conditions, which is used to minimise reserve deficits by making use of available interconnector capabilities.
Technical envelope	The power system's technical boundary limits for achieving and maintaining a secure operating state for a given demand and power system scenario.
Transmission network	The high-voltage transmission assets that transport electricity between generators and distribution networks. Transmission networks do not include connection assets, which form part of a transmission system.
Transmission network service provider (TNSP)	An entity that owns operates and/or controls a transmission network.
Unserved energy (USE)	The amount of energy that is required (or demanded) by consumers but which is not supplied due to a shortage of generation or interconnection capacity. Unserved energy does not include interruptions to consumer supply that are caused by outages of local transmission or distribution elements that do not significantly impact the ability to transfer power into a region.

A TERMS OF REFERENCE

A.1 Introduction

These terms of reference are intended to guide the Reliability Panel (the Panel) in its annual market performance review (AMPR). The Australian Energy Market Commission (AEMC) requests that the Panel consider these to be the standing terms of reference for its annual review of the performance of aspects of the market specified under clause 8.8.3(b) of the National Electricity Rules (NER). For clarity, the market that this review relates to is the National Electricity Market (NEM). The purpose, scope and timing for this review are set out below.

A.2 Background

The functions of the Panel are set out in clause 8.8.1 of the NER.

- Under clause 8.8.1(a)(1), the Panel has a role to monitor, review and report on the performance of the market in terms of reliability of the power system.[89]
- Under clause 8.8.1(a)(5), the Panel has a role to report to the AEMC and participating jurisdictions on overall power system reliability matters, power system security and reliability standards and the Australian Energy Market Operator's (AEMO) power to issue directions in connection with maintaining or re-establishing the power system in a reliable operating state. The Panel may also make recommendations on changes to the market or the NER and any other matters which it considers necessary.

Consistent with these functions, clause 8.8.3(b) of the NER requires the Panel to conduct a review of the performance of certain aspects of the market, at least once every financial year and at other such times as the AEMC may request. The Panel must conclude each annual review under this clause by the end of the financial year following the financial year to which the review relates. The Panel must conduct its annual review in terms of:

- reliability of the power system;
- the power system security and reliability standards;
- the system restart standard;
- the guidelines referred to in clause 8.8.1(a)(3);[90]
- the policies and guidelines referred to in clause 8.8.1(a)(4);[91] and
- the guidelines referred to in clause 8.8.1 (a)(9).[92]

89 In performing this function, clause 8.8.1 (b) prohibits the Panel from monitoring, reviewing or reporting on the performance of the market in terms of reliability of distribution networks. However, the panel may collate, consider and report information in relation to the reliability of distribution networks as measured against the relevant standards of each participating jurisdiction, in so far as the reliability of those networks impacts on overall power system reliability

90 The guidelines referred to in clause 8.8.1 (a)(3) govern how AEMO exercises its power to issue directions in connection with maintaining or re-establishing the power system in a reliable operating state.

91 The policies and guidelines referred to in clause 8.8.1 (a)(4) govern how AEMO exercises its power to enter into contracts for the provision of reserves.

92 The guidelines referred to in clause 8.8.1 (a)(9) identify, or provide for the identification of, operating incidents and other incidents that are of significance for the purposes of the definition of "Reviewable operating incident" in clause 4.8.15.

In addition, at the request of the AEMC, the Panel must provide advice in relation to the safety, security and reliability of the national electricity system.[93]

The Panel may, but is not required to, conduct this review in accordance with the Panel review process outlined in clauses 8.8.3(d)-(l) of the NER.

A.3 Purpose of the review

The AMPR provides the Panel with the opportunity to consider specific events that have occurred in the NEM over the previous financial year, and to assess the performance of the power system against various reliability, security and safety measures.

The AEMC requests the Panel to prepare:

1. at least one concise market performance update to communicate key findings for the previous financial year period, or other relevant period determined by the Panel.
2. a written report, to communicate the findings of its full review of the previous financial year, including its observations and commentary on the reliability, security and safety performance of the power system.

The concise market performance update provides an opportunity for the Panel to report on initial findings, update information in a timely manner and to contextualise this update of the power system and market for that chosen period. Among other things, this will allow for more timely information to be communicated to stakeholders and supplements the Panel's engagement with stakeholders.

The written report provides an opportunity for the Panel to consolidate key information related to the performance of the power system and to present its observations and commentary in a single publication for the purpose of informing stakeholders. Among other things, this may assist governments, policy makers and market institutions to monitor the performance of the power system, and to identify the likely need for improvements to the various measures available for delivering reliability, security and safety.

A.4 Scope of the review

The AEMC requests that the Panel:

1. review the performance of the market in terms of reliability, security and safety of the power system; and
2. provide advice in relation to the safety, security and reliability of the power system.

The Panel should have regard to the following matters when conducting its review:

- Overall power system performance

  To provide an overview of the performance of the power system, and where relevant information is available, the Panel should consider performance in terms of reliability and security, and from the perspective of:

93 National Electricity Law s.38(2)(b).

   - the transmission and distribution sectors
   - the generation sector.

  The Panel's review of overall power system performance should include consideration of the impact on end-use customers. For example, customer impact could be measured in terms of the length of time that energy was not supplied to customers due to an incident occurring on the power system.

  The Panel should also consider significant power system incidents ("reviewable operating incidents") which have occurred in the previous year.

  The Panel should also consider general trends in the power system, to the extent possible, such as changes in the generation mix or bulk transmission capability. This should include consideration of historic changes, as well as any forecasts or projections of future changes in the power system.

- Reliability performance of the power system, historic and forecast

  The Panel should review performance against the reliability standard for generation and bulk transmission. This would require consideration of actual observed levels of unserved energy (USE) over the previous financial year, as well as projections and forecasts of expected levels of USE in future years. As such, consideration could be given to actual and forecast supply and demand conditions, by way of providing context and explanation as to the potential causes and drivers of these historic and forecast USE outcomes. This may assist the Panel to form a view on whether any underlying changes to reliability performance have, or are expected to have, occurred.

  The Panel should also consider AEMO's use of the reliability safety net mechanisms over the previous financial year. This includes incidents of, and reasons for, the use of directions and the Reliability and Emergency Reserve Trader (RERT) mechanism. It also includes consideration of the frequency of AEMO's issuance of lack of reserve notices over the previous year.

- Security performance of the power system, historic and forecast

  The Panel should review historic performance of the power system against the relevant technical standards. In particular, the Panel could have regard to: frequency operating standards; voltage limits; interconnector secure line rating limits; system stability; and any other factors that the Panel may consider relevant. The Panel should also consider any projections or forecasts of future power system security performance, and to the extent relevant, provide any context and explanation on the potential causes and drivers of both historic and forecast power system security performance.

- Safety performance of the power system

  Safety of the power system is closely linked to the security of the power system and relates primarily to the operation of assets and equipment within their technical limits. Therefore, for the purposes of the safety assessment the Panel should only consider the maintenance of power system security within the relevant standards and technical limits.

The Panel may also wish to consider the following matters when conducting its review, if it is appropriate to do so:

- A comparison of power system performance against the previous year, and the reasons for any variations.
- A comparison of power system performance between regions, and reasons for any variations.
- The degree of accuracy in forecast and actual data, and reasons for any variations.
- Mechanisms in place for promoting power system performance, and whether they are effective.

The Panel should also have regard to any relevant reviews, reports or other processes being progressed by the other market bodies, or any other agency, that considers or proposes potential market framework changes that will directly impact the NEM power system. The Panel should consider these in its review.

A.5 Process and deliverables

The Panel must notify all registered participants of the commencement of this review and of the indicative timetable for this review. This information is to be published by the AEMC on its website.

The Panel may consider where practicable inviting stakeholders' submissions and/or holding a public meeting, in each case with a reasonable period of notice to stakeholders.

The Panel must send a copy of the market performance update to the AEMC for publication on the AEMC website.

By the end of the financial year following the financial year to which the review relates, the Panel must send a copy of the final report to the AEMC for publication on the AEMC website.

The Panel should consider engaging with key stakeholders during the AMPR for the purposes of coordinating and gathering all relevant information for preparation of the market performance update and the final report. Key stakeholders include the following:

- AEMO.
- The Australian Energy Regulator.
- Transmission network service providers.
- Distribution network service providers.
- Jurisdictional regulatory bodies and governments.

The Panel may also engage more broadly with other external stakeholders including consumer representatives.