AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

# Renewable Integration Study Response to Stakeholder Submissions

**October 2020**

# Important notice

## PURPOSE

This publication sets out the key themes raised in stakeholder written submissions in response to the Renewable Integration Study (RIS) Stage 1 report, published as part of AEMO's responsibilities under section 49(2) of the National Electricity Law. It provides discussion of how these themes have been considered by AEMO and provides an indication of future RIS bodies of work.

This publication has been prepared by AEMO using information available at the time of publication. Information made available after this date may have been included in this publication where practical.

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## VERSION CONTROL

| Version | Release date | Changes |
|---|---|---|
| 1.0 | 15/10/2020 | Initial publication |

# Executive summary

Following release of the Renewable Integration Study (RIS) Stage 1 report on 30 April 2020, AEMO consulted with a wide range of stakeholders, providing information on the methodology, results and recommendations of the study and discussing feedback, concerns, or suggestions regarding the RIS Stage 1 report and priority focus areas for the future.

The purpose of this report is to provide stakeholders with a view of how the key issues raised in written submissions to the RIS Stage 1 report have been considered and an indication of future RIS bodies of work.

Stakeholders were generally positive about the release of the RIS Stage 1 report, with many emphasising the importance of ongoing engagement and the need for a consolidated future roadmap out to 2025.

The feedback received on the RIS Stage 1 report can be broken into seven discrete themes, as shown in Table 1.

AEMO values the input from stakeholders who engaged and provided feedback on the RIS Stage 1, across all stakeholder activities.

AEMO is using feedback from the RIS, and its recent consultation to review its engagement model across the industry[1], to inform the content, format and engagement for subsequent stages of the RIS.

[1] AEMO, Reviewing AEMO's engagement model, consultation page, available at https://aemo.com.au/en/consultations/current-and-closed-consultations/renewing-aemos-engagement-model.

**Table 1 Summary of key themes**

| No. | Theme | Summary of submissions | AEMO response | Report section |
|---|---|---|---|---|
| 1 | Support for the RIS | Support provided for RIS studies and actions. | AEMO thanks stakeholders for engagement and support and looks forward to working with stakeholders in subsequent stages of the RIS. | Section 3.1 |
| 2 | Alignment with AEMO's Integrated System Plan (ISP) | The RIS analysis was based on the 2020 Draft ISP. Stakeholders suggested there may be benefit in reviewing RIS analysis and actions based on the Final ISP. | Change between Draft and Final 2020 ISP did not result in material changes out to 2025 (the study horizon of the RIS). Further, several of the RIS actions were incorporated into the Final 2020 ISP analysis and costing. | Section 3.2 |
| 3 | Assessment of costs and benefits | Stakeholders raised the need for a cost benefit analysis to be performed on the RIS actions. | Assessments of costs and benefits are being pursued via two main avenues:<br>• RIS analysis and recommendations were incorporated and costed where possible in the Final 2020 ISP, including available fault level and system strength mitigation in RES's, provision of inertia and the role of future technologies.<br>• As RIS actions are used to inform Australian Energy Market Commission (AEMC) and Energy Security Board (ESB) processes, these actions will be assessed as part of the extensive cost benefit analysis that is conducted via these existing processes. | Section 3.3 |
| 4 | Emergency distributed PV generation curtailment capability: implementation | Stakeholders acknowledged that the RIS actions were seeking to avoid the implementation of stricter regional hosting capacity limits, however, were concerned about the ramifications of emergency distributed PV generation curtailment. | AEMO understands concerns raised by stakeholders about how emergency DPV generation curtailment capability would be implemented in practice and seeks to reiterate that emergency DPV generation curtailment would be implemented only as a last resort measure to manage power system security during exceedingly rare circumstances, if severe abnormal operational conditions arise and market mechanisms and other available approaches have been exhausted.<br>AEMO is engaging with state governments and the other market bodies on the necessary governance and regulatory arrangements necessary for emergency DPV generation curtailment as a last resort measure for power system security. | Section 3.4 |
| | Emergency distributed PV generation curtailment capability: alternatives | Alternatives suggested included update of complementary technologies (such as batteries, electric vehicles [EVs]), market approaches (such as tariff reform, demand management) and DNSP solutions (using network-controlled load). | AEMO agrees a suite of complementary measures can help manage the supply demand balance during high DPV, low underlying demand periods in the daytime, and reduce the likelihood that emergency DPV curtailment will ever be activated. These alternate measures should be encouraged. AEMO also notes the work currently being done by the ESB to investigate potential barriers and enablers for these solutions. | Section 3.4 |
| | Emergency distributed PV generation curtailment | Stakeholders were concerned that DPV curtailment would be disproportionately costly to DPV households and that a cost-benefit analysis should be conducted. | AEMO recognises that emergency DPV generation curtailment may have a cost for DPV consumers, including implementation costs and costs associated with a reduction in export revenue when DPV generation is shed. | Section 3.4 |

| No. | Theme | Summary of submissions | AEMO response | Report section |
|---|---|---|---|---|
| | capability: consumer impacts | | AEMO considers the benefits with more consumers installing DPV will exceed the costs associated with requiring last-resort DPV generation curtailment capability on those systems. This benefit is experienced across the integrated power system for all consumers, not just those with DPV installed. To this end, AEMO recognises the need for ongoing engagement with stakeholders on this matter. | |
| | Emergency distributed PV generation curtailment capability: network considerations | Stakeholders reiterated that any DPV curtailment should be done in coordination with DNSPs. | AEMO agrees with the need for coordination between DNSPs and AEMO in the implementation of a last resort DPV generation curtailment mechanisms.<br>AEMO is agnostic about exactly how a last resort mechanism will be implemented, so long as the necessary change in the supply demand balance can be achieved with sufficient levels of robustness and reliability when called on. | Section 3.4 |
| 5 | Areas of future work | Several areas of potential future work were raised across the study areas of system strength, frequency and variability and uncertainty. | AEMO is progressing several pieces of work that will cover many of the potential future areas suggested by stakeholders, including:<br>• Advanced Inverter White Paper (due early 2021).<br>• Frequency Control Work Plan (released September 2020).<br>• Collaboration with the AEMC investigation into system strength frameworks (ongoing).<br>• RIS Integrated Roadmap update (by January 2021). | Section 3.5 |
| 6 | Integration with other industry processes | Stakeholders suggested that waiting 12 months for the release of the next stage of the RIS was too long and that technical input from AEMO was needed in the current ESB and AEMC market and regulatory reform processes. | AEMO recognises the urgency of the next stage of the RIS. The first step in releasing AEMO's Integrated Roadmap is through the Frequency Control Work Plan[2] that was published in September 2020.<br>AEMO is also working closely with the AEMC and ESB to ensure technical insights are integrated into market and regulatory reforms in a timely manner. | Section 3.6 |
| 7 | Stakeholder engagement and timing | Stakeholders noted that a more detailed stakeholder plan and regular publications were needed going forward.<br>Feedback from 575 individuals from Solar Citizens indicated unprecedented level of consumer interest in an AEMO technical report. | AEMO's notes that a consultation on its engagement model is underway. Learnings from this consultation will be integrated into stakeholder engagement for subsequent stages of the RIS.<br>AEMO also notes the increasing interest by consumers and consumer advocacy groups and recognises that a more two-way collaborative experience for stakeholders is needed. | Section 3.7 |

[2] AEMO, frequency control work plan, September 2020, available at https://aemo.com.au/-/media/files/electricity/nem/system-operations/ancillary-services/frequency-control-work-plan/external-frequency-control-work-plan.pdf?la=en.

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# Tables

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# 1. Background

AEMO has prepared this paper to provide stakeholders with a view of how the key issues raised in written submissions to the Renewable Integration Study (**RIS**) Stage 1 report have been considered and an indication of future RIS bodies of work.

Following release of the RIS Stage 1 report on 30 April 2020, AEMO consulted with a wide range of stakeholders, providing information on the methodology, results and recommendations of the study and discussed feedback, concerns, or suggestions regarding the RIS Stage 1 report and priority focus areas for the future.

Given COVID-19 restrictions, AEMO used a variety of engagement options to maximise the value to all stakeholders, including:

- A webinar series for technical and non-technical audiences[3].
- Open industry and consumer workshops.
- Targeted video conference workshops for industry and international groups.
- Factsheets to answer frequently asked questions raised in workshops[4].
- The opportunity for written submissions.

Written submissions on the RIS Stage 1 report and priority focus areas for the future closed on 30 June 2020, and AEMO received submissions from 16 respondents, listed in Table 2 below.

**Table 2 List of respondents**

| | |
|---|---|
| AGL | Essential Energy |
| AusNet Services | Gail Warman (consumer) |
| CitiPower, Powercor, United Energy | Highview Power |
| Energy Australia | Lloyds Register |
| Energy Networks Australia | Planet Ark Power |
| Energy Queensland | Solar Citizens |
| Enova Community Energy | Solar Citizens Consumer 'Supporters'[A] |
| ERLPhase Power Technologies | Third Equation |

A. This submission included comments from 575 individuals who are either owners or supporters of distributed PV.

AEMO has prepared this paper to provide stakeholders with a view of how the key issues raised in written submissions have been considered and an indication of future RIS bodies of work.

[3] The five-part webinar series on the RIS is available at https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

[4] RIS fact sheets are available at https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

# 2. Summary of themes

The key themes raised by stakeholders in written submissions are summarised in the table below. Questions and comments were also raised by stakeholders in the virtual workshops held throughout May and June 2020. A summary of questions and responses arising in these workshops are available in the RIS Frequently Asked Questions document[5] and RIS Instantaneous Penetration Summary Graphic document[6].

**Table 3 Summary of stakeholder responses**

| No. | Theme | Stakeholders |
|---|---|---|
| 1. | Support for the RIS | AGL, AusNet Services, Citipower, Powercor, United Energy, Energy Australia, Energy Networks Australia, Enova, Lloyd's Register, Solar Citizens, Third Equation |
| 2. | Alignment with AEMO's ISP | AGL, Energy Australia, Energy Networks Australia |
| 3. | Assessment of costs and benefits | AGL, Energy Australia, Energy Networks Australia, Essential Energy |
| 4. | Emergency distributed PV (DPV) generation curtailment capability | AGL, Energy Australia, Gail Warman (consumer), Planet Ark, Solar Citizens, Solar Citizens Consumer 'Supporters' |
| | Alternatives to emergency DPV generation curtailment | AGL, Energy Queensland, Enova, ERLPhase, Essential Energy, Gail Warman (consumer) Highview Power, Solar Citizens, Solar Citizens Consumer 'Supporters', Third Equation |
| | Customer impacts | AGL, Essential Energy, Planet Ark Power, Solar Citizens, Solar Citizens Consumer 'Supporters' |
| | Distribution network considerations | Energy Queensland, Energy Networks Australia, Essential Energy Citipower, Powercor, United Energy, Energy QLD |
| 5. | Areas of future work | AGL, Citipower, Powercor, United Energy, Energy Australia, Energy Networks Australia, Lloyds Register, Planet Ark Power |
| 6. | Integration with other industry processes | AGL, Energy Australia |
| 7. | Stakeholder engagement and timing | AusNet Services, Energy Australia, Energy Networks Australia |

Additional questions or issues raised by stakeholders in submissions, together with AEMO's responses, are in **Appendix A1**.

[5] AEMO, RIS Frequently Asked Questions, June 2020, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-faq.pdf?la=en.

[6] AEMO, RIS Instantaneous Penetration Summary Graphic, June 2020, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-summary-graphic-1-pager.pdf?la=en.

# 3. Discussion of themes

Section 3 provides an overview of key themes raised in written submissions. For detailed submissions and responses please refer to **Appendix A1**.

## 3.1 Support for the RIS Stage 1 study

### 3.1.1 Theme description and submissions

The RIS Stage 1 report was published on 30 April 2020. The report is the first stage of a multi-year plan to maintain system security in a future National Electricity Market (**NEM**) with a high share of renewable resources.

This RIS Stage 1 report took the Draft 2020 ISP projections as given and investigated in detail the challenges in the short term, to 2025, of maintaining power system security while operating the ISP resource mix at very high instantaneous penetrations of wind and solar generation. It recommended actions and reforms needed to keep operating the NEM securely, now and as the power system transitions.

Support for the RIS studies and actions was offered by several of the written respondents. In particular, many stakeholders noted the criticality of a technical study to assess future operability of the grid under higher wind and solar penetrations. Also noted were AEMO's "efforts to provide a foundational engineering perspective with which to inform future NEM investment, design and operation" (Energy Australia).

### 3.1.2 AEMO response

AEMO thanks the broad range of stakeholders from across the energy industry for their support of the RIS. Valuable insights and contributions have been gained from the workshops, forums, expert panel and written submissions, among other engagements. These contributions have helped shape AEMO's thinking around the next stage of the RIS, including the integrated roadmap for the secure transition to higher penetrations of wind and solar in the NEM, including key study areas, actions, and reforms.

AEMO looks forward to engaging further on subsequent RIS stages and providing clarity among stakeholders on the priority focus areas as the system continues to transition.

## 3.2 Alignment with AEMO's Integrated System Plan

### 3.2.1 Theme description and submissions

AEMO envisages a feedback loop between the RIS and the ISP.

- The Draft ISP, published on 12 December 2019, established the core inputs for the RIS.
- The RIS Stage 1, published on 30 April 2020, supplied insights into the Final 2020 ISP, published on 30 July 2020.

The majority of RIS Stage 1 insights were related to operational and short-term measures to ensure the security of the power system out to 2025. The Final 2020 ISP assumed that some RIS recommendations are ultimately implemented, while focusing on medium and long-term solutions that go far beyond the RIS horizon.

Three stakeholders (Energy Australia, Energy Networks Australia, AGL) noted that the RIS analysis and outcomes were based on the inputs and assumptions from the Draft 2020 ISP. They noted that there may

be benefit in reviewing the RIS analysis and outcomes based on changes that were made between the Draft and Final ISP.

### 3.2.2 AEMO response

The 2020 ISP Appendix 7 on Future Power System Security[7] identified the key recommended actions from RIS Stage 1 that fed into the ISP, as shown in Table 4.

**Table 4 Recommended RIS actions feeding into the ISP**

| RIS action | ISP Section |
|---|---|
| **Investigate the introduction of a system inertia safety net for the mainland NEM, under system intact conditions** | The outcomes from consideration of a NEM minimum inertia level safety net are explored further in Section A7.4.2. |
| **Improving the transparency of system strength across the grid** | System strength outcomes are demonstrated in a number of ways in the ISP:<br>• Expected available fault levels across the NEM (Figure 1).<br>• Expected TNSP fault level node fault levels (Section A7.3.2).<br>• Available fault levels and remediation amounts in identified renewable energy zones (REZs) (see REZ scorecards in Appendix 5).<br>• Publishing of results on an interactive map. |
| **Promoting the development of scale-efficient REZs that are designed for the connection of inverter-based resources (IBR)** | Appendix 5 discusses the development of REZs in the NEM. |
| **Presenting evidence that coordinated system strength services can deliver positive net market benefits** | Section A7.5 demonstrates the need to co-ordinate network upgrades and system strength remediation in order to be able to develop a least-cost solution. |
| **Outlining an efficient strategy for the coordinated delivery of system strength services** | This will be explored further in the 2020 Inertia Report and 2020 System Strength Report, expected for publication by the end of 2020. This will ensure incorporation of anticipated updates to minimum demand forecasts, and the exploration of additional sensitivities. |

Source: 2020 ISP, Appendix 7, p.12

Appendix 6 of the Final 2020 ISP[8] replicates some of the RIS analysis with the Final 2020 ISP Central scenario outcomes, including the renewable generation penetration as a share of demand. This analysis further shows that there are no major differences between the RIS and ISP outcomes out to 2025.

For the system strength analysis, a major difference between the Draft and Final ISP (Appendix 7) was the use of the Step Change scenario results to provide a comparison to the Central scenario results. The comparison of these two scenarios did not show a material differences to the results out to 2025, which was the RIS study period. However, early retirement of coal plant in 2026-27 (just after the RIS study horizon), as shown in the Final ISP Step Change scenario, brought forward potential issues in the NEM, such as the potential for system strength shortfalls in New South Wales, Victoria and Queensland by 2030. The RIS made use of worst-case sensitivities to ensure that potential issues over the next five years were flagged.

[7] AEMO, 2020 ISP Appendix 7. Future Power System Security, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--7.pdf?la=en.

[8] AEMO, 2020 ISP Appendix 6. Future Power System Operability, Section A6.3.2, July 2020, available at https://www.aemo.com.au/-/media/files/major-publications/isp/2020/appendix--6.pdf?la=en.

AEMO views the challenges identified in the RIS Stage 1 as agnostic to timing. For example, the findings can be translated to the ISP Step Change scenario instead, to show that the recommendations identified in the RIS increase in urgency but not in nature. The RIS is able to highlight risks that the ISP needs to account for in the longer term, and integrate into the overall long term optimal development strategy.

The RIS Stage 1 highlighted that all components of the action plan should start immediately, regardless of lead time, so that they can be enabled when needed. If transition occurs faster than the recommendations can be implemented, then there will be increased inefficiencies and renewables may need to be curtailed until challenges have been addressed.

## 3.3 Cost-benefit analysis

### 3.3.1 Theme description and submissions

Stage 1 of the RIS was established to be a technical analysis of system security limits NEM-wide and for NEM regions. While it identifies recommended actions that would meet the system's technical needs, it does not investigate the costs of proposed actions or all the specific mechanisms that could be implemented.

Four stakeholder submissions (AGL, Energy Australia, Energy Networks Australia, Essential Energy) commented on the need for a cost benefit analysis on the RIS actions. Key to this cost benefit analysis was the need to accurately understand the potential impact of solutions on customers and anticipated market benefits and to ensure activities are in the best long-term interests of consumers as per the National Electricity Objective (**NEO**).

Energy Australia also raised concern regarding the plausibility of the ISP least-cost futures if a cost benefit analysis of the RIS is not completed and incorporated into the ISP. They noted in particular that recommendations critical to maintaining system security under different ISP scenarios must be costed and included as part of the overall ISP net market benefits assessment.

Additional stakeholder submissions were received that provided comment on the cost of distributed PV (**DPV**) generation curtailment to consumers. These are discussed in Section 3.4.

### 3.3.2 AEMO response

The RIS Stage 1 report noted that costing questions would be explored as part of future work and other workstreams such as the ISP and the Energy Security Board's (**ESB**) and Australian Energy Market Commission's (**AEMC**) market reform processes.

The RIS Stage 1 has already provided technical input into the ESB post 2025 workplan[9] and several AEMC rule changes[10]. These regulatory processes will involve a thorough analysis of benefits and costs for specific solutions and engagement with relevant stakeholders throughout the process.

To the extent possible, the 2020 ISP looked to integrate the RIS recommendations into its analysis and put a cost on the actions identified in the RIS.

As an example, available fault levels and potential system strength mitigation for all Renewable Energy Zones (**REZs**) are detailed as part of the REZ scorecards in the 2020 ISP Appendix 5[11]. Generator system strength remediation costs are not explicitly stated in ISP economic analyses; however, as the results in the

[9] SEE ESB post 2025 system service and ahead markets workstream at http://www.coagenergycouncil.gov.au/post-2025/system-service-and-ahead-markets.

[10] AEMC, System services rule changes, Consultation paper, 2 July 2020, available at https://www.aemc.gov.au/sites/default/files/2020-07/System%20services%20rule%20changes%20-%20Consultation%20paper%20%E2%80%93%20%202%20July%202020.pdf.

[11] AEMO, 2020 ISP Appendix 5. Renewable Energy Zones, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--5.pdf?la=en.

ISP Appendix 7[12] show, when well-coordinated, these costs can be as low **as 2-3% of the overall project costs**, and well within the error margins of the total project cost estimates. A well-planned centralised system strength solution will help ensure remediation requirements are timely. This can avoid lengthy commissioning periods where generator output is limited due to unforeseen system strength issues.

AEMO acknowledges that further work is needed to detail transmission network service provider (TNSP) fault level remediation costs that are expected to be encountered as coal plant retires. This will be further explored in the 2020 System Strength report to be released in December.

Regarding inertia, much of the inertia can be provided by the same potential solution in common with system strength. For example, the inclusion of high-inertia flywheels on synchronous condensers which could be delivered by TNSPs to meet fault level requirements at key nodes could also provide the majority of the inertia required across the NEM in the coming 20 years. The cost of these flywheels is a small percentage of the cost for a synchronous condenser if it is part of the initial design and construction, whereas adding high-inertia flywheels after a synchronous condenser is already commissioned is often impractical or cost-prohibitive.

The four large synchronous condensers being installed in South Australia (see Appendix 3[13]) are being fitted with high-inertia flywheels. This is a good example of a robust strategic investment that provides a wide range of system security services both for current needs and expected future requirements. ElectraNet estimated that the cost of adding flywheels represented **only 3%** of the total capital works. The inertia requirements published are applicable only when the system is at risk of islanding.

AEMO also highlights the role future technology is likely to play in meeting these requirements. For example:

- The development of inverter and control systems providing grid forming services could provide alternative options that partly address the requirements.
- Hydro plant or gas generation to operate in synchronous condenser mode when not generating.
- Replacement of retiring or new static var compensators (SVCs) with synchronous condensers with flywheels.
- Synthetic inertia from inverter-based resources (**IBR**).

These solutions would likely decrease the overall costs by avoiding the need for synchronous condensers. AEMO identifies the areas for immediate action in the RIS and continues to refine its work in this area. Near-term, detailed assessments incorporating the latest 2020 Electricity Statement of Opportunities (**ESOO**) minimum demand forecasts will be conducted as part of the 2020 System Strength, Inertia and Network Support and Control Ancillary Services (**NSCAS**) reports due to assess requirements and declaration of any new shortfalls by the end of 2020.

## 3.4 Emergency distributed PV generation curtailment capability

### 3.4.1 System need and recommendation

As highlighted in the RIS International Review, the NEM is at world-leading levels of decentralisation. This is primarily due to the growth in DPV generation over the last decade – from around 10,000 systems (35 megawatts [MW] combined capacity) in 2010 to 2.5 million systems in 2020 (more than 10 gigawatts [GW] combined capacity). This is contributing significantly towards the decarbonisation of the energy supply chain and is reducing energy costs for many end users.

[12] AEMO, 2020 ISP Appendix 7. Future Power System Security, Section A7.5, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--7.pdf?la=en.

[13] AEMO, 2020 ISP Appendix 3. Network Investments, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--3.pdf?la=en.

Although this growth has been enormously beneficial across consumers and industry, the aggregate size of this fleet is beginning to materially impact both the distribution network and bulk power system operation.

AEMO is focused on maximising the value of DPV generation for Australian households and businesses across the integrated electricity supply chain. To achieve this, a range of technical capabilities and market based-signals and incentives are required to maximise value. The RIS Technical Appendix A[14] investigates the system limits associated with the continued growth of DPV generation and recommends actions that can help address these limits. In doing so, AEMO considers these recommended actions will reduce the system integration costs associated with increasing DPV uptake so the consumer and system benefits associated with this growth can continue to be achieved.

The RIS identifies the bulk system operational challenges associated with an increasingly large source of uncontrollable and invisible generation – in particular, securely managing the supply-demand balance if extreme abnormal system events were to occur during periods with high DPV generation online and low underlying demand.

Frameworks for the continued and efficient integration of increasing DPV generation into the future will require:

- Mechanisms for the daily operation of active two-sided markets (where all types of energy users can actively buy and sell electricity), incentivising demand in the middle of the day to soak up excess DPV generation, through load and storage flexibility behind-the-meter and embedded within the distribution network.
- Emergency backstop mechanisms that enable AEMO to work with networks and retailers/aggregators to manage power system security if extreme abnormal system conditions were to occur during high DPV generation periods.

The above are essential elements of a secure, reliable and efficient power system with increasingly high levels of DPV generation.

### Market mechanisms

Effective market and regulatory arrangements that incentivise demand during the middle of the day would help minimise the occurrence of these extreme minimum load conditions. Innovative solutions could include providers/aggregators of distributed energy resources (**DER**) offering services such as increased DPV controllability, load flexibility, storage, and load shifting.

This will require a range of technical capabilities that can be leveraged by actors on behalf of consumers, and market-based signals and incentives to best utilise all resources in the most effective and efficient manner for all consumers connected to the grid. AEMO is working with industry towards establishing enduring market and regulatory frameworks for two-way markets in the Markets and Framework stream of the DER program[15].

As two-sided markets mature and larger volumes of flexible load and storage become available at times of high DPV output, both the efficiency and resilience of the system will experience a step change. This new state should remove the need to activate emergency mechanisms such as emergency DPV curtailment in all but the most extreme circumstances. However, these frameworks will take time to emerge.

[14] AEMO, Renewable Integration Study Stage 1 Appendix A, April 2020, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf?la=en.

[15] AEMO, DER Program Markets and Framework, available at: https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/markets-and-framework

## Emergency backstop mechanism

AEMO has identified an urgent need in South Australia today (and other regions within the next 2-3 years) for sufficient emergency backstop mechanisms to be available if extreme abnormal system conditions (such as a region islanding from the NEM) were to occur during high DPV, low underlying demand periods. Under these circumstances, there is currently not enough dependable load and storage flexibility available to feasibly activate in the middle of the day, given the very large quantities of DPV generation online. Emergency DPV generation curtailment is therefore the most technically feasible means of achieving this emergency backstop mechanism and large enough to sufficiently impact the supply-demand balance to restore power system security.

The intended usage and occurrence of emergency DPV curtailment capability can be considered similar to other emergency backstops available, such as load shedding. Load shedding is used in rare, extreme abnormal system conditions as a last resort to maintain power system security when demand exceeds available supply and market-based responses have not been able to address the deficit. Similarly, DPV curtailment will be required for managing power system security, if unusual operating conditions arise.

All large-scale generation output is controllable when necessary. This is now an essential capability for distributed resources, as they comprise such a large proportion of total system generation at times.

## Further information

Since the RIS, AEMO has published two additional reports, which further explore the system challenges associated with increasing levels of DPV generation:

- Minimum Operational Demand Thresholds in South Australia[16] – undertaken at the request of the South Australian Government. Following publication of this report, AEMO has been engaging with the South Australian Government and SA Power Networks (**SAPN)** on the implementation of new DPV generation capabilities in South Australia.
- 2020 ESOO[17] – considered reducing minimum operational demand in NEM regions over a 10-year outlook period, and identified other regions (Victoria and Queensland) likely to require last resort emergency DPV generation curtailment capability within the next 2-3 years.

Further opportunities to engage with this topic include:

- The RIS webinars – specifically the RIS 101 webinar[18], which provides a non-technical overview of the challenges identified in the RIS, and the RIS Appendix A webinar[19], which provides a summary of the key concepts, findings and actions for the RIS DPV study.
- AEMO's DER Program[20] – specifically the DER standards and operations streams, which have been considering and engaging on performance standards for solar inverters and collaborating with industry to develop new standards to improve their capability in line with international best practices.
- Rule change request to the AEMC to introduce uniform technical standards for distributed energy resources (DER), including residential solar PV[21] – at the request of the federal and state governments, AEMO, in collaboration with the ESB, recently submitted this rule change request. These standards would apply to new inverters and would not apply retrospectively.

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[16] See https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/sa_advisory/2020/minimum-operational-demand-thresholds-in-south-australia-review.pdf?la=en.

[17] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo.

[18] See https://www.youtube.com/watch?v=34W46QjO3Is.

[19] See https://www.youtube.com/watch?v=5Sj9jVl1TSs.

[20] See https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program.

[21] For information related to the technical standards for the DER rule change, see https://www.aemc.gov.au/rule-changes/technical-standards-distributed-energy-resources.

- Distributed Energy Integration Program[22] (DIEP) – AEMO is a participant is this program, which seeks to collaborate with other market authorities, government agencies, industry and consumer associations to maximise the value of consumers' DER for all energy users.
- ESB paper[23], April 2020, exploring what a two-sided market could look like and its foundations – following on from the consultation, the ESB is currently undertaking detailed analysis on the topic. This will be coordinated through the post 2025 market design project[24], where the ESB is to advise on a long-term, fit-for-purpose market framework that supports reliability, modifying the NEM as necessary to meet the needs of the future and incorporate storage and DER participation.
- Solar Citizens – this organisation has a supporter base of around 70,000 householders who own or encourage rooftop solar power. AEMO has invited Solar Citizens to join its regular Consumer Advocate panel, so the organisation can keep its supporters informed about AEMO's program of works, including the DER workstream.

### 3.4.2 Feedback received – themes and description

In response to the RIS, AEMO received strong feedback from several stakeholders on the DPV generation curtailment recommendations in the RIS. These have been grouped into four key categories:

- How emergency DPV generation curtailment would be implemented.
- Alternatives to emergency DPV generation curtailment.
- Consumer impacts.
- Distribution network considerations.

The main concerns are summarised below, and AEMO's responses are addressed in Section 3.4.3.

#### Emergency DPV generation curtailment capability

Four stakeholders commented on AEMO's recommendations regarding the need for emergency DPV generation curtailment capabilities and how this capability might be utilised. These submissions unanimously stated that the ability to curtail DPV systems should be a last resort and only used in extreme, abnormal system conditions or events.

In particular, Solar Citizens (supported by the Solar Citizens Consumer Supporters submissions) acknowledged that the RIS actions were seeking to avoid the implementation of stricter regional hosting capacity limits; however, the submissions highlighted a growing concern about the ramifications of emergency DPV generation curtailment. The submissions noted that AEMO should:

- Increase transparency around the circumstances in which generation curtailment will be allowed to occur.
- Ensure any change to regulation to enable DPV curtailment is rigorous in design to ensure curtailment could only be used for its intended design and no perverse impacts were forthcoming.

#### Alternatives to emergency DPV generation curtailment

Several submissions raised potential alternatives to emergency DPV generation curtailment capability to serve as a last resort backstop mechanism, which encompassed the utilisation of different sources of load and storage flexibility to 'soak up' excess DPV generation in the daytime.

These approaches can be grouped as follows:

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[22] ARENA, Distributed Energy Integration Program, see https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/.

[23] COAG Energy Council, Two-Sided Markets, see: https://www.aemc.gov.au/news-centre/media-releases/consultation-open-energy-security-boards-two-sided-market-paper.

[24] COAG Energy Council, Post 2025 Market Design Issues Paper, see: http://www.coagenergycouncil.gov.au/publications/post-2025-market-design-issues-paper---september-2019.

- Increased **uptake of complementary technologies** was highlighted in several submissions, including AGL, Enova, Solar Citizens, Solar Citizens Consumer Supporters and Gail Warman (consumer).
  - For example, individual and community-scale battery storage was raised by Solar Citizens, Solar Citizens Consumer Supporters, and Gail Warman (consumer) as a technology that could be used to alleviate minimum load periods (such as in the middle of the day).
  - AGL also raised the need for further analysis on EVs to provide grid support services for the benefit of all energy consumers, through orchestration and managed charging.
  - Enova suggested that enabling sub-regional self-sufficiency may provide an alternate solution (for example, community sharing of storage, embedded networks, micro-grids and virtual power plants, and demand management).
- **Market-based approaches** were raised by AGL, Essential Energy, Solar Citizens, Solar Citizens Consumer Supporters and Third Equation.
  - AGL suggested that market management strategies, such as orchestrated services, may provide a more cost-effective solution than curtailment. AGL also noted the DEIP as an avenue for considering market-based approaches.
  - Essential Energy suggested that tariff reform and connections standards reform could be used to grow load and generation DER base capability.
  - Solar Citizens and Solar Citizens Consumer Supporters noted that market strategies, including demand management, should be encouraged.
  - Planet Ark suggested that an exploration of solutions applied internationally was warranted, as well as exploring tariff structures and load control schemes.
  - Third Equation agreed with AEMO's action to incorporate aggregators more extensively as part of a decentralised approach to energy.
- **DNSP solutions**, such as utilising network-controlled load, were highlighted by Energy Queensland and Essential Energy.

### Consumer impacts

Five stakeholder submissions commented on the potential consumer impact of emergency DPV generation curtailment. The key observations and concerns raised in submissions were:

- Solar Citizens, Solar Citizens Consumer Supporters, Planet Ark and Gail Warman (consumer) expressed concern that the emergency DPV generation curtailment mechanism would be disproportionately costly to and unfairly impact DPV households, compared to non-DPV customers. These stakeholders noted that many households had installed DPV as an investment and for environmental concerns, and that curtailing their DPV systems would act as a financial penalty.
- AGL suggested that consumer impacts should be considered in broader market reforms, such as those where customers choose to offer control of their asset or orchestrated services. They also suggested a formal cost benefit analysis, to ensure the impact of proposed solutions on consumers is appropriately valued.

### Distribution network considerations

Energy Queensland, Energy Networks Australia and Essential Energy noted that any changes to DPV operation would require consultation with DNSPs. Submissions noted that:

- DNSPs have responsibility for DPV connection arrangements and the local network operation and performance.

- The challenges of integrating DPV are not uniform across all networks and solutions must be tailored accordingly.
- Any emergency DPV generation curtailment requested at the bulk system level is best directed and/or actioned by the DNSP at the local distribution level to ensure distribution level assets can be effectively coordinated and safely operated during a generation curtailment event.

Further, Essential Energy highlighted that the investment required to ensure DPV systems are compatible with the generation curtailment requirements would be disproportionately costly to implement for rural households. Essential Energy also recommended a cost benefit analysis be undertaken to ensure consumers are not paying more than necessary to connect to the grid.

### 3.4.3 AEMO response

AEMO acknowledges the concerns regarding emergency DPV generation curtailment capability raised in written submissions and throughout industry consultation following publication of the RIS. AEMO acknowledges the need for a broader set of reforms to best leverage DER to the benefits of all consumers – those with and also those without such resources.

These broad reforms include, but are not limited to:

- Uplifting technical capability.
- Evolution of technology such as storage and electric vehicles (EVs).
- Enabling the aggregation of resources by actors (retailers and aggregators) and offering these as both peak shaving and load shifting capability.
- Tariff reform.
- The role of networks as they evolve into distribution system operators that work with AEMO and other actors in the industry to manage local security issues, and also help AEMO manage bulk system issues.

A number of these activities are in train through DEIP and ESB reforms. AEMO will continue to work through these forums to support these changes to system and market arrangements. Like all market-based arrangements, backstop mechanisms are also required to manage the system under certain rare conditions. Such arrangements will need to be in place and used only as a last resort. This section sets out AEMO's responses to concerns raised in written submissions and directs stakeholders to further information.

#### Emergency DPV generation curtailment capability

AEMO understands concerns raised by stakeholders about how emergency DPV generation curtailment capability would be implemented in practice and seeks to reiterate that emergency DPV generation curtailment would be implemented only as a last resort measure to manage power system security during exceedingly rare circumstances, if severe abnormal operational conditions arise and market mechanisms and other available approaches have been exhausted. An example of such circumstances could be the combination of both:

- High DPV generation online and low underlying demand, as can be plausibly experienced during sunny, mild temperature weekends or public holidays in spring, and which results in periods with very low operational demand, which will continue to reduce as DPV growth continues; and
- An extreme abnormal system event occurring during such a period – for instance, a major incident in the transmission network resulting in an entire region islanding from the NEM or at elevated risk of separation, significantly reducing inter-regional transfer capacity.

AEMO is engaging with state governments and the other market bodies on the necessary governance and regulatory arrangements necessary for emergency DPV generation curtailment as a last resort measure for power system security.

AEMO expects emergency DPV curtailment to be implemented operationally through instructions from AEMO's control room to the DNSP, via the TNSP. Implementing DPV generation curtailment directly with individual devices, or through third parties such as aggregators, would require DNSPs to build, own and operate any communication and enablement infrastructure needed to enable DPV generation curtailment.

This is urgently required in South Australia. AEMO is currently preparing an options paper on the various ways this emergency DPV generation curtailment capability could be enabled, and the merits/feasibility of each, and welcomes feedback from stakeholders as part of the ongoing consultation for Minimum Technical Standards for DER[25].

### Alternatives to emergency DPV curtailment

Consistent with stakeholder submissions, AEMO agrees a suite of complementary measures can help manage the supply-demand balance during high DPV, low underlying demand periods in the daytime, and reduce the likelihood that emergency DPV curtailment will be required.

AEMO's analysis has found that:

- Complementary solutions can be pursued to soak up excess solar generation in the middle of the day, both behind-the-meter and embedded within the distribution network, including EV and storage charging and load shifting.
  - Nationally, market mechanisms incentivising more active management of behind-the-meter resources as a source of system flexibility are currently being evaluated through the ESB reforms. Long term, this will provide pathways for other DER types to balance DPV generation in the daytime. In South Australia, SAPN and the South Australian Government have announced several measures that will enable this kind of flexibility – including dynamic exports for DPV systems and 'solar sponge' tariffs to incentivise load and storage activation in the middle of the day.
  - Longer term, AEMO's ISP is forecasting significant uptake of storage (through both grid-scale batteries, and aggregated small scale) and EVs across the NEM. Today at least, and into the short term, there is not enough dependable load and storage flexibility available in South Australia to feasibly activate in the middle of the day to sufficiently impact the supply-demand balance, given the very large quantities of DPV generation online.
- Even with increasing storage and load flexibility in the daytime, there will still be a need for emergency DPV generation curtailment as an operational lever to manage the supply-demand balance securely if extreme abnormal events were to occur during high DPV generation, low underlying demand periods.

The intended usage and occurrence of emergency DPV curtailment capability can be considered similar to other emergency backstops available, such as load shedding. Load shedding is utilised in rare, extreme abnormal system conditions as a last resort to maintain power system security when demand exceeds available supply. Similarly, DPV curtailment will be required for managing power system security, if unusual operating conditions arise. All large-scale generation output is controllable when necessary. This is now an essential capability for distributed resources, as they comprise such a large proportion of total system generation at times.

### Consumer impacts

AEMO recognises emergency DPV curtailment may have a cost on DPV consumers, including:

- **Implementation costs** – costs incurred at the time of installation to enable curtailment at the device level, and costs to implement a coordinated emergency DPV curtailment scheme when required.
  - International experience suggests generation curtailment backstop mechanisms can be implemented at relatively low cost, with several examples of DPV feed-in management being

[25] Minimum technical standards for DER rule change, see https://www.aemc.gov.au/rule-changes/technical-standards-distributed-energy-resources.

demonstrated at scale by both distribution and transmission operators. Most implementations have been through simple one-way curtailment commands communicated through low-bandwidth networks – for example, one-way radio ripple control in Germany and disconnect switching of smart meters in Hawai'i. Typically, device-level capability is achieved on an opt-in basis, with conservative generation or export limits applied if the user has not chosen to be available for last resort curtailment[26,27].

  - Given projected DPV uptake across all NEM regions, AEMO considers device-level capability for remote emergency generation curtailment in new DPV systems at the time of installation to be a 'no regrets' action. This would significantly reduce the cost, complexity and time associated with implementing a functional emergency DPV curtailment scheme when required for system security in each NEM region. Importantly this would not preclude DER devices from being able to provide other services in future.

- **Costs associated with a reduction in export revenue when DPV generation is shed** – as discussed above, because this would only be activated during rare, extreme abnormal system events (occurring during high DPV generation, low underlying demand periods), this impact is not expected to be material. If other mitigating measures (such as market mechanisms to incentivise more flexible load and storage) are implemented, this would further reduce how often emergency DPV curtailment would ever need to be activated (and therefore any cost imposition on DPV owners).

It is also important to recognise the wider system and consumer benefits associated with enabling the transition to a secure and reliable power system with high levels of distributed resources. Having sufficient levels of DPV generation available for last-resort curtailment allows more customers to install DPV systems over time. In the absence of adequate last resort mechanisms, moratoriums or restrictions on new DPV systems may be needed.

There are a range of important policy questions that need to be considered in order to facilitate the optimal integration of DPV within the power system. These policy questions sit at the national level and will require ongoing engagement between governments, industry, and consumer groups to reach an agreed direction:

- Consistent national policy consideration of the role of DPV in Australia's energy future, including an examination of the extent to which distribution networks and the bulk power system should be able to host increasing levels of DPV generation.
- Based on this level of hosting capacity, consideration needs to be given to how the costs of integrating increasing levels of DPV generation are allocated across both DPV and non-DPV customers.
- In regard to costs, consideration should also be given to new market mechanisms to enable and incentivise sources of load flexibility that compliment DPV generation, reducing the need for DPV generation curtailment. To this end, work being completed by the ESB's two-sided market workstream as part of the post 2025 market design project and other initiatives including several technical trials and demonstration projects and current AEMC rule changes on both technical standards for DER and the governance of DER technical standards are also of importance.

### Distribution network considerations

AEMO agrees with DNSP feedback on the need for coordination between DNSPs and AEMO in the implementation of a last-resort DPV generation curtailment mechanism, given the need to safely and reliably manage distribution networks within their operational limits. Operationally, AEMO expects DPV

[26] International Review of Residential PV Feed-in Management, Electric Power Research Institute, October 2018, available at https://aemo.com.au/-/media/files/electricity/nem/der/2019/standards-protocols/epri-pv-feed-in-management-report.pdf?la=en.

[27] AEMO, Maintaining Power System Security with High Penetrations of Wind and Solar Generation: International Insights For Australia, October 2019, available at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/future-energy-systems/2019/aemo-ris-international-review-oct-19.pdf?la=en.

curtailment would be enacted through instructions to the DNSP (via the TNSP) for an aggregate change in the supply demand balance, within at least 30 minutes – the timeframe to restore system security if an extreme abnormal system event were to take place.

AEMO considers DNSPs are best placed to build, own and operate any infrastructure needed to enable DNSPs to communicate with devices behind the meter, either directly or through third parties such as aggregators. This is consistent with how DNSPs meet their obligations associated with other bulk power system security operational practices such as manual load shedding. Where other agents (such as metering coordinators) are potentially involved in the last resort curtailment process, DNSPs will be central to ensure activation of the curtailment commands across DPV systems are coordinated so flows and voltages within the distribution network are maintained within their technical limits.

AEMO is agnostic about exactly how a last resort mechanism will be implemented, so long as the necessary change in the supply demand balance can be achieved with sufficient levels of robustness and reliability when called on.

For emergency DPV curtailment, technically feasible options might include:

- Simple one-way curtailment commands to either the inverter or Advanced Metering Infrastructure (AMI) via low-bandwidth communications network (for example, radio/power line carrier).
- High-complexity web-based protocols (for example, IEEE 2030.5) over the internet/cellular networks.

Over time, AEMO expects load activation to gradually enter into last resort mechanisms but, today at least, given current and projected levels, the focus is on the DPV fleet. Where possible, implementation should leverage the existing technological pathways available in each distribution network and currently available device capabilities. Differences across and within distribution networks, for example communication network challenges in rural service areas, should also be recognised. Such an approach would minimise the need for new infrastructure spending. Where new infrastructure is needed, potential synergies should be explored with DNSP plans to implement DER management systems.

## 3.5 Areas of future work

### 3.5.1 Theme description and submissions

This RIS Stage 1 has been a large undertaking and explored several critical power system security questions in detail; however, its scope has been focused on system operability, integration of DPV, frequency management, system strength management, and variability and uncertainty (resource adequacy).

Several areas for further study were highlighted as a result of the RIS Stage 1 findings.

Feedback on future activities and priorities was a key question posed to stakeholders following the RIS Stage 1 report.

Six stakeholders provided feedback on areas for future work. Feedback received on future work and priorities for DPV is discussed in Section 3.4, particularly with respect to exploring alternate measures to emergency DPV generation curtailment. The remaining suggestions on future work are summarised below.

#### System strength

Three stakeholders commented on the future direction of system strength work. Key observations from these stakeholders were:

- AGL suggested that active participation by AEMO in the AEMC's investigation into system strength frameworks in the NEM[28] and adoption of outcomes from this review, including any update to the definition of system strength, was warranted.

[28] See https://www.aemc.gov.au/market-reviews-advice/investigation-system-strength-frameworks-nem.

- Citipower, Powercor and United Energy suggested that enabling quicker and more transparent access to network information for current and intending participants and NSPs should be prioritised. In particular, if the process to understand committed and proposed generation that may impact system strength is slow and relatively opaque, this can lead to project delays and a requirement for multiple reassessments. AEMO interprets that the information in question here relates specifically to power system models, such as those in PSCAD.
- Energy Networks Australia identified that improved coordination of system strength (and inertia) that is aligned to the ISP would be beneficial.

#### Frequency

Four stakeholders commented on the future direction of frequency work. The key observations raised in submissions were:

- AGL recommended that the impacts of near-universal primary frequency response (PFR) on power system performance should be considered as part of the next stage of the RIS. AGL also suggested that the decline in load relief should be addressed on both the generation and load side.
- Energy Australia asked when the work on understanding the impact of the sub 5-minute variability on ability to maintain frequency under normal operating conditions would be released.
- Highview Power noted that the frequency studies did not focus on the challenges associated with rotor angle stability scarcities and highlighted that similar studies had been performed for the ERCOT and EirGrid systems.
- Lloyds Register suggested that the RIS analysis on inertia should be broadened to consider non-mechanical sources of inertia.

#### Variability and uncertainty

Two stakeholders (AGL, Energy Australia) commented on the future direction of variability and uncertainty work. Both submissions highlighted that ramping requirements were heavily dependent on interconnector headroom. AGL acknowledged that AEMO had identified this in the RIS report and suggested this should be the position reflected in subsequent documents. Energy Australia suggested that further investigation of projects, such as Project EnergyConnect, and understanding the system under different network configurations, should be prioritised to better understand the system response to ramping requirements.

### 3.5.2 AEMO response

Given the high level of complexity and inter-relatedness of power system security challenges, AEMO sees value in developing and publishing an integrated roadmap of priority security activities needed to support the generation mix transition. This will provide greater transparency and facilitate better co-ordination of activities among stakeholders and market bodies.

This roadmap will be published no later than June 2021, and will include:

- Publication of the Frequency Workplan in 2020 (RIS Stage 1 recommendation 4.2)[29].
- A workplan to improve coordination of system strength activities (RIS Stage 1 recommendation 5.1).
- An advanced inverter white paper investigating how advanced power electronic functionality could be used to overcome system challenges, to be published early 2021.

[29] AEMO, frequency control work plan, September 2020, available at https://aemo.com.au/-/media/files/electricity/nem/system-operations/ancillary-services/frequency-control-work-plan/external-frequency-control-work-plan.pdf?la=en.

- Identification of key areas of further study, including but not limited to the resilience of a high renewable future system to complex system events, and a study of the latest advancements in inverter technology.

AEMO welcomes ideas and recommendations provided in submissions regarding further areas of study. Specific comments on these include:

- **System strength:**
  - AEMO will continue to work closely with the ESB and AEMC in their respective regulatory and reform processes, including active participation in the AEMC's investigation into system strength frameworks in the NEM.
  - AEMO agrees that improved coordination of system strength and inertia that is aligned to the ISP would be beneficial. The 2020 ISP Appendix 7[30] highlights that a centralised coordinated solution to system strength can lead to lower-cost outcomes by accessing the benefits of economies of scale for solutions, especially for large clusters of IBR in REZs. Further, AEMO's 2020 System Strength and Inertia report, scheduled for publication in December 2020, will outline an efficient strategy for the coordinated delivery of system strength services. This will incorporate the ESOO 2020 updates to minimum demand forecasts, and the exploration of additional sensitivities.
  - AEMO is working collaboratively with NSPs to bring more efficiency and transparency to the connection process.
- **Frequency:**
  - PFR outside of frequency control ancillary services (FCAS) and control of frequency under normal conditions – at the time the RIS was drafted, there was regulatory uncertainty regarding PFR provision, and this is still the case due to the open rule changes related to frequency. The frequency control analysis was designed to be relevant regardless of the outcome of the PFR rule changes, and the findings are still applicable now that the Mandatory PFR rule is in place[31]. AEMO continues to work in this area, and recently published the PFR Response (PFRR) Stage 1 report[32], with Stage 2 of this publication due in December 2020.
  - Angular Stability – while not a focus of the RIS Stage 1 report, angular stability is routinely studied as part of a number of processes across AEMO's functions, and will be included in any future areas of study relating to the resilience of a high renewable future system to complex system events.
  - Non-mechanical inertia sources – AEMO is working with the Australian Renewable Energy Agency (**ARENA**) and industry on a range of trials of advanced inverter capabilities and plans to publish a white paper on advanced inverter capabilities in early 2021.
  - Load relief – the response of load results from the technological changes in the types of devices customers choose to install, so AEMO has little or no influence on it. However, as the response of the load affects the performance of the power system, AEMO does take it into account when setting contingency FCAS volumes, and has recently revised volumes to consider lower levels of support from customer load[33]. For clarification, load relief, as referred to in the RIS report, is not inclusive of the effects of DER; these are addressed separately.

[30] AEMO, 2020 ISP Appendix 7. Future Power System Security, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--7.pdf?la=en

[31] See https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response.

[32] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-frequency-risk-review.

[33] See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Frequency-and-time-error-reports/2019/Update-on-Contingency-FCAS-Aug-2019.pdf.

- AEMO's work on frequency control – detail on additional work AEMO is conducting in the area of frequency control is available in the AEMO Frequency Control Work Plan[34]. AEMO stated in the RIS report that it was progressing work to better understand the impact of the variable nature of wind and solar generation on maintaining frequency under normal operating conditions in the sub 5-minute timeframe[35]. As such, AEMO has published a report by DIgSILENT on Frequency Control modelling: Investigation of ramp impacts on frequency control in the NEM under high VRE penetrations[36].

- **Variability and uncertainty:**
  - AEMO acknowledges that ramping requirement outcomes studied in the RIS were heavily dependent on interconnector headroom across all studied timeframes. Following these studies, AEMO's 2020 ISP Appendix 7 on Future Power System Security[37] includes discussion on the need to maintain headroom on the Heywood interconnector for increasing contingency sizes. The 2020 ISP also assumed that at least two synchronous generating units would be required in South Australia prior to completion of Project EnergyConnect to meet the power system requirement for operating reserves in the region[38]. Maintaining headroom on transmission assets (such as interconnectors) is a proven effective method to manage contingencies and is likely to play a major role in managing ramp events. Other approaches, such as generation technologies providing fast response, can also serve to manage these events. The optimal approach will likely be a mix of these (and potentially others). Investigation and analysis of the potential events and approaches to manage them will be part of AEMO's future work (including the ISP).

## 3.6 Integration with other industry processes

### 3.6.1 Theme description and submissions

The RIS Stage 1 report was established in part to provide foundational engineering perspectives to industry, the ESB, the AEMC, market institutions, and policy-makers to support their consideration of future investments, regulations, and market designs.

The RIS recommended actions 2.3, 3.3, 5.1 and 6.2 directly reference the ongoing reform and regulatory work being actioned by the ESB and AEMC and highlight where the RIS technical studies can be leveraged.

Three stakeholders made note of the interaction between the RIS and other industry processes. The key observations and concerns raised in submissions on this aspect of the RIS were as follows:

- Energy Australia highlighted the need for technical analysis to feed into rule change processes. They suggested that a timeline of 12 months for the next stage of the RIS publication is too long, and this should be expedited to help inform and enable an effective, efficient energy market transition.
- AGL commented that AEMO should provide technical input into the implementation of regulatory reform processes determined by the ESB and AEMC, rather than identifying an AEMO preferred solution as was done in the RIS action plan.

[34] AEMO, Frequency Control Work Plan, September 2020, available at https://aemo.com.au/-/media/files/electricity/nem/system-operations/ancillary-services/frequency-control-work-plan/external-frequency-control-work-plan.pdf?la=en.

[35] AEMO, Renewable Integration Study Stage 1, Appendix C, April 2020, p.16, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-c.pdf?la=en.

[36] DIgSILENT, Frequency Control modelling: Investigation of ramp impacts on frequency control in the NEM under high VRE penetrations, March 2020, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/3563-etr-01-version-20.pdf?la=en.

[37] AEMO,2020 ISP Appendix 7. Future Power System Security, July 2020, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--7.pdf?la=en.

[38] AEMO,2020 ISP Appendix 7. Future Power System Security, July 2020, p.54, available at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--7.pdf?la=en.

- Essential Energy highlighted the need to address the system challenges of moving to higher penetrations of wind and solar through holistic reform, rather than individual rule changes.

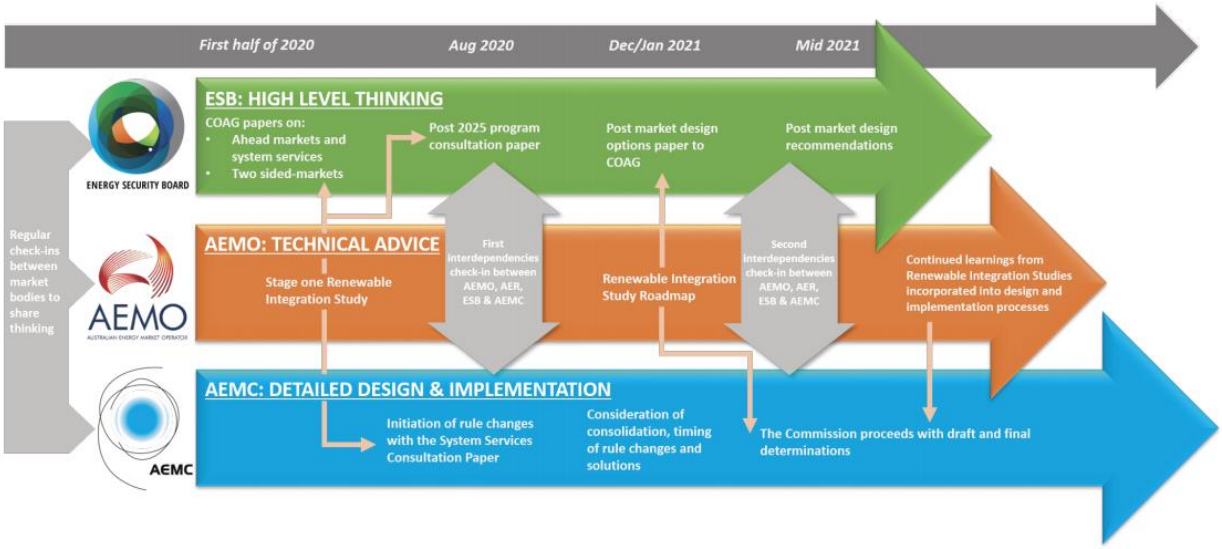
### 3.6.2 AEMO response

AEMO recognises the urgency of the next stage of the RIS, which is needed to feed into ongoing regulatory processes. However, consideration also needs to be given to how best to balance competing priorities.

To balance these priorities and secure the transition to higher penetrations of wind and solar in the NEM, the RIS Stage 1 report highlighted the release of an integrated roadmap by Q2 2021[39]. The first step in this roadmap is the release of the AEMO frequency control workplan in 2020[40].

AEMO is working closely with the ESB and AEMC to ensure that the technical input from RIS Stage 1 and development of the next stage of the RIS are closely aligned with regulatory and reform programs that are underway. Figure 1 demonstrates the AEMC's view of the way these work programs fit together. AEMO is continuing to work closely with the AEMC and ESB to best align timings between the work programs.

**Figure 1 AEMC consultation timeline including relevant ESB post-2025 milestones**




Source: AEMC, System services rule changes, Consultation paper, 2 July 2020, p5.

The RIS Stage 1 action plan[41] identified 15 actions to address key challenges posed in the study, with the goal of pointing to technical solutions to the challenges explored. Of the actions identified, 10 were ongoing at the time of publication and five were new. Of the five new actions:

- Three related to collaboration with the AEMC, ESB and industry to enhance governance structures for technical standards and improvements to DPV dispatchability.
- One related to the development of an AEMO frequency workplan to complement the workplan published by the AEMC.
- One related to uplifting AEMO's treatment of uncertainty and risk in forecasting ramps.

[39] AEMO, Renewable Integration Study Stage 1, April 2020, p. 14, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en&hash=BEF358122FD1FAD93C9511F1DD8A15F2.

[40] Ibid,. p. 11.

[41] AEMO, Renewable Integration Study Stage 1, April 2020, pp. 8-11, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en&hash=BEF358122FD1FAD93C9511F1DD8A15F2.

It was always AEMO's intent that any specific solutions, for both ongoing and new actions, would be assessed, contrasted against other potential innovative solutions, and consulted on through appropriate regulatory channels.

## 3.7 Stakeholder engagement and consultation

### 3.7.1 Theme description and submissions

Throughout the analysis, drafting and publication of the RIS, several methods were used to engage with industry. These included:

- **DNSP workshops** – in June 2019, AEMO consulted with DNSPs through a series of workshops to understand the issues emerging in DNSP networks due to DPV. Outcomes of these workshops were presented in the RIS Technical Appendix A through the discussion of technical challenges faced by DNSPs and case studies to provide insight into specific challenges[42].
- **Updates and dissemination of information** – this included:
  - RIS information sheet and website landing page to communicate the project scope[43].
  - Publication of the International Insights for Australia paper to set the scene for ongoing investigations into renewable integration in Australia and highlight key areas for RIS investigation[44].
  - Limited briefings to government, market and industry bodies on the RIS scope and areas of analysis[45].
  - RIS representation at AEMO ISP workshops, including giving brief updates and drawing out linkages between the RIS and ISP[46].
- **External advisory panel** – in February 2020, AEMO sought input and feedback on the draft RIS from a small panel of technical experts[47].
- **Post publication briefings and workshops** – these were targeted at:
  - Communicating results and key insights to interested stakeholders.
  - Enabling stakeholders to ask questions and receive clarification and additional information from AEMO about the methodology and results of the study.
  - Promoting discussion regarding the actions arising from this report and priority focus areas for the future.
  - Exploring the findings and insights from this work with regulatory bodies and policymakers to help inform ongoing reform processes.

[42] The RIS Technical Appendix A Section A3.3 summarises the technical challenges faced by DNSPs and case studies throughout the appendix report provide insight into specific challenges. See https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf?la=en.

[43] See https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

[44] AEMO, Maintaining Power System Security with High Penetrations of Wind and Solar generation, International Insights for Australia, October 2019, available at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/future-energy-systems/2019/aemo-ris-international-review-oct-19.pdf?la=en.

[45] See example slides as presented to ARENA, available at https://arena.gov.au/knowledge-bank/presentation-aemo-renewable-integration-study-update/.

[46] For example, the RIS team were involved in the consultation workshop on the Draft ISP from 3-5 February 2020, including hosting a Q&A station. See https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2020/q-and-a-stations.pdf?la=en&hash=C6B59D9DD909FC42BFAB3079C5A40589.

[47] Advisory panel members listed on pp. 2-3 of the Renewable Integration Study Stage 1 report, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en&hash=BEF358122FD1FAD93C9511F1DD8A15F2.

  - Leveraging stakeholder feedback and perspectives to help shape a roadmap for the secure transition to higher penetrations of wind and solar in the NEM, including priority study areas, actions, and reforms.

- **Post-publication supplementary information** – this included the webinar series for technical and non-technical audiences and information sheets on the RIS[48].

Four stakeholders commented on stakeholder engagement and consultation throughout the RIS Stage 1 process and for future RIS stages. The key observations and concerns raised on this aspect of the RIS were:

- AusNet Services noted its appreciation for AEMO's engagement throughout the development of the RIS and post-publication.
- Energy Networks Australia suggested that a more detailed stakeholder engagement plan was needed going forward, particularly with regard to engagement with consumers.
- Energy Australia suggested that regular, integrated reports on priority issues, based on stakeholder interest or known ISP limitations, should be included. It noted that better coordination and prioritisation of investigation would maximise resource efficiency across the industry.
- Essential Energy noted that between engagement with DNSPs and publication of the RIS, a number of new technical challenges had arisen in their network.
- The submission of feedback from 575 individual householders via the Solar Citizens group was significant. This indicated an unprecedented level of consumer interest in an AEMO technical report.

### 3.7.2 AEMO response

AEMO acknowledges that the dominant engagement method throughout the RIS Stage 1 was the dissemination of information and there was limited opportunity for stakeholder feedback during development of the study.

Going forward, AEMO would like to ensure that the next stage of the RIS is as collaborative and engaging as practicable, noting the balance between the need for consultation and also the need to move quickly given the rate of change in the industry. AEMO notes in particular the increasing interest by consumers and consumer advocacy groups in the findings and implications of the RIS on household PV systems.

AEMO currently has an open consultation to review its engagement model across the industry[49]. The aim of this review is to ensure the delivery of a more collaborative, transparent and dynamic experience for stakeholders as they engage with AEMO. Any new model is intended to deliver a material shift in both:

- The level of transparency market participants, consumers, and other stakeholders enjoy regarding AEMO's understanding of current and emerging challenges, and
- A more two-way, collaborative experience for stakeholders, including consumers and their advocacy groups, in both defining problems and identifying solutions.

AEMO is always open to hearing feedback on how stakeholder engagement can be improved. For feedback on AEMO's stakeholder engagement model, please contact StakeholderRelations@aemo.com.au.

Building on the RIS Stage 1 findings and subsequent stakeholder engagement, by Q2 2021 AEMO has committed to developing a roadmap for the secure transition to higher penetrations of wind and solar in the NEM, including key study areas, actions, and reforms. The intent of this roadmap is to, in part, assist with visibility of forward priorities. The first step in this plan is the recent release of the Frequency Control

[48] The webinar series and fact sheets are available at https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

[49] AEMO, Reviewing AEMO's engagement model, consultation page, available at https://aemo.com.au/en/consultations/current-and-closed-consultations/renewing-aemos-engagement-model.

Work Plan[50]. As noted, AEMO is working closely with the ESB and AEMC to ensure that the timing of the next stage of the RIS is aligned where possible to ensure timely inputs to ongoing regulatory and reform programs.

[50] AEMO, Frequency Control Work Plan, September 2020, available at https://aemo.com.au/-/media/files/electricity/nem/system-operations/ancillary-services/frequency-control-work-plan/external-frequency-control-work-plan.pdf?la=en.

# 4. Next steps

The findings of the RIS Stage 1 report have far-reaching implications for the energy sector in Australia, and highlight that industry needs to collaboratively address the collective challenges of operating the NEM now and in the coming years.

The next stage of the RIS is currently in the scoping stage and AEMO anticipates an update on this integrated roadmap by January 2021. Details will be shared on the website[51] and stakeholders can also receive the latest updates via AEMO's RIS mailing list. To be added to this list, stakeholders can email FutureEnergy@aemo.com.au.

As a first step in this integrated roadmap, AEMO's Frequency Control Work Plan has been published in September 2020. The early release of this plan is to provide immediate visibility on AEMO's current frequency control work to inform industry, and the current AEMC and ESB processes.

Table 5 lists key planned RIS publications. As plans for the next stage of the RIS mature, AEMO will share additional information on ways to get involved and plans for interim publications prior to the final roadmap.

**Table 5 RIS publications**

| Publication | Description | When published/expected |
|---|---|---|
| **Frequency Control Modelling Report (DIgSILENT Report)** | Report on frequency control modelling: Investigation of ramp impacts on frequency control in the NEM under high VRE penetration. This subsequent report was mentioned in the RIS Stage 1 Appendix B (frequency management) and C (variability and uncertainty). | Published September 2020 (see AEMO website here) |
| **Frequency Work Plan** | Delivery of the frequency control workplan, as detailed in the RIS Stage 1 recommended action 4.2. | Published September 2020 (see AEMO website here) |
| **RIS Integrated Roadmap update** | - | By January 2021 |
| **Advanced inverter white paper** | Investigation into how advanced power electronic functionality could be used to overcome system challenges. What is the current technology status? What is the trajectory? What are the roadblocks? | Early 2021 |
| **RIS Integrated Roadmap update** | - | Mid-2021 |

[51] At https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

# A1. Summary of submissions and AEMO responses

## A1.1 Summary of submissions on support for the RIS

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| 1. | AGL | AGL acknowledges the challenges identified by AEMO, specifically the dispatchability and predictability of a power system with increasing levels of variability and uncertainty. | Noted. See Section 3.1. |
| 2. | AusNet Services | AusNet Services strongly supports RIS-1 focus on maintaining power system security as we look forward to operating the system with increasingly higher penetrations of wind and solar generation. The actions recommended in the RIS-1 are crucial and urgent. | Noted. See Section 3.1. |
| 3. | CitiPower, Powercor, United Energy | We support many of the recommended actions identified by AEMO as the National Electricity Market (NEM) transitions to operating with an even higher share of renewable resources, while maintaining system security now and in the future. | Noted. See Section 3.1. |
| 4. | Energy Australia | EA, therefore, appreciates AEMO's efforts to provide a foundational engineering perspective with which to inform future NEM investment, design and operation. In the face of world-leading wind and solar generation penetration, the RIS represents a crucial, technical piece of the national planning puzzle with critical implications for many current and ongoing NEM reforms. | Noted. See Section 3.1. |
| 5. | Energy Networks Australia | Energy Networks Australia supports AEMO's work in assessing the technical limits and requirements of the power system under future scenarios that are critical to maintaining secure electricity supply to all consumers. | Noted. See Section 3.1. |
| 6. | Enova | We congratulate AEMO on the essential work it is carrying out to "identify futures for the NEM that maximise consumer benefits at the lowest system cost while meeting reliability, security, and emissions expectations. We also applaud the recognition that "the NEM's least cost future features large increases in renewable generation" including distributed solar photovoltaics (DPV) installed by households and businesses as a significant and growing part of the mix. We also recognise the need to identify action to be taken to ensure the NEM can be operated securely at up to 75% instantaneous penetration of wind and solar by 2025. | Noted. See Section 3.1. |
| 7. | Lloyd's Register | It is our view that the RIS provides a valuable framework for consideration by the entire industry of system technical issues arising from the high penetration of renewable energy, with Australia's National Electricity Market at the forefront of global developments in this area. In particular it contributes to AEMO's ongoing | Noted. See Section 3.1. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| | | Integrated System Plan process and underpins the contemplated move to a future 100% renewable electricity system. | |
| 8. | Solar Citizens | Solar Citizens supports sensible measures that allow for a greater uptake of rooftop solar. We appreciate that AEMO is seeking to avoid the implementation of stricter regional hosting capacity limits with the actions outlined in the Renewable Integration Study. | Noted. See Section 3.1. |
| 9. | Third Equation | We agree with AEMO's recognition of solar energy as having great potential as a significant part of Australia's energy mix. Australia could regularly generate far beyond its consumption needs, despite being currently subject to curtailment. To do so, it must overcome existing system design limits and constraints. For the NEM to be able to rely on DPV it must have supporting technologies and localised resilience built in. | Noted. See Section 3.1. |

## A1.2 Summary of submissions on alignment with AEMO's ISP

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| 10. | AGL | The inputs and assumptions from the Draft ISP's projections are taken as given in the RIS analysis. AGL encourages AEMO to consider the adjustments to the inputs and assumptions between the Draft and Final ISP and how this might impact the RIS.<br>The RIS modelling relies heavily on the inputs and assumptions from the Draft ISP. We note that any significant changes made between the Draft and Final ISP will likely influence RIS outcomes. AGL encourages AEMO to consider the adjustments to the inputs and assumptions between the Draft and Final ISP on the possible modelling implications and how this might impact the RIS analysis. | Updates to the ISP between the Draft and Final did not materially impact the outcomes in the first five years (out to 2025), which is the timeframe covered by the RIS.<br>The RIS Stage 1 highlighted that all components of the action plan should start immediately.<br>See Section 3.2. |
| 11. | Energy Australia | As witnessed this year when the RIS was published after the Draft 2020 ISP had been released, this runs the risk that late publication of the RIS leaves insufficient time for considered stakeholder deliberation and appropriate integration within the Final ISP.<br>To remedy this situation, EA suggests that the RIS is integrated within the ISP process. | AEMO envisages a feedback loop between the RIS and ISP. While the RIS and 2020 ISP were published in quick succession, AEMO does not foresee such a tight timeline between the RIS and ISP in any subsequent iterations. See Section 3.2. |
| 12. | Energy Networks Australia | When the study commenced in mid-2019, the initial assumptions included the 2018 ISP neutral scenario generation mix and certain network configurations based on Group 1 ISP projects and Project Energy Connect.<br>AEMO is about to release the mid 2020 ISP in late July. Energy Networks Australia note that there have been a number of energy policies released recently that may impact the Final 2020 ISP. There may be benefit in AEMO reviewing the RIS workplan and priorities, in relation to the generation mix and network configurations in the Final 2020 ISP, to ensure that actions are commissioned in the power system in a timely manner. | AEMO views the challenges identified in the RIS Stage 1 as agnostic to timing. Further, the RIS Stage 1 highlights that all recommendations need to start immediately, regardless of lead time, so that they can be enabled when needed. See Section 3.2. |

## A1.3 Summary of submissions on a cost-benefit analysis

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| **13.** | AGL | We would recommend that AEMO commission appropriate cost benefit analysis of these proposed actions, to accurately understand the potential impact of these solutions to customers and the anticipated market benefits. | Noted.<br>AEMO's position is that costing questions arising from the RIS should be explored in existing processes, including AEMO's ISP, and regulatory processes run by the ESB and AEMC. Further detail on these processes is available in Section 3.3.2. |
| **14.** | Energy Australia | The ISP objective is to provide a whole-of-system plan to maximise net market benefits and deliver low-cost, secure and reliable energy across a complex range of plausible energy futures to 2040. However, EA questions how this can be achieved if the technical implications of the RIS, particularly the costs of remedial actions associated with managing system security under various ISP scenarios, are not considered as part of the ISP process. That is, how can AEMO, market participants and customers be confident that an alternate ISP pathway that includes lower wind and solar penetration, with commensurately lower remedial system security costs, does not have higher overall net market benefits?<br>This question highlights two areas for immediate action. First, RIS recommendations critical to maintaining system security under different ISP scenarios must be costed.<br>Second, these costs must be included as part of the overall ISP net market benefits assessment. Doing so will obviate the risk that ISP pathways and RIS recommendations are pursued at any cost and will thereby help to ensure that the ISP objective and the National Electricity Objective (NEO) are both met. | Noted. Section 3.3.2 details where RIS recommendations are included in the 2020 ISP. |
| **15.** | Energy Networks Australia | We recommend that any proposed solution not only be tested with consumers and NSP's directly, but also fully consider the costs and benefits of any solution before its implemented. This is essential given the requirements of the NEO to ensure that activities are in the best long-term interests of consumers. | AEMO agrees that the costs and benefits of any solution should be tested with industry and against the NEO, before it is implemented.<br>AEMO believes that the market reform processes run by the AEMC and ESB provide the forum to ensure that specific solutions are rigorously tested and are in the best interest of consumers. |
| **16.** | Essential Energy | The report references the aim for SCADA visibility of all new commercial scale systems >100kW – again, this will come at a cost and may not provide long term value for customers. Essential Energy suggests SCADA visibility is more useful when targeted on a location basis (where constraints are known/expected issues) rather than a blanket condition across all sites.<br>It is also not clear in the report whether the information will be provided by an aggregator or by the DNSP.<br>It is imperative that a comprehensive cost benefit analysis of the RIS is undertaken to ensure customers are not paying more than is required to access the NEM. | AEMO acknowledges that there will be a cost incurred to uplift the visibility capabilities. However, the intent of increased visibility is to reduce costs for customers, as it enables the system operator to act less conservatively in operating a power system with high penetrations of DER.<br>Specific locational visibility requirements will be developed in conjunction with the local DNSP to ensure that a cost-effective solution is put forward. |

## A1.4 Summary of submissions on emergency DPV generation curtailment capabilities

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| **Emergency generation curtailment capabilities for DPV** | | | |
| **17.** | AGL | While we appreciate the need to better manage DER for the benefit of all consumers, we believe that control approaches to customer assets should only be applied in rare instances where services cannot be procured through a market framework. | See Section 3.4.1 Emergency Backstop Mechanism. |
| **18.** | Planet Ark | Planet Ark Power supports prosumers only being curtailed during extreme, abnormal system conditions or events ("back stop").<br><br>Under current arrangements, DER curtailment will only impede the transition of Australia's energy networks to a cleaner energy future. It is understandable that network operators must prioritise the safety and security of electricity infrastructure and services to provide all consumers with a consistent, reliable product. However current responses to increasing DER is resulting in higher electricity prices due to the ongoing investment in energy infrastructure upgrades to enable more DER primarily from the residential sector, to be exported into local networks.<br><br>Would welcome the opportunity to Contribute to the development of any DPV generation shedding capabilities discussions and/or technical requirements deemed necessary to support the electricity system transition to renewables through to 2025 during extreme, abnormal system conditions (''back stop"). | See Section 3.4.1 Emergency Backstop Mechanism.<br><br>See Section 3.4.3 Emergency DPV generation curtailment capability.<br><br>See Section 3.4.1 Further Information. |
| **19.** | Solar Citizens | Solar Citizens supports sensible measures that allow for a greater uptake of rooftop solar. We appreciate that AEMO is seeking to avoid the implementation of stricter regional hosting capacity limits with the actions outlined in the Renewable Integration Study. However, we are concerned about the ramifications of Action 3.4, which enables generation shedding capabilities for new DPV installations in South Australia.<br><br>Furthermore, AEMO must be transparent about the circumstances in which generation shedding will be allowed to occur. Curtailing household solar generation should be an absolute last resort and only utilised in emergency situations. It's important that this rule change is rigorous in design and cannot be exploited by third parties who would profit from less solar energy in the system. | See Section 3.4.1 Emergency Backstop Mechanism.<br><br>See Section 3.4.3 Emergency DPV generation curtailment capability.<br><br>AEMO has invited Solar Citizens to join its regular Consumer Advocate panel, with the intent to keep their members informed about AEMO's program of works including on emergency DPV generation curtailment. |
| **20.** | Solar Citizens Consumer 'Supporters' | 575 submissions were received from the Solar Citizens Consumer 'Supporters'. Key themes from these submissions included:<br>• "Curtailment should only be done in an emergency and as a last resort"<br>• "Rooftop solar must only be curtailed in emergency situations as a last resort measure and there needs to be transparency about how frequently this is likely to happen."<br>• "Your plans for emergency Power maintenance need to be more progressive and forward thinking with a concentration on the stability of renewables." | See Section 3.4.1 Emergency Backstop Mechanism.<br><br>See Section 3.4.3 Emergency DPV generation curtailment capability. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| | | • "Climate change is here now. Measures which will make the adoption or retention of rooftop solar less attractive will reduce its adoption at the very time we need greater numbers of households using this resource."<br>• "We should be supporting those who are helping our country move towards a cleaner energy future and away from polluting fossil fuels."<br>• "The process needs to be carefully regulated by an independent consumer representative to be sure it is not used to reduce contributions to the grid other than in emergency." | |
| **Alternate measures to generation curtailment** | | | |
| **21.** | AGL | We would welcome further consideration of market-based approaches, including through the Distributed Energy Integration Program (DEIP) Market Development Working Group.<br>We would also recommend further assessment of alternative management strategies, including market-based solutions, which may prove more cost efficient in delivering appropriate grid-support benefits. | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **22.** | AGL | In addition to the insights developed on DPV, we would recommend further analysis on the potential for energy storage and EV's to provide grid support services for the benefit of all energy consumers, through orchestration and managed charging.<br>To ensure 'no regrets' regulatory and market changes, we also support industry and market participants trialling and piloting innovative technologies and business models in Australia's energy markets. | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **23.** | Energy Australia | Further investigation might also be undertaken into RIS recommendations 3.4 and 3.5. These combined recommendations would see AEMO working with industry to increase standards and visibility of Distributed Energy Resources (DER) to enable remote curtailment of DER generation. As highlighted in a recent Energeia report, however, there may be other, alternative solutions that are cheaper from a whole of system perspective. | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **24.** | Energy Queensland | With the increasing decentralisation of the energy supply chain it is critical that documents like the Integrated System Plan (ISP) and the RIS consider both Distribution Network Service Provider (DNSP) and supply side solutions to help address these challenges. We believe that there is a range of additional DNSP solutions not currently considered in the RIS that could be implemented in Queensland, to help address some of the identified issues. We look forward to exploring these with AEMO in the next iterations of the RIS work plan. | See Section 3.4.3 Alternatives to emergency DPV curtailment and Distribution network considerations. |
| **25.** | Enova | As a community scale energy retailer focussed on working with communities, and with a customer base which is already 60% solar PV enabled, we would like to see more recognition of (and support for) the results that can be achieved through the development of sub-regional (in AEMO's terms) | See Section 3.4.3 Alternatives to emergency DPV curtailment. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| | | self-sufficiency including storage i.e. enabling regions within states to move to near complete self-sufficiency.<br><br>So, for example, we would argue that sub-regions e.g. the Northern Rivers of NSW, could be developed, in which streets and small towns share storage; embedded networks, microgrids and virtual power plants operate; energy efficiency and demand management technologies are effectively implemented; local investors own community generation assets; and hospitals, airports and local industry are served with local generation and storage (with whatever appropriate combination of pumped hydro, solar, wind, hydrogen and bioenergy).<br><br>In summary, our case is that rather than seeking to implement actions required to control and curtail passive solar in the near term future, as penetration increases, AEMO should act to facilitate individuals in communities taking control of their power and shifting from a passive to an active approach. | |
| **26.** | ERLPhase | AEMO will benefit with having intelligent devices that will monitor the system in real time, provide real time data to a dispatch center and provide operational features with the intention of maintaining power system security while operating this resource mix at very high instantaneous penetrations of wind and solar generation.<br><br>This will be needed to maintain the proper operation of the National Electricity Market, and maximize consumer benefits at the lowest system cost, while meeting reliability, security, and emissions expectations | Noted. |
| **27.** | Essential Energy | Could load be switched on (i.e. network controlled load) rather than generation shedding to achieve the same outcome? In addition, tariff reform and connections standards reform could be used to grow load and generation DER base capability, potentially through a multi-staged approach based on cost and time to achieve. | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **28.** | Third Equation | We agree with AEMO's action to incorporate aggregators more extensively as part of the decentralisation of identification of solutions for stability services. Price signals and incentives to aggregators and market participants creates a framework for innovation in a low certainty environment. | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **29.** | Gail Warman (consumer) | Storage is the key to making the most of renewable electricity. | Noted. |
| **30.** | Planet Ark Power | Whilst the focus of the RIS Stage 1 is one of introducing new layers of integration for PV and wind with AEMO and DNSPs, we suggest that there are other factors that need to be considered to help overcome the issues outlined in the report. For example: | See Section 3.4.3 Alternatives to emergency DPV curtailment. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| | | • Leverage National Grid market concepts from the UK that have introduced 12 new market signals such as capacity needs for batteries to support the national electricity system - employing both short and long duration storage.<br>• Change tariff structures to encourage additional load during solar producing hours.<br>• Re-adjust load control schedules to align with solar production and act as a solar soak; and<br>Enable customers to island in times of network emergencies, to provide self-sufficiency and value whilst meeting grid needs. | |
| **31.** | Solar Citizens | From a fairness perspective, homes and businesses with solar should not incur a financial burden because of regulatory failures. It's vital that AEMO continues to encourage the implementation of solutions, such as battery storage and demand response, to overcome the issues associated with an increase of rooftop solar. | See Section 3.4.1 System need and recommendation.<br>See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **32.** | Solar Citizens Consumer 'Supporters' | 575 submissions were received from the Solar Citizens Consumer Supporters. Key themes from these submissions included:<br>• "There are more effective ways to overcome grid issues … AEMO must focus on driving the implementation of household and community-scale battery storage, demand management and other market incentives that encourage solar owners to increase their electricity usage during the daytime."<br>• "You need to look at storage options."<br>• "Other measures such as encouraging community networks and batteries will be much more beneficial than the draconian measures that are proposed."<br>• "Perhaps the electricity providers could spend some money upgrading the grid to help ease the problems they are concerned about, rather than penalise people who are trying to do the right thing." | See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **Consumer impacts** | | | |
| **33.** | AGL | Consumer impacts should also be appropriately considered and quantified together with greater market reforms, to ensure that DER can effectively participate in the broader energy market system where customers choose to offer control of their asset or orchestrated services. In developing proposed actions, we would recommend that AEMO commission a formal cost benefit analysis, to ensure that the impact of proposed solutions to DER customers is appropriately valued. | See Section 3.4.3 Consumer Impacts. |
| **34.** | Gail Warman (consumer) | I am concerned that AEMO's proposal to engage in generation shedding is wasteful and will disproportionately affect DPV and other renewable generators, many of whom are householders who, at considerable expense, have installed renewable collectors to offset their electricity costs. | See Section 3.4.1 System need and recommendation. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| **35.** | Planet Ark Power | The principle we support is that customers' investments should not be put at risk by frequent curtailment that negatively impact on returns-on-investment and also not to introduce increased risk through the introduction of new rules/regulations that reduces the attractiveness of investing in cheaper, clean renewable electricity (DPV-DER).<br>Planet Ark Power offers a cheaper alternative by dynamically managing network stability (eg voltages) and increasing the renewable energy hosting capacity of existing network infrastructure to host much more DER than network operators currently allow. | Noted.<br>See Section 3.4.1 System need and recommendation.<br>See Section 3.4.3 Alternatives to emergency DPV curtailment. |
| **36.** | Solar Citizens | Their personal investment in clean energy technology has helped lower the wholesale price of electricity, reduced network costs, and provided health benefits to the community by lowering pollution. It stands to reason that increasing the amount of rooftop solar generation, if done correctly, is to the benefit of all electricity consumers. | See Section 3.4.1 System need and recommendation. |
| **37.** | Solar Citizens Consumer 'Supporters' | 575 submissions were received from the Solar Citizens Consumer Supporters. Key themes from these submissions included:<br>• "We believe those who have PV installed will be unfairly penalised by this action."<br>• "We are diving headlong into a recession, the poor, young and the elderly will be particularly adversely impacted. The last thing we need now is to increase costs on people that can least afford it."<br>• "I have made a considerable financial sacrifice to just get solar power before I retire in September this year. I will be on a full pension after this. I have attempted to reduce my carbon footprint considerably by getting double glazing, not driving my car unless absolutely essential and now getting solar. I think that the AEMO should be transparent about overriding my solar power to stabilise the grid, and using other means to stabilise the grid so that I, and many other solar uses who are on a low, fixed income, are not penalised financially, when saving money was a big (possibly main) incentive to get solar in the first place."<br>• "Curtailing input on top of this would be an added impost on those who are driving the transition to renewables and helping deal with the climate change challenge from fossil fuel emissions." | See Section 3.4.1 System need and recommendation.<br>See Section 3.4.3 Consumer impacts. |
| **Distribution network considerations** | | | |
| **38.** | CitiPower, Powercor, United Energy | The need for system strength in distribution networks should be recognised due to the potential impact of connections to the distribution network on the transmission system; and the increasing level of both large scale (>30MW) and small scale non-synchronous generation (<5MW), as well as residential/commercial/industrial rooftop PV and battery systems connected to the networks. | In the current process for assessment of system strength, AEMO is responsible for identifying the key transmission nodes and levels. These levels account for the minimum fault levels required for security on the transmission and distribution system. This is what is shown in the RIS as the system strength limits. Under the current do no harm framework new connecting generators are required to remediate for their own system strength above the minimum levels. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| | | | These frameworks are currently under review by the AEMC and we would encourage participation in this process to identify challenges with existing frameworks and new potential regulations to solve. |
| 39. | Energy Queensland | Any consideration of changes to DER operation requires close consideration by the local network, who retain the responsibility for these connection arrangements and the local network operation and performance outcomes. | See Section 3.4.3 Distribution network considerations. |
| 40. | Energy Networks Australia | The challenges of integrating renewable generation, particularly residential and smaller-scale solar PV, are not uniform across Australia or indeed a given NSP area. Solutions must therefore be developed with NSPs since they will have the best understanding of the local impact of system-level centrally designed options. | Agreed. See Section 3.4.3 Distribution network considerations. |
| 41. | Essential Energy | It is expected that the cost impacts on rural distribution networks of the RIS are likely to be significant; given the visibility and communication issues with DER, the variety of DER assets connected, the size of the DER generation investments, and the lower customer base to pay for the changes. It is imperative that a comprehensive cost benefit analysis of the RIS is undertaken to ensure customers are not paying more than is required to access the NEM. Anything that furthers the divide between rural and urban customers on the basis of cost or access to different products or services should be very carefully considered. | See Section 3.4.3 Distribution network considerations. |

## A1.5 Summary of submissions on future RIS work

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| 42. | AGL | The power system's ability to respond to increasing ramping requirements as the RIS has identified, depends heavily on interconnector headroom. Therefore, AGL encourages AEMO to ensure that the next version of the RIS reflects this position. | Noted. |
| 43. | AGL | AGL, through our engagement with the AEMC's System Strength Review understands that there is no commonly accepted definition of 'System Strength' and what it means in the NEM context. The AEMC's newly formed technical working group is working through this issue. The findings and conclusions from the AEMC's review will likely impact the current position put forward in the RIS. AGL encourages AEMO to actively participate in the Review and ensure that the next iteration of the ISP and RIS appropriately reflects its decision. | AEMO is currently engaging in the AEMC's System Strength Review and will reflect outcomes of this review. See Section 3.5. |
| 44. | AGL | AGL considers this [PFR] rule change to have a significant impact on overall frequency management in the NEM, and even though theoretical implications are somewhat considered, actual power system performance with PFR enabled has not been considered in the RIS. AGL recommends considering the impacts of PFR as part of stage 2 of the RIS. | AEMO is pleased to receive the recommendations regarding the next stage of the RIS. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
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| | | Further, AGL believes that the decline in load relief should be addressed at both the generation and load side. | See Section 3.5.2 on response on PFR outside of FCAS and control of frequency under normal conditions and response on load relief. |
| **45.** | CitiPower, Powercor, United Energy | We recommend further actions above what is proposed in the RIS, focused more towards the immediate challenges of modelling the changing generation mix and improved provision of information to both current and intending participants, and network service providers (NSPs).<br>AEMO are currently the only body in the NEM with access to the NEM-wide picture of committed and proposed new generation connections that will impact system strength. Actions to facilitate quicker and more transparent access to this information will aide all NSPs in more efficiently facilitating integration of new projects for participants. The current process lacks transparency and can incur significant delays for proponents with a high probability of multiple re-assessments due to the lack of transparent information. | AEMO is working collaboratively with NSPs to bring more efficiency and transparency to the connection process. |
| **46.** | Energy Australia | EA agrees and considers that investigation into the impacts of Project EnergyConnect should be a high priority.<br>Given the high impact of interconnector headroom on system ability to respond to ramping requirements, understanding potential limitations under different network configurations will be critical to maintaining a secure power system. | Noted. See Section 3.5. |
| **47.** | Energy Australia | The RIS variability and uncertainty analysis looked at system ramping and forward-looking forecast error. However, deviations to forecast on a dispatch interval basis were not evaluated.<br>This omission may be explained by a purported, forthcoming paper that will speak to balancing requirements. However, to the extent that this does not appear in a timely fashion, or address headroom implications, EA suggests that further RIS investigation into frequency management be expedited. | This work was published September 2020. |
| **48.** | Energy Networks Australia | From a transmission perspective, we note that system strength and inertia shortfalls have been declared in many NEM States. Improved coordination of system strength (and inertia) in a proactive, forward looking manner aligned to the ISP would be beneficial. | AEMO agrees that improved coordination of system strength and inertia that is aligned to the ISP would be beneficial, as noted in the 2020 ISP Appendix 7. See Section 3.5. |
| **49.** | Highview power | I can see Frequency, Short Circuit level, Voltage and Inertia well covered in the RIS Stage 1 report. However, I couldn't find your views on challenges posed by Rotor Angle Stability scarcities. I see with concern that most system operators see Synchronous Condensers as a solution for inertia and other stability issues. The only grid operator that has published analysis on this matter is ERCOT and lately EirGrid is performing more studies. | AEMO is pleased to receive the recommendations regarding further areas of study. While angular stability was not a focus of the RIS Stage 1 report, angular stability is routinely studied as part of a number of processes across AEMO's functions, and will be included in future areas of study relating to the resilience of a high renewable future system to complex system events. |
| **50.** | Lloyds Register | Our recommendation is the broadening of this approach to consider not only the adaptation of the NEM system to conditions of low system inertia, but also to operation with more varied sources of inertia, including non-mechanical sources. | Noted. AEMO is currently scoping and commencing areas of further study of the latest advancements in inverter technology. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
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| | | Our submission has outlined a technical case that system inertia, as a practical service that limits the short-term RoCoF for frequency disturbances, should not be regarded as fundamentally a mechanical concept but rather as an analogue to a mechanical concept. | |

## A1.6 Summary of submissions on integration with other industry processes

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| 51. | AGL | The RIS also provides recommendations to address a range of technical issues that have been identified. AGL encourages AEMO to focus its efforts on analysing these issues and to provide valuable operational input into the implementation of regulatory reform processes determined by the ESB and AEMC, rather than identifying an AEMO preferred solution. | See Section 3.6. |
| 52. | Energy Australia | There are numerous rule changes and reforms on foot or slated to begin soon, that bear on the integration and coordination of increasing VRE penetration in the NEM. … Lacking further technical insight that would be provided by additional RIS investigation, the risk is that sub-optimal regulatory outcomes result. Given this risk, EA contends the proposed 12-month delay before RIS stage two work is to begin is far too long. EA, therefore, strongly suggests that second stage RIS investigations are expedited to help inform and enable an effective, efficient energy market transition. | Noted. See Section 3.6. |
| 53. | Essential Energy | Essential Energy is supportive of such significant issues as renewable integration being dealt with through whole of industry action plans, rather than via individual rule change requests, with any changes paced to meet the circumstances prevailing in each individual network (including differences in the level of penetration of DER and the level of digital maturity) and taking account of the cost of change to customers. | Noted. See Section 3.6 and Section 4. |

## A1.7 Summary of submissions on stakeholder engagement and consultation

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| 54. | AusNet Services | AusNet Services appreciates AEMO's stakeholder engagement throughout the development of the RIS-1 and the industry briefings following publication of the Stage 1 report. | Noted. |
| 55. | Energy Australia | Regular, integrated reports on priority issues, based on stakeholder interest or known ISP limitations should be included. By better coordinating and prioritising investigation of the technical considerations relevant to the ISP, AEMO and stakeholder resource efficiency will be maximised. More importantly, confidence in ISP modelling results will be enhanced, thereby strengthening signals for efficient investment. | Noted.<br>Section 4 on next steps notes AEMO's commitment to stakeholder engagement for the next stage of the RIS and providing regular information on updated, including, where appropriate, integrated reports on priority issues. |

| No. | Stakeholder | Comment/recommendation | AEMO response |
|---|---|---|---|
| **56.** | Energy Networks Australia | Where AEMO is leading workstreams (as opposed to ESB) there is benefit in AEMO providing a more detailed plan on how stakeholder engagement including with consumers, will be undertaken. This stakeholder engagement plan should indicate the method of engagement and timing of any engagement.<br>Engagement should also occur throughout the work, not only on completion. Communications should be clear and use approachable language suitable for non-technical audiences.<br>Many of the solutions proposed in the RIS have major impacts on consumers and delivering clarity on the approach in all public communications would avoid unnecessary alarm. | AEMO acknowledges that there was limited opportunity for stakeholder feedback during development RIS Stage 1. Going forward, AEMO would like to ensure that the next stage of the RIS is as collaborative and engaging as possible.<br>AEMO has committed to develop a roadmap for the secure transition to higher penetrations of wind and solar in the NEM by Q2 2021. The intent of this roadmap is to, in part, assist with visibility of forward priorities.<br>See Section 3.7. |
| **57.** | Essential Energy | In the RIS report, Table 7 – 'Summary of DPV integration issues experienced by DNSPs', appears to be out of date for Essential Energy, with impacts only shown in five areas. The business is now being impacted in significantly more areas by these issues. For completeness, please ensure that the following areas are also included to reflect DPV integration impacts for Essential Energy:<br>– Distribution substation transformer - tap setting;<br>– Distribution substation transformer - thermal capacity;<br>– Zone substation feeder - voltage regulation;<br>– Zone substation transformer - tap range;<br>– Zone substation transformer - voltage set point; and<br>– Subtransmission transformer - voltage set point. | AEMO acknowledges the feedback from Essential Energy on Table 7 of the RIS Stage 1 report. This was based on engagement with Essential Energy in May-June 2019. Subsequent iterations of this table will include the additional areas identified. |
| **58.** | Solar Citizens Consumer 'Supporters' | The large number (575) of submissions by individual householders is highly unusual for an AEMO technical study, and illustrates a requirement for AEMO to uplift our engagement with consumer advocates and end-users of rooftop solar. | AEMO is uplifting its engagement activities and increasing its focus on consumer-centric communications. |