AEMO SERVICES

2022 Infrastructure Investment Objectives Report

December 2022

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VERSION CONTROL

Version	Release date	Changes
1.0	2 December 2022	Initial release.

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Summary

At a glance

- This report does not amend the timing or indicative size of Tender 1 in Q4 2022.
- A tender will be held in Q2 2023 for an indicative amount of 380 MW of firming infrastructure located in the Sydney-Newcastle-Wollongong sub-region.
- A new tender for long-duration storage has been scheduled for Q2 2023 to coincide with the firming tender, with its indicative size contingent on the outcomes of Tender 1.
- There are no other changes to the generation and long-duration storage elements of the Development Pathway and 10-Year Plan from the 2021 IIO Report.
- At this stage, a draft 2023 IIO Report is expected to be published for consultation in Q1 2023.

AEMO Services, as the Consumer Trustee under the *Electricity Infrastructure Investment Act 2020* (NSW) (EII Act), has been directed by the NSW Minister for Energy to conduct a competitive tender for long-term energy services agreements (LTESAs) for firming infrastructure (Firming Direction).[1]

As set out in this report, the Consumer Trustee intends to conduct a tender in Q2 2023 for an indicative amount of 380 MW of firming infrastructure. This infrastructure must be located within the Sydney-Newcastle-Wollongong sub-region[2] identified in AEMO's latest Inputs, Assumptions and Scenarios Report.[3]

The firming infrastructure, including its location, is necessary to address a forecast gap in firm capacity required to meet the NSW energy security target from 2025-26 as a result of the earlier than previously scheduled closure of the Eraring Power Station.[4] This forecast gap was identified in AEMO's latest Energy Security Target Monitor (ESTM) Report [5] and has been the subject of updated modelling for the purposes of this report.

This Infrastructure Investment Objectives Report (IIO Report) follows the 2021 Infrastructure Investment Objectives Report (2021 IIO Report), which was published in December 2021.[6] The Consumer Trustee is required to exercise certain functions – including conducting competitive tenders – on the basis of the IIO Reports it prepares. [7] As discussed below, the Consumer Trustee has updated the Development Pathway and 10-Year Plan for competitive tenders from the 2021 IIO Report (which covered generation and long-duration storage infrastructure) to also include the firming infrastructure described above. Accordingly, this report reflects the latest Development Pathway and 10-Year Plan, and prospective participants in the competitive tenders should now have regard to this report.[8]

1. The Firming Direction was issued under section 47(2) of the EII Act.
2. Projects located outside (but in close proximity to) this sub-region may also be eligible if they are able to demonstrate their contribution to meeting the energy security target.
3. AEMO (July 2021), *2021 Inputs, Assumptions and Scenarios Report*, https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-inputs-assumptions-and-scenarios-report.pdf.
4. See EII Act, Part 3.
5. AEMO (May 2022), *Energy Security Target Monitor Report*, https://www.energy.nsw.gov.au/sites/default/files/2022-08/2022-energy-security-target-monitor-report.pdf.
6 AEMO Services (December 2021), *Infrastructure Investment Objectives Report*, https://aemoservices.com.au/-/media/services/files/publications/iio-report/2021/iio-report-2021.pdf?la=en.
7 EII Act, section 45(6).
8 This report sets out the methodology for designing the firming element of the Development Pathway and 10-Year Plan, and the rationale for retaining the generation and long-duration storage elements from the 2021 IIO Report. The rationale and methodology underpinning the generation and long-duration storage elements are contained in the 2021 IIO Report.

Development Pathway

As noted above, the Consumer Trustee has retained the generation and long-duration storage infrastructure elements of the Development Pathway from the 2021 IIO Report and added 380 MW of firming infrastructure as described above. Reflecting the passage of time since the last report, the Development Pathway now runs from 2023-24 to 2042-43.

The Consumer Trustee considers retention of the generation and long-duration storage elements of the Development Pathway in the 2021 IIO Report (2021 Development Pathway), with the addition of firming infrastructure in response to the Firming Direction, to be in the long-term financial interests of NSW electricity customers for the following reasons:

- For the next decade, the 2021 Development Pathway and corresponding 10 Year Plan, represents a sufficiently contemporary view of a cost-minimised pathway, given that it was produced in the last 12 months and supply chain constraints are expected to constrain the development of new generation infrastructure beyond that contained in the 2021 IIO Report.
- For the second decade to 2043, as noted in the 2021 IIO Report, the build trajectory is subject to significant uncertainty. This uncertainty is particularly driven by the potential for material increases in demand for electricity in that decade as a result of electrification and by recent announcements such as the decision by AGL Energy to bring forward the retirement of its Loy Yang A Power Station by 10 years to 2035.[9] These developments indicate that additional generation infrastructure is likely to be required, and the Consumer Trustee will explore this further in the 2023 IIO Report.
- The 2021 Development Pathway was designed to be resilient to market changes, such as early coal withdrawal.
- Retaining the 2021 IIO Report elements provides certainty to the market regarding the first tender for LTESAs, which commenced on 4 October 2022, and thereby supports greater competition in that tender (which should drive improved cost outcomes).
- The Consumer Trustee considers that the 2021 Development Pathway and the underpinning assumptions are best tested through the conduct of:
  - competitive tenders for built energy, and
  - procurement processes for network infrastructure projects such as the Waratah Super Battery and the Central-West Orana renewable energy zone, which are currently being conducted by the Energy Corporation of NSW (EnergyCo).

Market information collated through these processes will provide new information which will then be used to develop the 2023 IIO Report.

9 AGL Energy (September 2022), *Outcomes of Review of Strategic Direction and FY23 earnings guidance*, https://cdn-api.markitdigital.com/apiman-gateway/ASX/asx-research/1.0/file/2924-02574155-2A1401683?access_token=83ff96335c2d45a094df02a206a39ff4.

The Development Pathway for firming, generation and long-duration storage infrastructure is set out in Figure 1, Figure 2 and Figure 3 below. Figure 2 includes a representation of the amount of generation infrastructure committed since November 2019[10] that can be expected to contribute to the Development Pathway.

Figure 1: Development Pathway (Firming - Annual)

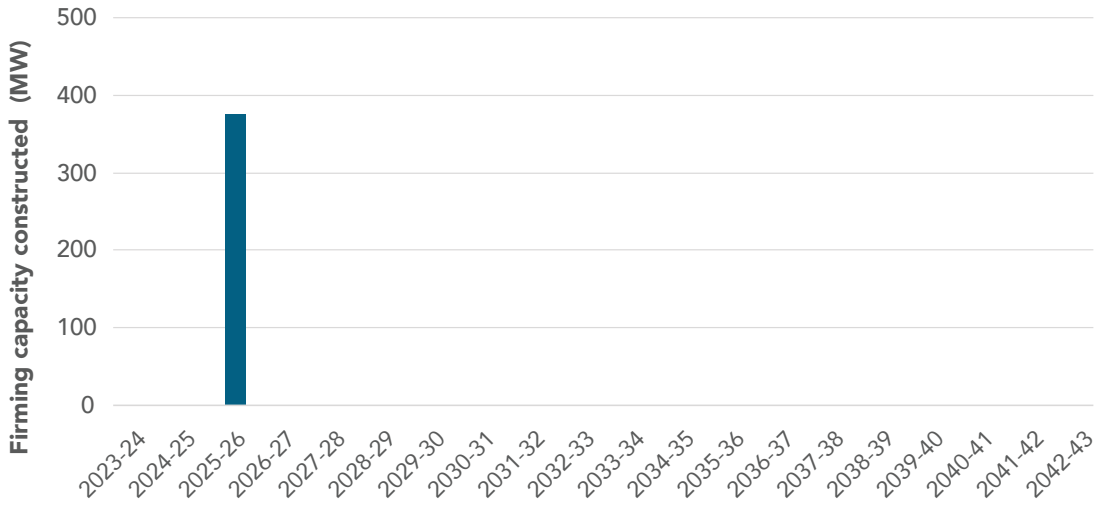
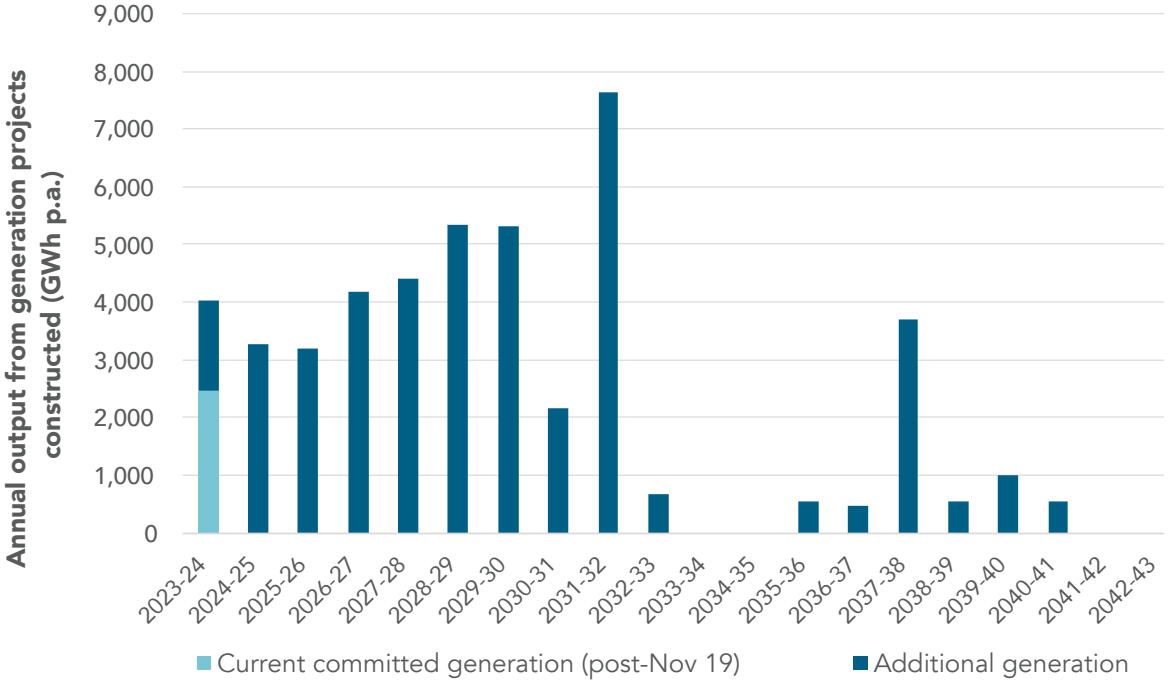
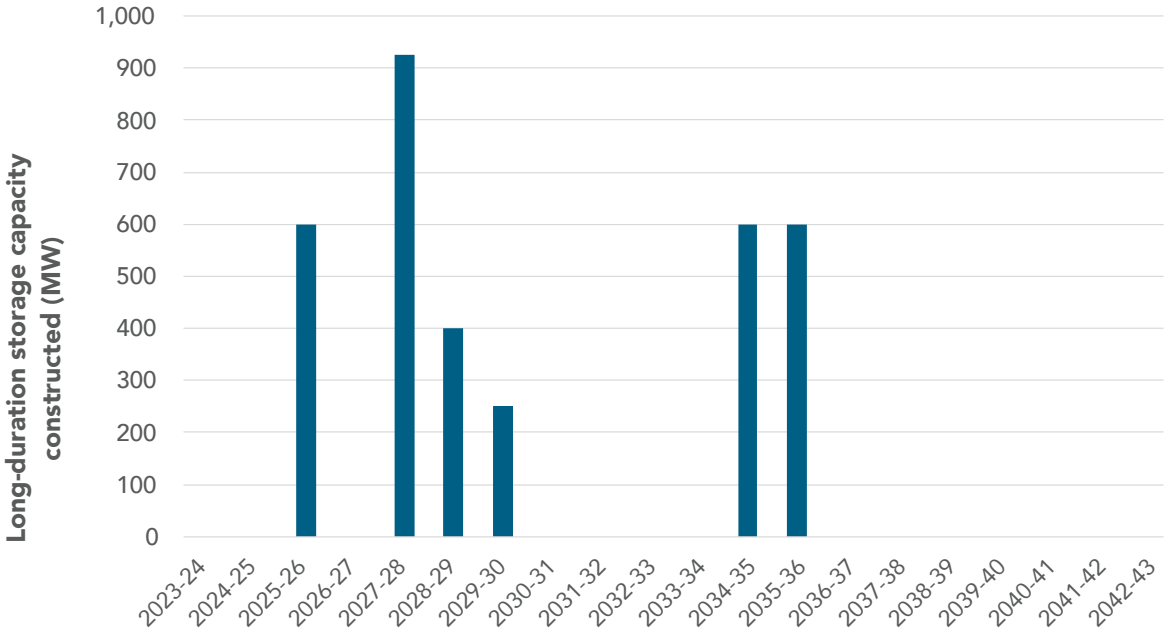


Figure 2: Development Pathway (Generation - Annual)



10 Under EII Act, section 43(2), infrastructure that was committed on or before 14 November 2019 does not count towards the achievement of the infrastructure investment objectives.

Figure 3: Development Pathway (Long Duration Storage - Annual)



10-Year Plan

This report sets out a new 10-Year Plan for competitive tenders for built energy infrastructure to give effect to the Development Pathway. Market participants should now have regard to this updated plan, rather than that contained in the 2021 IIO Report. The updated plan remains substantially the same as that contained in the 2021 IIO Report, except for the following three changes:

- A Q2 2023 tender for an indicative amount of 380 MW of firming infrastructure has been added.
- A tender for long-duration storage infrastructure has been added alongside the Q2 2023 firming tender, with its indicative size contingent on the conduct of the Q4 2022 tender for long-duration storage infrastructure.
- Given the passage of time since the 2021 IIO Report, the 10-Year Plan has been extended to cover 2031-2032, but no additional tenders are identified to be required in that year to give effect to the next year of the Development Pathway.

The Q4 2022 tender for generation infrastructure and long-duration storage infrastructure remains unchanged from the Consumer Trustee's announcement on 7 April 2022. That tender commenced on 4 October 2022 and, as at the date of this report, is currently underway.

The 10-Year Plan for tenders for firming, generation and long-duration storage infrastructure is set out in Figure 4, Figure 5 and Figure 6 below. The indicative tender sizes in the 10-Year Plan align with the annual build trajectories for each element of the Development Pathway (see Figures 1 to 3), brought forward to account for assumed project lead-times.[11]

Figure 4: 10-Year Plan (Firming)

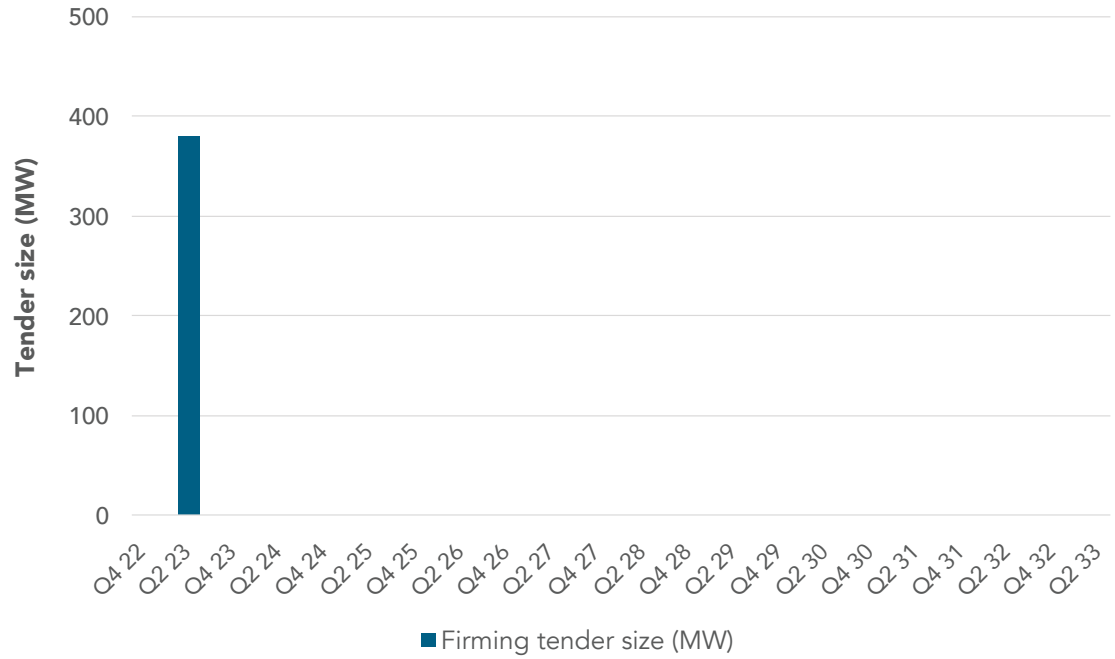
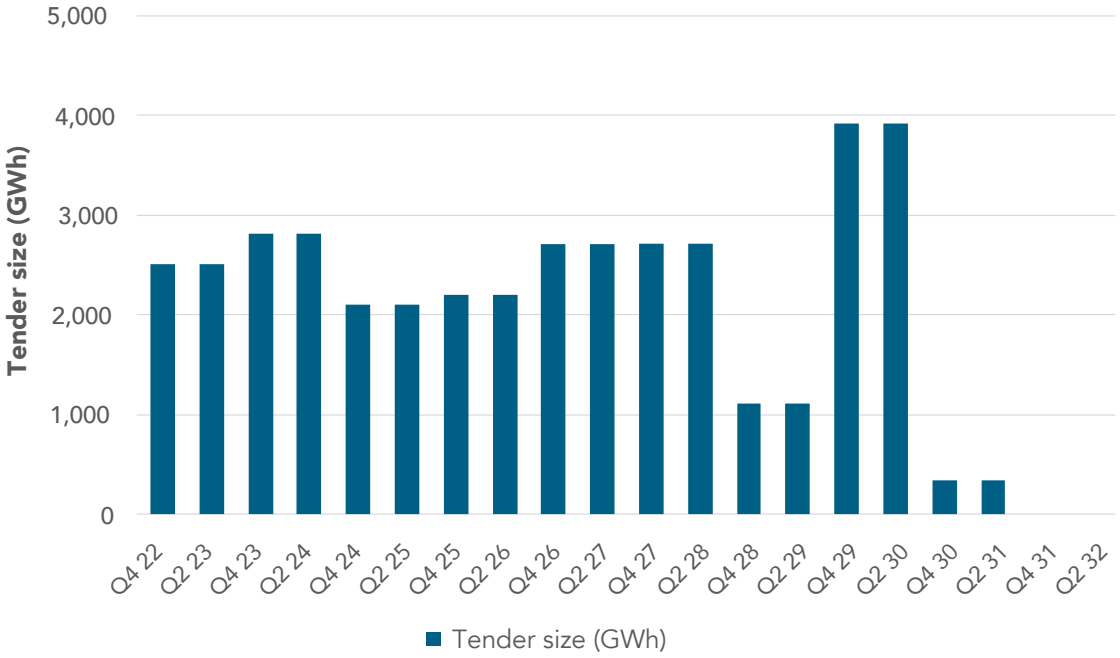
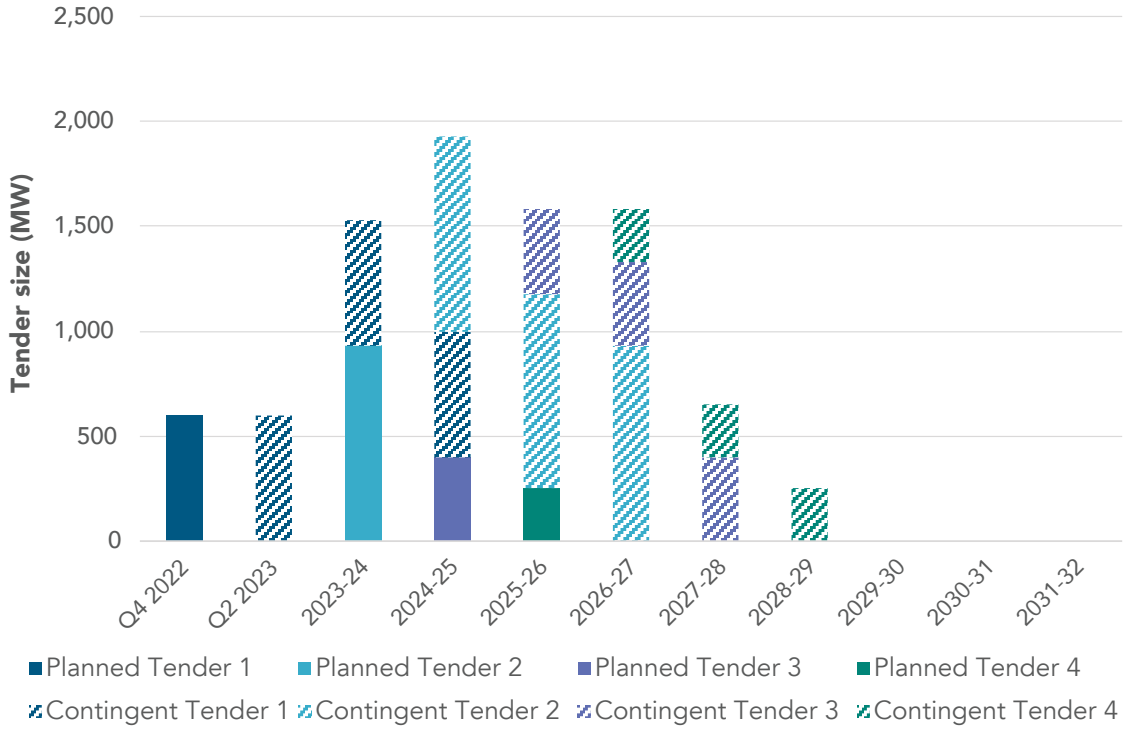


Figure 5: 10-Year Plan (Generation)



11 The assumed lead-times were two years for firming and generation infrastructure, and four years for long-duration storage infrastructure.

Figure 6: 10-Year Plan (Long-Duration Storage)



Next Steps

AEMO Services will shortly commence preparation of a draft 2023 IIO Report, as part of its usual biennial reporting process. That report will be informed by new information and insights gained from the conduct of the first generation and long-duration storage tender and EnergyCo's network procurement processes. At this stage, AEMO Services intends to release a draft 2023 IIO Report in Q1 2023 and consult on the draft during the first half of 2023.

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Abbreviations

Term	Definition
AEMO	Australian Energy Market Operator
DSP	Demand side participation
EII Regulations	Electricity Infrastructure Investment Regulation 2021 (NSW)
EII Act	Electricity Infrastructure Investment Act 2000 (NSW)
EnergyCo	Energy Corporation of NSW
ESOO	Electricity Statement of Opportunities
ESOO Update	AEMO's Update to the 2021 Electricity Statement of Opportunities (April 2022)
2022 ESOO	AEMO's 2022 Electricity Statement of Opportunities
EST	Energy Security Target
EST Monitor	Energy Security Target Monitor
ESTM Report	Energy Security Target Monitor Report
Firming Direction	Direction by the Minister under section 47(2) of the EII Act to conduct a competitive tender for LTESAs for firming infrastructure
Further ESTM Report	Energy Security Target Monitor Report dated May 2022
IASR	Inputs, Assumptions and Scenarios Report
2021 IASR	AEMO's 2021 Inputs, Assumptions and Scenarios Report
IIO Report	Infrastructure Investment Objective Report
2021 IIO Report	2021 Infrastructure Investment Objective Report dated 7 December 2021
2023 IIO Report	2023 Infrastructure Investment Objective Report (forthcoming)
ISP	AEMO's Integrated System Plan
(Draft) 2022 ISP	AEMO's (Draft) 2022 Integrated System Plan
LDS	Long-duration storage
LTESA	Long-term energy services agreement
Minimum objectives	The minimum infrastructure investment objectives established by section 44(3) of the EII Act
Minister	NSW Minister for Energy
NEM	National Electricity Market

NER	National Electricity Rules
Overall objectives	The overall infrastructure investment objectives established by section 44(2) of the EII Act
OECC	NSW Office of Energy and Climate Change
PDRS	Peak Demand Reduction Scheme
QNI	Queensland to NSW Interconnector
REZ	Renewable Energy Zone
Roadmap	NSW Electricity Infrastructure Roadmap
UNSW	University of New South Wales
USE	Unserved energy
VNI	Victoria to NSW Interconnector
VRE	Variable renewable energy

1. Introduction

1.1 NSW Electricity Infrastructure Roadmap

In November 2020, the NSW Parliament passed the Electricity Infrastructure Investment Act 2020 (EII Act), the legislation enabling the delivery of the NSW Government's Electricity Infrastructure Roadmap (Roadmap). The Roadmap is the NSW Government's plan to support investment in the new generation, storage and network infrastructure required to ensure affordable, reliable, and sustainable electricity supply as coal-fired power stations retire.

The EII Act establishes the role of Consumer Trustee. This is an independent statutory role with various planning, advisory and procurement functions to enable the delivery of energy investment in the long-term financial interests of NSW electricity customers. AEMO Services was appointed as Consumer Trustee in October 2021.

The Consumer Trustee's key functions are set out in the EII Act and include:

- Planning for the construction of electricity infrastructure to meet legislated objectives through the production of infrastructure investment objectives reports (IIO Reports),
- Conducting competitive tenders for built energy, including LTESAs and access rights, and
- Authorising the carrying out of network infrastructure in NSW Renewable Energy Zones (REZs).

The Consumer Trustee plays a key role in the broader Roadmap, working closely with other entities, including EnergyCo, to support firmed renewables and network infrastructure to power NSW into the future.

1.2 Infrastructure Investment Objective Reports

As the Consumer Trustee, AEMO Services is required to prepare an Infrastructure Investment Objective Report (IIO Report) every two years. In addition, AEMO Services must prepare an IIO Report as soon as practicable after being directed by the NSW Minister for Energy (Minister) to conduct a tender for LTESAs in respect of firming infrastructure.[12]

Each IIO Report must contain:

- A **Development Pathway** for the construction of infrastructure necessary to meet the infrastructure investment objectives over the following 20 years, and
- A **10-Year Plan** for competitive tenders that the Consumer Trustee will conduct to give effect to the development pathway.

Regulations made under the EII Act set out additional items that the report must contain or matters that the Consumer Trustee must have regard to in preparing the report.[13]

In December 2021, AEMO Services (acting as the Consumer Trustee) published its inaugural infrastructure investment objectives report (2021 IIO Report).

That report set out a 20-year Development Pathway for renewable generation and long-duration storage infrastructure that sought to minimise costs for NSW electricity customers and maintain reliable supply by meeting the energy security target and reliability standard.[14] That pathway focused on ensuring that sufficient electricity supply is available ahead of coal withdrawal over the next decade, the timing of which is uncertain. As there had been no direction for AEMO Services to conduct a tender for firming infrastructure at the time of that report, it did not include firming infrastructure.

The Consumer Trustee is to exercise its functions under Part 6 of the EII Act – which include conducting competitive tenders – on the basis of the IIO Reports. The Consumer Trustee's overriding obligation is to exercise its functions in the long-term financial interests of NSW electricity customers, and accordingly the Consumer Trustee will take into account any new information of which it has become aware after publication of the most recent IIO Report in conducting competitive tenders. Where the Consumer Trustee does so, it will make its best endeavours to communicate publicly and transparently with all stakeholders and otherwise act, to the extent reasonable, on the basis of the IIO Reports prepared under section 45 of the EII Act.

12 The Firming Direction is made under section 47(2) of the EII Act.

13 *Electricity Infrastructure Investment Regulation 2021* (EII Regulation), clauses 24 and 25.

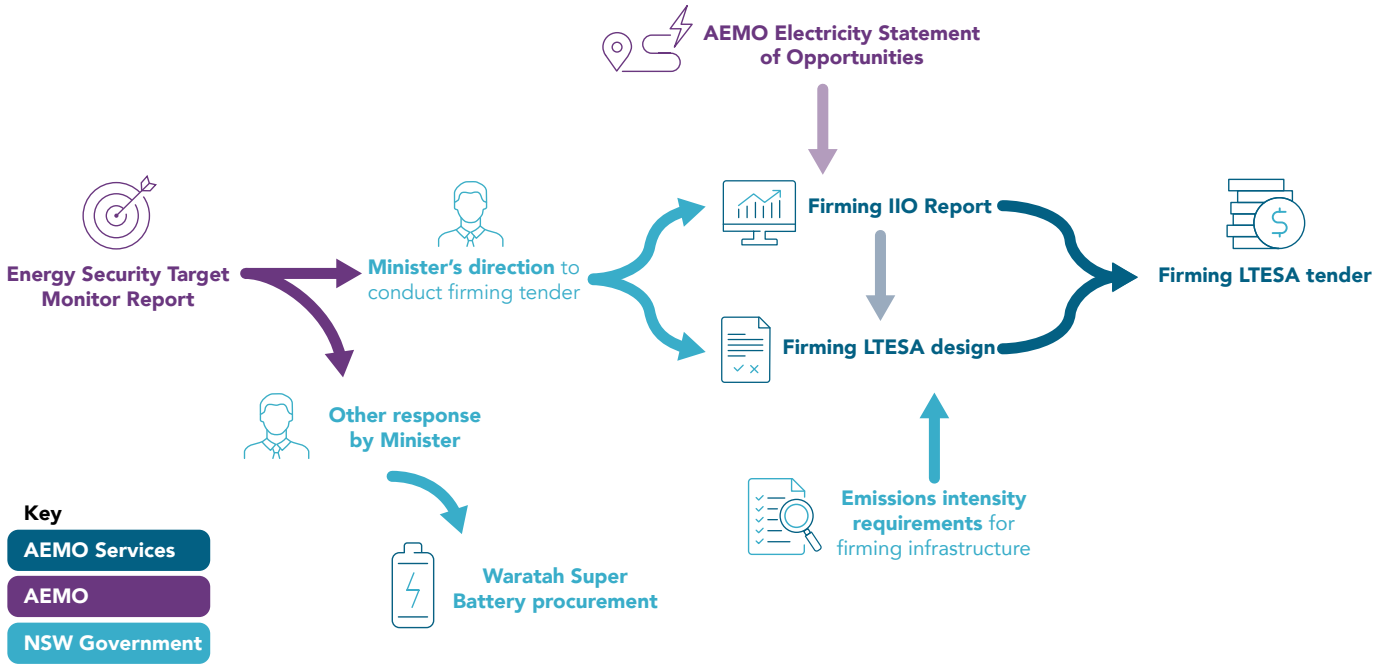
14 See EII Act, section 44(2).

1.3 Background to the 2022 IIO Report

The preparation of this 2022 IIO Report, is in response to a Firming Direction and sits outside the Consumer Trustee's usual biennial reporting process, is driven by a series of mechanisms under the EII Act.

The regulatory process leading to the 2022 IIO Report, and ultimately the conduct of a firming tender, is set out in Figure 7.

Figure 7: Regulatory process for firming tender



Separately, 2022 has seen significant increases in wholesale electricity prices across the NEM due to a combination of factors, including unplanned outages of coal-fired generation and supply chain issues for coal and gas.[15] These challenges underscore the importance of the Consumer Trustee's task in facilitating the delivery of new renewable generation and storage infrastructure in line with the Development Pathway set out in the 2021 IIO Report. This is consistent with AEMO's 2022 Integrated System Plan (2022 ISP), which found that "[i]nvestment in low-cost renewable energy, firming resources and essential transmission remains the best strategy to deliver affordable and reliable energy, protected against international market shocks."

15 See AEMO (July 2022), *Quarterly Energy Dynamics Q2 2022*, https://aemo.com.au/-/media/files/major-publications/qed/2022/qed-q2-2022.pdf?la=en.

Firming Direction

In August 2022, it was announced that AEMO Services as Consumer Trustee had been directed to conduct a competitive tender for LTESAs for firming infrastructure. The Firming Direction followed the identification of a forecast breach of the energy security target, as discussed further below. This report reflects the statutory requirement under section 45(3) of the EII Act for the Consumer Trustee to prepare an IIO Report as soon as practicable after being so directed by the Minister.

Energy Security Target Monitor Report

The energy security target under the EII Act is a NSW-specific reliability measure (distinct from system security).[16] AEMO has been appointed as the Energy Security Target Monitor (EST Monitor) under the EII Act, to monitor and report to the Minister about the energy security target.

In November 2021, the EST Monitor's first EST Monitor Report forecast a possible breach of the energy security target in 2028-29 where intra-regional transmission constraints were taken into account. Following this, in February 2022, Origin Energy announced that it would bring forward the retirement of the Eraring Power Station to August 2025.[17] In May 2022, an updated EST Monitor Report (Further ESTM Report) forecast an earlier energy security target breach of 1,250 MW in 2025-26 following the closure of the Eraring Power Station. However, this calculation excluded the Waratah Super Battery, the Hunter Transmission Project and the 2021 Development Pathway for generation and long-duration storage.

The NSW Office of Energy and Climate Change (OECC) indicated that, with the inclusion of the Waratah Super battery, at least 350 MW of firming infrastructure is necessary by summer 2025-26 to mitigate risks to meeting the energy security target.[18] Due to the prescribed methodology for calculating the energy security target, which includes accounting for intra-regional transmission constraints, the Further ESTM Report suggests that this additional capacity will be required within the Sydney-Newcastle-Wollongong sub-region in order to address the energy security target shortfall.

Figure 8: Integrated System Plan (ISP) sub-regions in the energy security target calculations

Explainer: ISP Sub-Regions in the Energy Security Target Calculations

As part of its modelling of the NEM, AEMO divides the NEM in regions (i.e., State jurisdictions) and sub-regions.[19] The NSW NEM region is made up of the Sydney-Newcastle-Wollongong sub-region, the Northern NSW sub-region, the Central NSW sub-region and the Southern NSW sub-region.

The EII Regulations prescribe that the Energy Security Target Monitor is to take into account major constraints on transmission infrastructure across different sub-regions of NSW.[20]

The Further ESTM Report identified a shortfall of capacity in the Sydney-Newcastle-Wollongong sub-region because there is insufficient capacity on the lines into that sub-region to import sufficient electricity from other sub-regions. This means that to meet demand within the Sydney-Newcastle-Wollongong sub-region in 2025-26, additional capacity is required within that sub-region (or in close proximity to the sub-region, depending on the ability of the project's output to reach peak demand in the Sydney-Newcastle-Wollongong sub-region subject to network constraints).

Modelling undertaken for this IIO Report confirms the breach even after accounting for the investment in the new generation and long-duration storage infrastructure set out in the 2021 Development Pathway.

16 The energy security target is a capacity target for firm-rated plant over the next 10 years and is set at the level of firm-rated capacity needed to service NSW's electricity needs during a one in 10-year peak demand period, with the largest two units of NSW's generators experiencing an outage and having regard to a range of matters, including intra-regional network constraints.

17 See https://www.originenergy.com.au/about/investors-media/origin-proposes-to-accelerate-exit-from-coal-fired-generation/

18 See https://www.energy.nsw.gov.au/nsw-plans-and-progress/major-state-projects/electricity-infrastructure-roadmap/entities-delivering/target-monitor.

19 AEMO (July 2021), *2021 Inputs, Assumptions and Scenarios Report*, https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-inputs-assumptions-and-scenarios-report.pdf

20 EII Regulations, clause 15(4).

1.4 Approach to the 2022 IIO Report

The EII Act establishes overall infrastructure investment objectives for three types of electricity infrastructure – generation, long-duration storage, and firming. The EII Act also sets minimum objectives for the construction of specified amounts of two of those infrastructure types – generation and long-duration storage – by the end of 2029. The Development Pathway must set out the generation, long-duration storage and firming infrastructure that is required to meet these objectives.

Retention of 2021 Development Pathway

The 2021 IIO Report set out a Development Pathway that is designed to deliver the infrastructure investment objectives in a feasible way. The build is approximately aligned with the anticipated timing of the development of REZ network infrastructure in NSW, but also seeks to avoid supply chain challenges associated with peaks and troughs in construction activity, by smoothing construction over the first 10 years.

The Consumer Trustee has retained the generation and long-duration storage infrastructure elements of the Development Pathway from the 2021 IIO Report.[21] The Consumer Trustee considers retention of the generation and long-duration storage elements, with the addition of firming infrastructure in response to the Firming Direction (discussed below), to be in the long-term financial interests of NSW electricity customers for the following reasons:

- For the next decade, the 2021 Development Pathway and corresponding 10 Year Plan, represents a sufficiently contemporary view of a cost-minimised pathway, given that it was produced in the last 12 months and supply chain constraints are expected to constrain the development of new generation infrastructure beyond that contained in the 2021 IIO Report.
- For the second decade to 2043, as noted in the 2021 IIO Report, the build trajectory is subject to significant uncertainty. This uncertainty is particularly driven by the potential for material increases in demand for electricity in that decade as a result of electrification and by recent announcements such as the decision by AGL Energy to bring forward the retirement of its Loy Yang A Power Station by 10 years to 2035.[22] These developments indicate that additional generation infrastructure is likely to be required, which the Consumer Trustee will explore further in the 2023 IIO Report.
- The 2021 Development Pathway was designed to be resilient to market changes, such as early coal withdrawal.
- Retaining the 2021 IIO Report elements provides certainty to the market regarding the first tender for LTESAs, which commenced on 4 October 2022, and thereby supports greater competition in that tender (which should drive improved cost outcomes).
- The Consumer Trustee considers that the 2021 Development Pathway and the underpinning assumptions – which are a central planning exercise – are best tested through the conduct of:
  - competitive tenders for built energy infrastructure, and
  - procurement processes for network infrastructure projects such as the Waratah Super Battery and the Central-West Orana renewable energy zone, which are currently being conducted by the Energy Corporation of NSW (EnergyCo).

Market information collated through these processes will provide new information which will then be used to develop the 2023 Infrastructure Investment Objectives Report (2023 IIO Report).

21 Reflecting the passage of time since the last report, the 20-year Development Pathway now runs from 2023-24 to 2042-43.

22 AGL Energy (September 2022), *Outcomes of Review of Strategic Direction and FY23 earnings guidance*, https://cdn-api.markitdigital.com/apiman-gateway/ASX/asx-research/1.0/file/2924-02574155-2A1401683?access_token=83ff96335c2d45a094df02a206a39ff4.

Addition of firming infrastructure

Following the Firming Direction, the Consumer Trustee has added firming infrastructure to the Development Pathway and 10-Year Plan. Accordingly, this report reflects the latest Development Pathway and 10-Year Plan, and prospective participants in the competitive tenders should now have regard to this report. This report sets out the methodology for designing the firming element of the Development Pathway and 10-Year Plan. The rationale and methodology underpinning the generation and long-duration storage elements are contained in the 2021 IIO Report.

The overall objective for firming infrastructure is the 'construction of firming infrastructure that is necessary to meet the energy security target and the reliability standard'. Accordingly, this report has been developed to set out a Development Pathway and 10-Year Plan that includes firming infrastructure to achieve this overall objective.

Retaining the 2021 Development Pathway and focusing on the addition of the firming element has allowed the Consumer Trustee to expedite the modelling and analysis in this IIO Report compared to that undertaken to produce the 2021 IIO Report. This is important for two reasons. First, it effects the Consumer Trustee's obligation to prepare this report as soon as practicable after being directed by the Minister under section 47(2) of the EII Act. Secondly, given the EST Monitor's latest report identifies a breach of the energy security target in 2025-26, it is critical for competition and the financial interests of NSW electricity customers that the Consumer Trustee conduct a tender as soon as possible. This will maximise the opportunity for firming projects that are capable of meeting the required commissioning timeframes to participate, particularly given the supply chain challenges currently faced across the energy and construction sectors.

1.5 2023 IIO Report

As part of this streamlined approach, AEMO Services is undertaking public consultation on the preparation of this report within a shortened timeframe. Notwithstanding, AEMO Services will shortly commence preparation of a draft 2023 IIO Report, which will set out an updated Development Pathway and 10-Year Plan for generation and long-duration storage. AEMO Services intends to consult on its approach to that report during the first half of 2023.
The draft and final 2023 IIO report may be informed by modelling the Consumer Trustee is undertaking to support EnergyCo in preparing a Network Infrastructure Strategy, which is expected to be published in Q1 2023. AEMO Services expects this work to include modelling exercises that co-optimises the delivery of generation, long-duration storage and network infrastructure required to achieve the infrastructure investment objectives under the EII Act.

2. Infrastructure Investment Objectives

2.1 Overview

The EII Act establishes the infrastructure investment objectives. These are set out in Figure 7 (and discussed further below) and include both:

- Minimum objectives for the construction of specified amounts of generation and long-duration storage infrastructure by the end of 2029, and
- Overall objectives to construct additional generation, long-duration storage, and firming infrastructure to minimise costs to NSW electricity customers and meet the NSW energy security target and reliability standard. These apply across the full 20-year period of the IIO Report and beyond 31 December 2029.[23]

The Development Pathway sets out how infrastructure will be constructed over 20 years to achieve the minimum and overall objectives.

As noted in section 1.4, this report retains the Development Pathway from the 2021 IIO Report for generation and long-duration storage infrastructure and adds firming infrastructure.

The overall objective for firming infrastructure is the construction of such infrastructure that is necessary to meet the energy security target and the reliability standard. There is no minimum objective in respect of firming infrastructure.

In addition to these objectives, the EII Act also has a broader set of objects and the Consumer Trustee must exercise its functions in a way that is consistent with these broader objects.[24]

Figure 9: Infrastructure investment objectives and eligible infrastructure

Infrastructure type	Definition	Infrastructure Investment Objectives: Minimum objective (volume/capacity target)	Overall Objectives: Minimise electricity costs for NSW customers	Overall Objectives: Meet reliability standard	Overall Objectives: Meet the energy security target
Generation	Generation from a renewable energy source ≥ 30MW	At least the same amount as 12 GW (~33.6TWh p.a) constructed by the end of 2029	✓	N/A	N/A
LDS	Storage able to be dispatched at registered capacity for ≥ 8hrs, and scheduled by AEMO in the central dispatch process under NER	2 GW constructed by the end of 2029	N/A	✓	N/A
Firming	Firm capacity scheduled by AEMO in the central dispatch process under the NER	None	N/A	✓	✓

23 EII Act, section 44(2).

24 EII Act, section 3(3).

2.2 Infrastructure Investment Objectives for firming infrastructure

Generally, firming infrastructure refers to flexible capacity that can be dispatched when there is a sudden increase in demand. Firming can be provided by a range of technologies, including both short- and long-duration storage such as pumped hydro and batteries, as well as gas generators. For the purposes of the infrastructure investment objectives, firming infrastructure must be scheduled by AEMO in the central dispatch process under the National Electricity Rules (NER). Projects that were identified as committed or existing in a generation information page[25] published by AEMO on or before 14 November 2019 are not counted towards the objectives.[26] More information will be made available in due course about the eligibility of projects to participate in the firming infrastructure tender.

As noted earlier, the EII Act does not establish a minimum objective for the construction of firming infrastructure. Rather, there is an overall objective for the construction of firming infrastructure that is necessary to meet the energy security target and the reliability standard. The Consumer Trustee may only conduct a competitive tender for LTESAs in respect of firming infrastructure if directed to do so by the Minister.

Details regarding generation and long-duration storage infrastructure, and their respective objectives are set out in section 2 of the 2021 IIO Report. While there are no specific infrastructure investment objectives for network infrastructure, regulations require that an IIO Report must contain details regarding the REZ network infrastructure projects required to achieve the infrastructure investment objectives.[27] Section 5.2.1 sets out the key network infrastructure, including REZ network infrastructure, underpinning the development pathway to achieve the infrastructure investment objectives.

2.3 Meeting the energy security target

The EII Act establishes an overall objective for the construction of firming infrastructure that is necessary to meet the energy security target[28]. The energy security target sets the target firm capacity required to meet NSW's maximum consumer demand in summer, with a reserve to account for the unexpected loss of the two largest generating units in the state.[29]

Under the EII Act, the EST Monitor is required to calculate the energy security target for each of the next 10 years and monitor and report on whether there is sufficient firm capacity to meet the target.[30] Regulations made under the EII Act set out various matters that the EST Monitor must take into account when calculating the energy security target and preparing its reports,[31] including inter-regional network constraints.

The Minister has appointed AEMO as the EST Monitor under the EII Act and may decide what action to take in response to a report received from the EST Monitor.[32] If the Minister directs the Consumer Trustee to conduct a tender for LTESAs in respect of firming infrastructure, the Consumer Trustee must prepare a new IIO Report as soon as practicable after being directed.[33] As noted above, the latest EST Monitor Report has identified a firm capacity gap and the Minister has directed the Consumer Trustee to conduct a firming infrastructure tender, in part to address this.

25 See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

26 EII Act, sections 43(2), 44(4).

27 EII Regulation, clause 24(1)(b)(ii).

28 EII Act, section 44(2)(c).

29 EII Act, section 12.

30 EII Act, sections 12 – 14.

31 *EII Infrastructure Investment Regulation 2021* (EII Regulation), Part 3.

32 EII Act, section 15.

33 EII Act, section 45(3).

2.4 Meeting the reliability standard

The EII Act establishes an overall objective for the construction of firming and long-duration storage infrastructure that is necessary to meet the reliability standard.[34]

The reliability standard is:

- Until 30 June 2025, the National Electricity Market (NEM) interim reliability measure of expected unserved energy in a region of 0.0006% of the total energy demanded in that region for a given financial year, and
- From 1 July 2025, the NEM reliability standard which is currently the expected unserved energy in a region of 0.002% of the total energy demanded in that region for a given financial year.[35]

Given the minimum objective for the construction of 2 GW of long-duration storage by the end of 2029, it is expected that long-duration storage will make a significant contribution to meeting the reliability standard over time. However, if the Minister directs the Consumer Trustee to conduct a tender for firming infrastructure, there may be circumstances where shorter-duration firming infrastructure to meet the reliability standard is justified over awarding long-duration storage LTESAs that exceed the minimum objective for long-duration storage. This may be the case, for example, where shorter-duration firming presents a lower-cost option to address a near-term reliability gap.

AEMO, in its annual Electricity Statement of Opportunities (ESOO), also assesses risks to meeting the reliability standard under the National Electricity Rules.

In its update to the 2021 Electricity Statement of Opportunities (ESOO Update),[36] AEMO identified that, without further investment, there is likely to be a breach of the reliability standard in December 2025. However, the ESOO Update also noted that, if the 2021 Development Pathway is achieved and the Waratah Super Battery is procured, then the reliability standard would be met even with the earlier than anticipated closure of the Eraring Power Station. Similar to the ESOO Update, the 2022 ESOO[37] identified a reliability gap in respect of the reliability standard in NSW from 2025-26, unless further investments are made. The 2022 ESOO noted that, in NSW, the reliability forecast would be improved by the achievement of the 2021 Development Pathway, the HumeLink augmentation and the Hunter Transmission Project (which, in AEMO's modelling, includes the Waratah Super Battery).[38]

However, the modelling undertaken by AEMO for the Central scenario in the ESOO only incorporates existing and committed generation projects and does not take account of the additional generation and long-duration storage included in the Consumer Trustee's Development Pathway (or the additional network infrastructure that is expected to be constructed in NSW under the Roadmap).

34 EII Act, section 44(2)(b) and (c).

35 See EII Regulation 2021, clause 23. Under EII Act section 43(3), the reliability standard is the standard implemented by AEMO under the National Electricity Rules that has been prescribed by the regulations.

36 AEMO (April 2022), *Update to 2021 Electricity Statement of Opportunities*, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2022/update-to-2021-electricity-statement-of-opportunities.pdf?la=en.

37 AEMO (August 2022), *2022 Electricity Statement of Opportunities*, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2022/2022-electricity-statement-of-opportunities.pdf?la=en&hash=AED781BE4F1C692F59B1B9CB4EB30C4C.

38 2022 ESOO, page 57.

3. Development Pathway

3.1 Role of the Development Pathway

The Development Pathway sets out the Consumer Trustee's plan for the construction of generation, long-duration storage and firming infrastructure to meet the minimum and overall infrastructure investment objectives in a manner that reflects the long-term financial interests of NSW electricity customers over the 20-year period from 2023-24 to 2042-43.

The Development Pathway is the outcome of a modelling exercise and represents the Consumer Trustee's preferred pathway for delivering on the infrastructure investment objectives. In conducting competitive tenders, the Consumer Trustee will be guided by the Development Pathway but may make recommendations that would result in the construction of infrastructure in excess of or less than the amounts indicated (including in excess of supply chain planning limits) if, in its view, such a result would be in the long-term financial interests of NSW electricity customers.

The Development Pathway set out in this section retains the elements of the 2021 Development Pathway for generation infrastructure and long-duration storage infrastructure, and also adds firming infrastructure.

3.2 Forthcoming 2023 IIO Report

The Development Pathway will be updated via the infrastructure investment objectives reporting process. Under the EII Act, the next IIO Report is due in December 2023.[39] That report will consider an updated Development Pathway that co-optimises the construction of generation, long-duration storage, and firming infrastructure with the construction of network infrastructure, taking into account the outcomes of procurement processes that will shortly be completed. Subject to an independent assessment by the Consumer Trustee, the network assumptions in this co-optimisation may be based on the pipeline of network projects set out in EnergyCo's Network Infrastructure Strategy.[40]

In preparing the 2023 IIO Report, the Consumer Trustee will also have the benefit of significant insights derived from the conduct of the first generation and long-duration storage tender, as well as updated, market-informed, network costs from the procurement processes for the Central-West Orana renewable energy zone and Waratah Super Battery.

3.3 Firming build

3.3.1 Overview of firming build

In accordance with the legislated infrastructure investment objectives, the purpose of the Development Pathway in respect of firming infrastructure is to meet the energy security target and the reliability standard.

The Development Pathway for firming infrastructure is set out in Figure 10 and Figure 11, which show the annual and cumulative capacity installed, respectively. The Development Pathway consists of 380 MW of firming infrastructure located within the Sydney-Newcastle-Wollongong sub-region (or in close proximity to this sub-region, provided it can demonstrate its contribution to meeting the energy security target), commissioned in 2025-26.[41] The Development Pathway for firming is technology-neutral.

39 The EII Act requires an IIO Report to be published every two years from date of the first report, which was published in December 2021. Where the Minister directs the Consumer Trustee to conduct a firming tender, the Consumer Trustee must produce an additional report. However, that report does not affect the standard two-year cycle.

40 The Network Infrastructure Strategy is expected to be published by early 2023.

41 The calculations undertaken for the Further ESTM Report and this IIO Report indicate that the breach of the energy security target will take place over summer 2026. Accordingly, the Consumer Trustee intends to tender for projects that will be commissioned by December 2025.

Figure 10: Development Pathway (Firming – Annual)

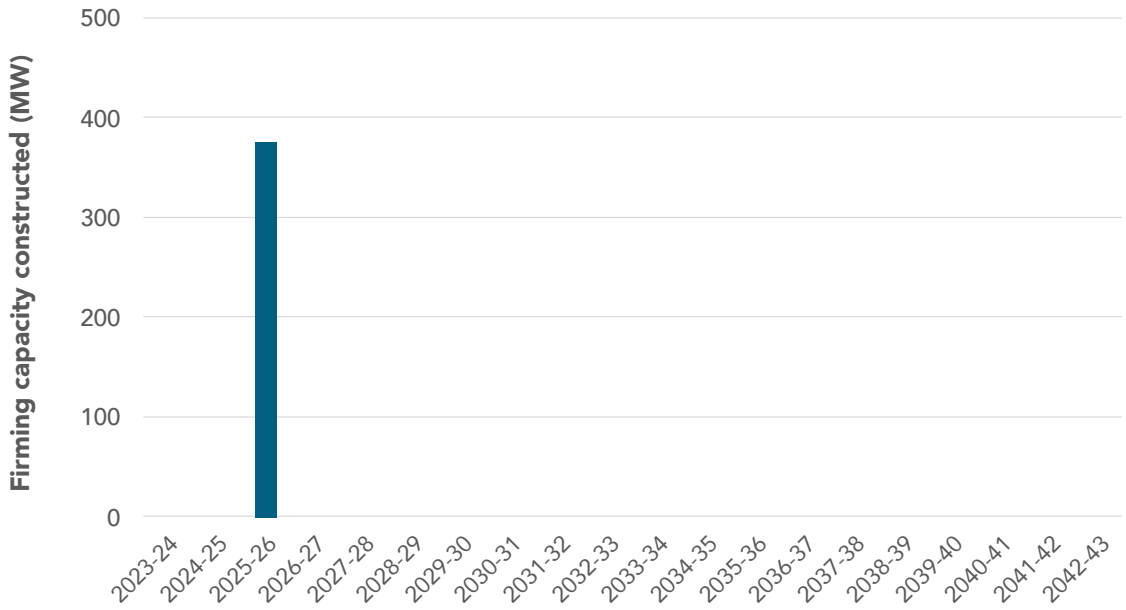
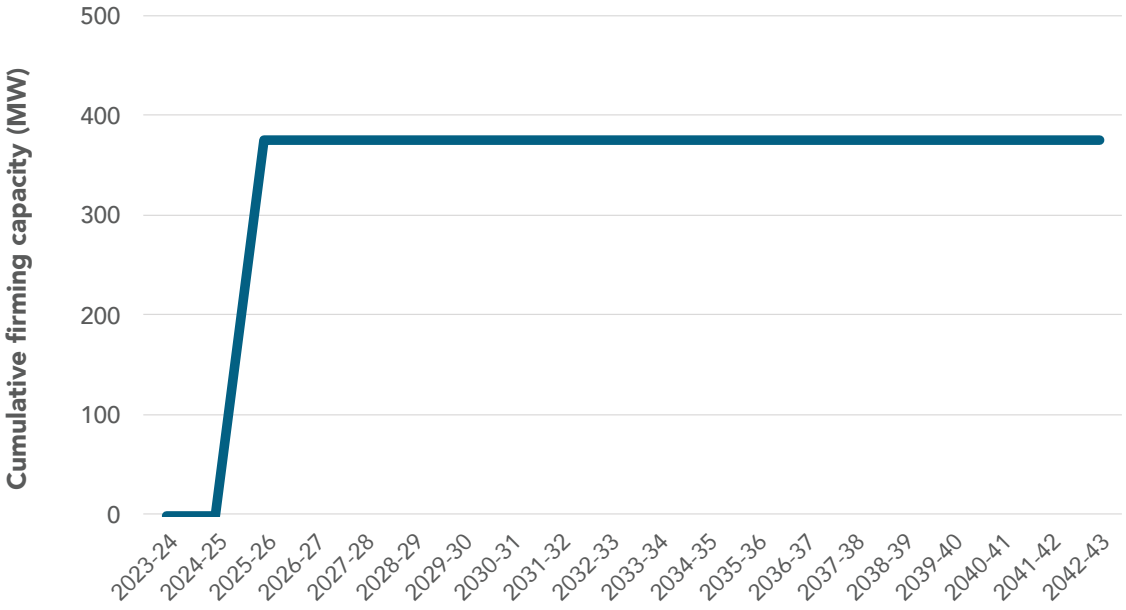


Figure 11: Development Pathway (Firming – Cumulative)



3.3.2 Design of firming build

In announcing the Firming Direction, the OECC indicated that it anticipated that at least 350 MW of firming infrastructure will be required in the Sydney-Newcastle-Wollongong sub-region. Following receipt of the Firming Direction, the Consumer Trustee undertook its own modelling and determined that the Development Pathway should include 380 MW of firming infrastructure. The variation is due to the Consumer Trustee's use of AEMO's May 2022 Generation Information, compared with the Further ESTM Report which relied on the February 2022 Generation Information update[42].

The Development Pathway for firming infrastructure is based on calculations undertaken by the Consumer Trustee regarding the capacity that is required to meet the energy security target, assuming:

- the Waratah Super Battery is delivered,
- the long-duration storage infrastructure forecast for 2025-26 under the 2021 Development Pathway is not commissioned until the end of that year, and
- the Peak Demand Reduction Scheme is not contributing to the firm capacity in the Sydney-Newcastle-Wollongong sub-region in 2025-26.

Reliability assessments undertaken in the course of preparing this report indicate that the reliability standard is met under the 2021 Development Pathway, assuming the Waratah Super Battery is also in place. Accordingly, the Consumer Trustee considers that no additional firming infrastructure is required to meet the reliability standard beyond that specified above to meet the energy security target.

Detailed information regarding these calculations and the underpinning assumptions are set out in section 5.

Consistent with the Further ESTM Report, the Consumer Trustee has determined that the forecast breach of the energy security target in 2025-26 is due to a lack of firm capacity in the Sydney-Wollongong-Newcastle sub-region. The modelling undertaken for this report (see section 5) indicates that the breach of the energy security target would be remedied in 2027-28 – without firming infrastructure – by the commissioning of the Hunter Transmission Project. Were the Hunter Transmission Project to be delayed, the breach of the energy security target would be extended over a greater number of years, but the size of the gap would not increase.

Accordingly, the Consumer Trustee considers that 380 MW is an appropriate amount of firming infrastructure to address the identified breach of the energy security target in 2025-26 and 2026-27 (and meet the overall infrastructure investment objective for firming infrastructure), as well as increasing the resilience of the overall Development Pathway to the risk of transmission augmentation delays. The calculations underpinning this report include assumptions regarding other capacity that is commissioned prior to 2025-26. If such committed or government-supported projects were to be delayed beyond 2025-26, then there may be a need for additional firming infrastructure to meet the energy security target.

The Consumer Trustee has analysed the risks to NSW electricity customers associated with early or delayed investment in firming infrastructure.[43]

42 The AEMO Generation Information page informs assumptions related to existing and committed generation and their rated capacities.

43 The risks associated with early or delayed investment in respect of generation and long-duration storage infrastructure are discussed in the 2021 IIO Report. See 2021 IIO Report, section 6.

Delayed or early investment	Risk	Analysis
Delayed investment	Delay to the firming infrastructure identified above beyond December 2025 would mean the Development Pathway would fail to meet the energy security target.	This would likely present risks to NSW electricity customers in respect of the reliability of the energy system during the type of peak events that the energy security target seeks to protect against.
Early investment	Bringing forward the firming infrastructure element of the Development Pathway would likely rule out certain projects and technologies from participating in a firming infrastructure tender (given project lead times and global supply chain constraints).	The Consumer Trustee considers that reducing the number of projects able to participate in the Q2 2023 tender would have an unacceptable impact on competition and, as a result, increase the financial impact on NSW electricity customers.

Given the risks associated with not meeting the energy security target, and the potential for construction and commissioning delays, there may be merit in planning to support the construction of firming infrastructure that is operational in advance of when the modelling indicates it is first needed in December 2025. However, the Consumer Trustee considers that this would have an unacceptable impact on competition and, as a result, increase the financial impact on NSW electricity customers. The timing of the firming infrastructure in the Development Pathway does not of itself preclude the participation in the firming tender of projects with earlier commissioning dates. The Consumer Trustee may take into account individual projects' timeframes to commissioning in evaluating tender submissions.

3.4 Generation build

3.4.1 Overview of generation build

The Development Pathway for generation infrastructure remains substantially the same as that contained in the 2021 IIO Report[44] and is set out in Figure 12 and Figure 13, which show the annual and cumulative annual output of the infrastructure, respectively.

To meet the minimum objective for generation infrastructure, the Development Pathway achieves 33,600 GWh available per annum of renewable generation constructed by the end of 2029.[45] The Development Pathway is also designed to meet the overall objective of minimising costs to NSW electricity customers, subject to annual planning limits that are intended to minimise the risks of supply chain constraints.

To reflect the passage of time since the last report, an additional year has been added to the Development Pathway. However, as seen in the figures below, this report does not plan for the construction of additional generation infrastructure in that year.

44 See 2021 IIO Report, section 3.1.1.

45 This is the estimate of the amount of electricity in GWh that is equivalent to the 12 GW of capacity required under the minimum objectives, which has been calculated (in accordance with clause 24(1)(g) of the EII Regulations) using information from AEMO's 2020 Integrated System Plan. See 2021 IIO Report, Box 3 (page 23) for further detail as to how this estimate was calculated.

Figure 12: Development Pathway (Generation - Annual)[46]

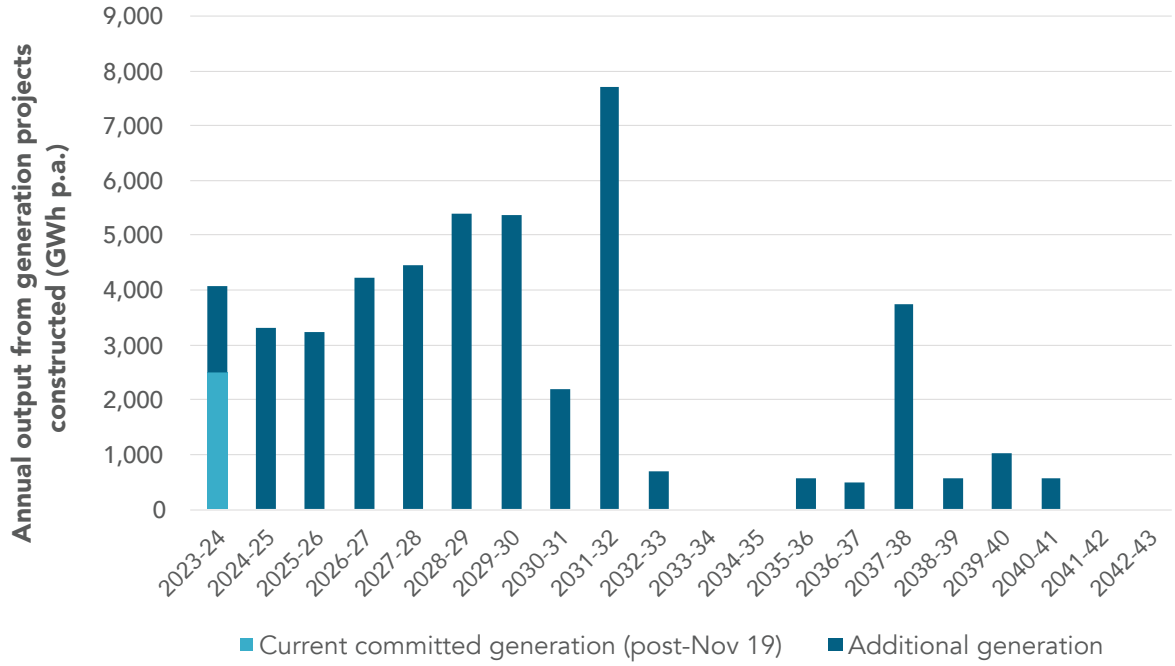
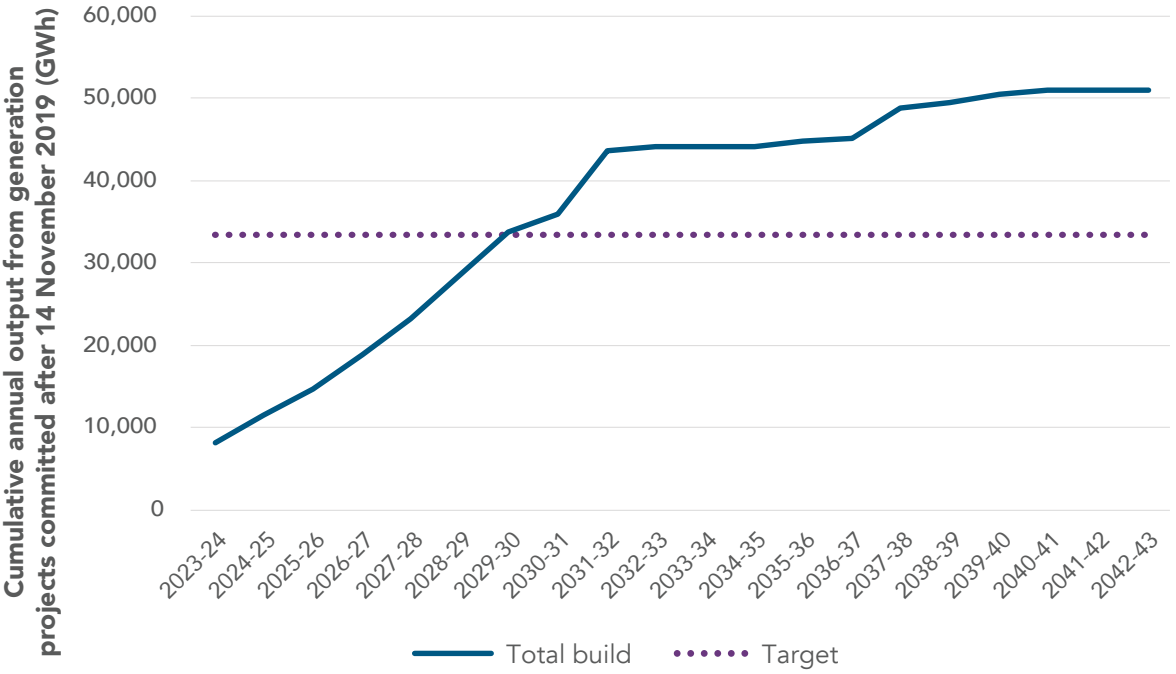


Figure 13: Development Pathway (Generation - Cumulative)



46 Annual available generation in the Development Pathway is expected to be met in part by projects that have achieved a committed status by AEMO as of August 2022 with an expected commissioning date within the 2023-24 financial year. The contribution of existing projects and committed projects with expected commissioning dates prior to 2023-24 to the 2021 Development Pathway is described in Section 3.6.3.

At the centre of the Development Pathway for generation infrastructure is the understanding that a managed buildout of electricity infrastructure can mitigate uneven investment and high-priced periods that can be expected to characterise normal market operation under current regulatory settings.

The Development Pathway consists of 33,600 GWh of renewable generation infrastructure by 2030 but is technology- and location-neutral.

As noted in the 2021 IIO Report, the build trajectory in the 2030s is subject to significant uncertainty. This uncertainty is particularly driven by the potential for material increases in demand for electricity in that decade, which will be strongly impacted by trends in electrification as the Australian economy decarbonises. In addition, the recent announcement by AGL Energy to bring forward the retirement of its Loy Yang A Power Station by 10 years to 2035 indicates that additional generation infrastructure is likely to be required in the 2030s.[47] Such developments, as well as the demand forecasts and other updated assumptions in AEMO's latest ISP, will be further explored in the 2023 IIO Report.

3.4.2 Design of generation build

Notwithstanding recent developments in the energy market, the 2021 Development Pathway still represents the Consumer Trustee's view as to how new generation infrastructure should be developed to deliver on the infrastructure investment objectives. The rationale for this is set out in section 1.4.

3.5 Long-duration storage build

3.5.1 Overview of long-duration storage build

The Development Pathway for long-duration storage infrastructure remains substantially the same as that contained in the 2021 IIO Report[48] and is set out in Figure 14 and Figure 15, which show the annual and cumulative storage capacity installed, respectively. To reflect the passage of time since the last report, an additional year has been added to the Development Pathway.

Long-duration storage infrastructure is first developed under the Development Pathway in 2025-26. The minimum infrastructure investment objective of 2 GW is then met through long-duration storage build in 2027-28 and 2028-29. Having undertaken the energy security target and reliability assessments detailed in section 5, the Consumer Trustee is satisfied that the Development Pathway consists of sufficient generation, long-duration storage, and firming infrastructure to meet the reliability standard (as required by the EII Act's overall objective for long-duration storage infrastructure).

47 AGL Energy (September 2022), *Outcomes of Review of Strategic Direction and FY23 earnings guidance*, https://cdn-api.markitdigital.com/apiman-gateway/ASX/asx-research/1.0/file/2924-02574155-2A1401683?access_token=83ff96335c2d45a094df02a206a39ff4.

48 See 2021 IIO Report, section 3.1.2.

Figure 14: Development pathway (Long-Duration Storage - Annual)

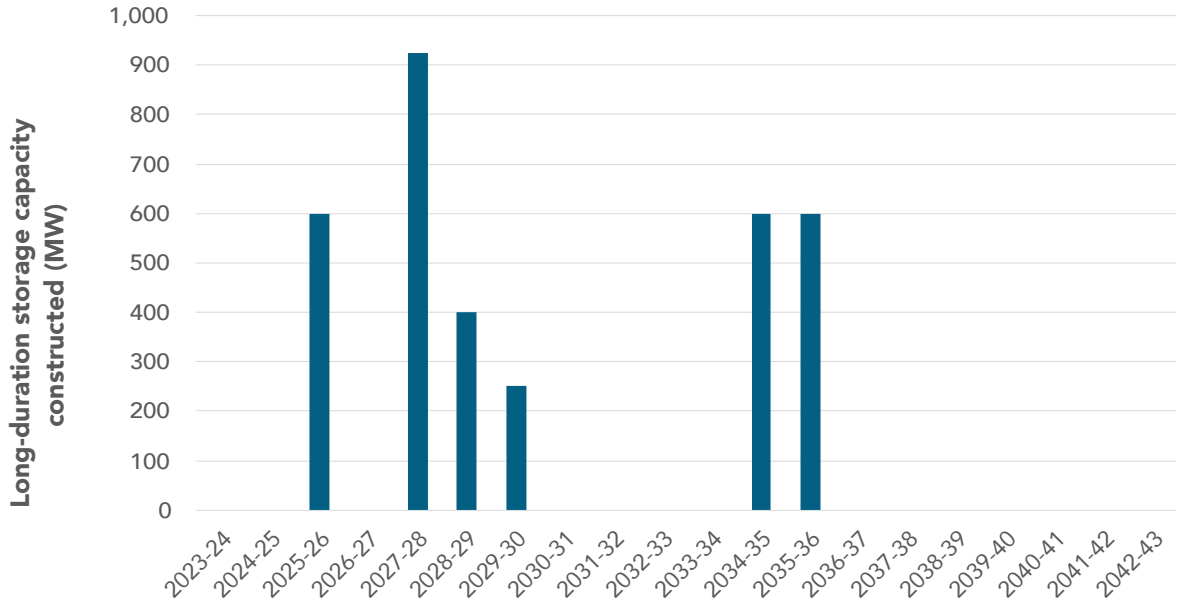
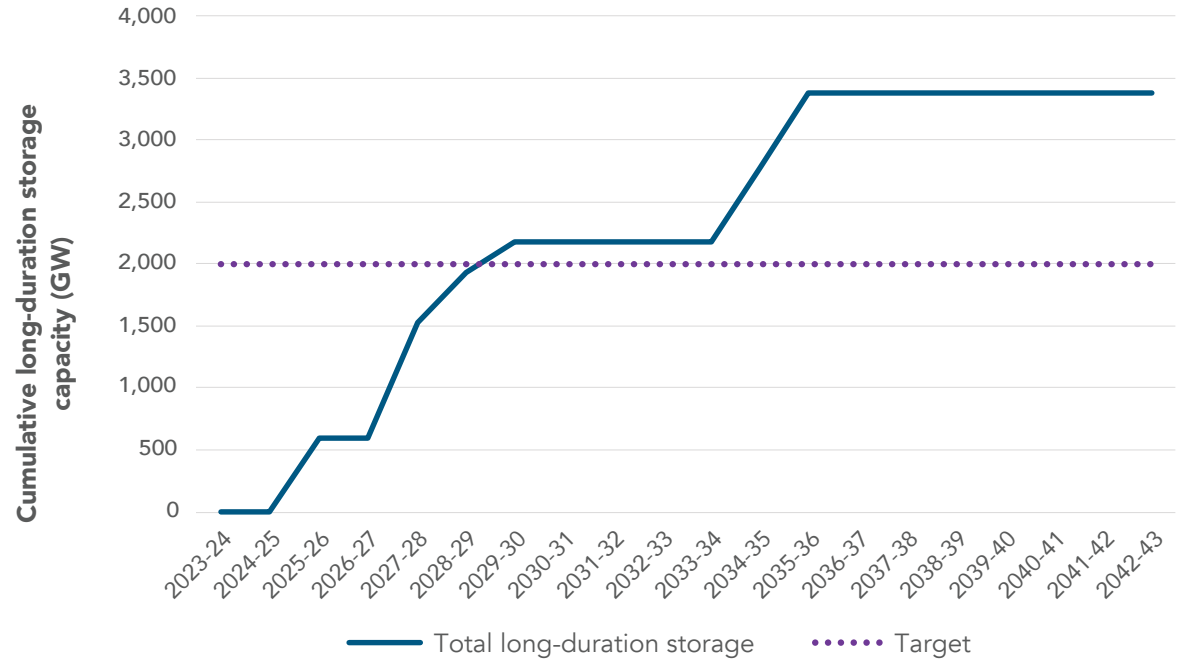


Figure 15: Development Pathway (Long-Duration Storage - Cumulative)



The Development Pathway for long-duration storage infrastructure is technology- and location-neutral. However, as set out in the 2021 IIO Report,[49] it has been designed having regard to the significant uncertainty and disparities regarding cost and lead-times for different long-duration storage technologies.

49 2021 IIO Report, pages 33-34.

3.5.2 Design of the long-duration storage build

For the reasons set out in section 1.4 of this report, the Consumer Trustee has retained the long-duration storage elements of the Development Pathway from the 2021 IIO Report.[50]

As noted in section 2, long-duration storage technologies may serve the same functions as firming infrastructure in meeting the reliability standard and the energy security target. Notwithstanding, there may be circumstances where one type of infrastructure is more preferable than the other – for example, in the case of long-duration storage, where it contributes to meeting the minimum objective of 2 GW by the end of 2029, or in the case of firming, because it presents a more cost-effective and timely means of addressing a near-term system reliability issue. The Consumer Trustee considers that the long-duration storage infrastructure set out in the 2021 IIO Report, with the addition of 380 MW of firming infrastructure in 2025-26, is the optimal means of meeting the infrastructure investment objectives. The implications of the crossover between these technologies for the tenders is discussed further in section 4.4.

3.6 Regulatory requirements

The EII Act and EII Regulation provide that an IIO Report must contain, or have regard to, certain matters.[51] These matters are included in or reflected throughout this report. However, the Consumer Trustee has set out certain key matters in this section below.

The matters that an IIO Report must contain include:

- a forecast of wholesale electricity costs and costs for NSW electricity customers that are due to contributions required to be paid by distribution network service providers under section 58 of the EII Act,[52]
- an assessment of the progress in achieving the minimum infrastructure investment objectives, and
- an assessment of the resilience of the NSW electricity system in relation to lulls in variable renewable energy sources, as it relates to the Development Pathway.

In addition, the EII Regulation requires the Consumer Trustee to take into account:

- how the Development Pathway will contribute to the object of the EII Act specified section 3(1)(a),[53] and
- the plan prepared by the NSW Renewable Energy Sector Board.[54]

An IIO Report is also required to include or take into account certain matters in relation to the conduct and outcomes of LTESA tenders.[55] As at the date of this report, the first tender has not yet been completed and information regarding such matters is therefore unavailable. Accordingly, this report does not address these issues.

50 See 2021 IIO Report, section 3.1.

51 EII Act, section 9(1) and EII Regulation, clauses 24 and 25.

52 EII Regulation, clause 24(1)(d).

53 EII Regulation, clause 25(1)(f).

54 EII Act, section 9(1).

55 EII Regulation, clauses 24(2)(b) – (c) and 25(1)(e).

3.6.1 Forecast of costs for the supply of wholesale energy services to NSW customers

In preparing this report, the Consumer Trustee has considered the costs associated with the Development Pathway for three scenarios reflecting different volumes of firming infrastructure, as detailed in Appendix A.[56] There was no material difference in cost outcomes between these three scenarios owing to the relatively small amount of capacity added in the context of the overall NSW electricity system.

As required by the EII Regulation,[57] the cost forecasts for three firming scenarios are set out in Appendix A. The Consumer Trustee notes that these forecasts do not reflect the outcomes of various procurement processes currently underway (or underway at the time of modelling), and that the assumptions regarding costs and timeframes for built energy infrastructure have not been tested in the market, given the first tender is currently in progress. As noted in section 3.4 above, the 2023 IIO Report is expected to include an updated Development Pathway, taking into account this new information. That report will also include cost forecasts, which are expected to provide a more granular and accurate, market tested, forecast of Roadmap costs into the future. At this stage, it is expected that a draft 2023 IIO Report will be released in Q1 2023.

3.6.2 Improving affordability, reliability, security, and sustainability of electricity supply

The Consumer Trustee considers that the Development Pathway reflects the object in section 3(1)(a) of the EII Act. The 2021 Development Pathway was designed having regard to affordability and consumer cost impacts.[58] Analysis undertaken for this report shows that the reliability standard and, with additional firming infrastructure, the energy security target, are met.[59] The 2021 Development Pathway was also shown to improve sustainability through reducing carbon emissions.[60] Further, the NSW Government has decided that "successful [firming] projects will be required to have an emissions intensity lower than the most recent NSW grid average and achieve net zero scope 1 emissions by 2035", and that this "can be achieved by purchasing and voluntarily surrendering offsets".[61]

3.6.3 Progress in achieving the minimum objectives

The EII Regulation requires that each IIO Report after the first report must contain an assessment of the progress in achieving the minimum objectives specified in the EII Act.[62]

As at the date of this report, no LTESAs have yet been recommended by the Consumer Trustee.[63] However, generation and long-duration storage infrastructure constructed since 14 November 2019 may contribute to the achievement of the minimum objectives regardless of whether they are awarded an LTESA. Since 14 November 2019, in NSW:

- 920 MW of generation infrastructure has been classified as existing, and
- 2,230 MW of generation infrastructure has been classified as committed, and
- No long-duration storage infrastructure has been classified as existing or committed,

on AEMO's generation information page.

This sums to a total of 3,150 MW of existing and committed generation in NSW as of August 2022, or approximately 7,400 GWh of available annual energy. Of this, 2,100 MW or 5,000 GWh per annum is expected to be commissioned before May 2023,[64] exceeding the 2021 Development Pathway, which included 4,100 GWh per annum by 2022-23. At the time of modelling for the 2021 IIO Report, 1,600 MW of generation infrastructure was incorporated as committed. Such projects may still participate in competitive tenders conducted by the Consumer Trustee.

56 The build trajectories for generation and long-duration storage infrastructure were per the 2021 Development Pathway across all three scenarios. The cost implications for different build trajectories for generation and long-duration storage were considered as part of the preparation of the 2021 IIO Report.

57 EII Regulation, clause 24(1)(d).

58 2021 IIO Report, section 6.1.

59 2021 IIO Report, section 6.3.

60 2021 IIO Report, section 6.2.

61 See: https://www.energy.nsw.gov.au/nsw-plans-and-progress/major-state-projects/electricity-infrastructure-roadmap/entities-delivering/target-monitor.

62 EII Regulation, clause 24(2)(d).

63 The first generation and long-duration storage tender commenced on 4 October 2022 and is expected to be completed in March 2023.

64 As per the August 2022 AEMO Generation Information Update.

Table 1 Comparison of 2021 Development Pathway and Existing/Committed Generation, cumulative

Annual generation available (GWh p.a.)[65]	2021-22	2022-23	2023-24
2021 Development Pathway	2,900	4,100	8,100
Existing and committed generation expected commissioning as at August 2022	2,900	5,000	7,400

3.6.4 Resilience to lulls in variable renewable energy sources

The EII Regulation requires that each IIO Report after the first report must contain an assessment of the resilience of the NSW electricity system in relation to lulls in variable renewable energy sources, as it relates to the Development Pathway, including by reference to climate modelling. This assessment is set out in Appendix B.

3.6.5 Renewable Energy Sector Board Plan

The EII Act requires the Consumer Trustee, in exercising its functions, to take into account the plan prepared by the NSW Renewable Energy Sector Board (RESB Plan). The RESB Plan was published in September 2022.[66] Its purpose is to set out how local workers, communities and industries can benefit from the economic opportunities presented by NSW's energy transformation.

The RESB Plan identifies major opportunities and barriers faced by the renewable energy sector in NSW. In particular, the Consumer Trustee notes that the plan identifies barriers including skill and labour shortages, including as a result of competition from a large general infrastructure pipeline, low levels of unemployment in renewable energy zones and shortages in key occupations (e.g., electricians).[67]

These findings regarding supply chain constraints are consistent with the research undertaken for the preparation of the 2021 IIO Report.[68] The risks of supply chain constraints were a key factor in the design of the 2021 Development Pathway for generation and long-duration storage infrastructure, including as part of the selection criteria[69] for the Development Pathway and the incorporation of an annual build limit in the 2030s.[70] The Consumer Trustee considers that the matters set out in the RESB Plan are consistent with its approach to the 2021 IIO Report and the retention of the 2021 Development Pathway for generation and long-duration storage projects. As discussed in section 3.3.2, the Consumer Trustee has also had regard to supply chain constraints in respect of firming infrastructure and seeks to mitigate these by conducting the tender for firming infrastructure as soon as practicable (i.e., Q2 2023).

65 Noting conversions from MW capacity to GWh available p.a. are estimates only.

66 Office of Energy and Climate Change (September 2022), *NSW Renewable Energy Sector Board's Plan*, https://www.energy.nsw.gov.au/sites/default/files/2022-09/nsw-renewable-energy-sector-board-plan.pdf.

67 RESB Plan, page 25.

68 2021 IIO Report, Appendix D.

69 2021 IIO Report, section 6 (see, in particular Table 7 and Table 8).

70 2021 IIO Report, section 3.1.1.

4. 10-Year Plan

4.1 Overview

The 10-Year Plan sets out the schedule and indicative amount of infrastructure for competitive tenders for built energy, which are necessary to give effect to the Development Pathway in respect of firming, generation, and long-duration storage infrastructure. The Consumer Trustee intends for the 10-Year Plan to provide a level of certainty to investors to enable them to plan for participation in upcoming competitive tenders for built energy and improve the likelihood of receiving high-value submissions.

The plan also provides the Consumer Trustee with a degree of flexibility. For any given tender, the Consumer Trustee may make recommendations for greater or less than that indicated in the 10-Year Plan. The decisions will be based on the evaluation of submissions received in each competitive tender process against a set of merit criteria, which will include the extent to which a project offers financial value to NSW customers and has a pathway to commercial operation.[71]

The timing and indicative size of tenders in the 10-Year Plan, particularly in respect of those tenders in the later years of the plan, is subject to change in future IIO Reports published every two years. The Consumer Trustee may also withdraw or amend the timing for or indicative amount of infrastructure that it intends to recommend under a future tender where it considers it is in the long-term financial interests of NSW electricity customers to do so, for example, where new information becomes available. Were this to occur; the Consumer Trustee will notify stakeholders of the change.

The timing and indicative scale of the firming (in MW), generation (in GWh) and long-duration storage (in GW) tenders are detailed in the following sections.

Importantly, the 10-Year Plan in this report does not affect the indicative size of the first competitive tender, which commenced on 4 October 2022 and, as at the date of this report, is currently underway.

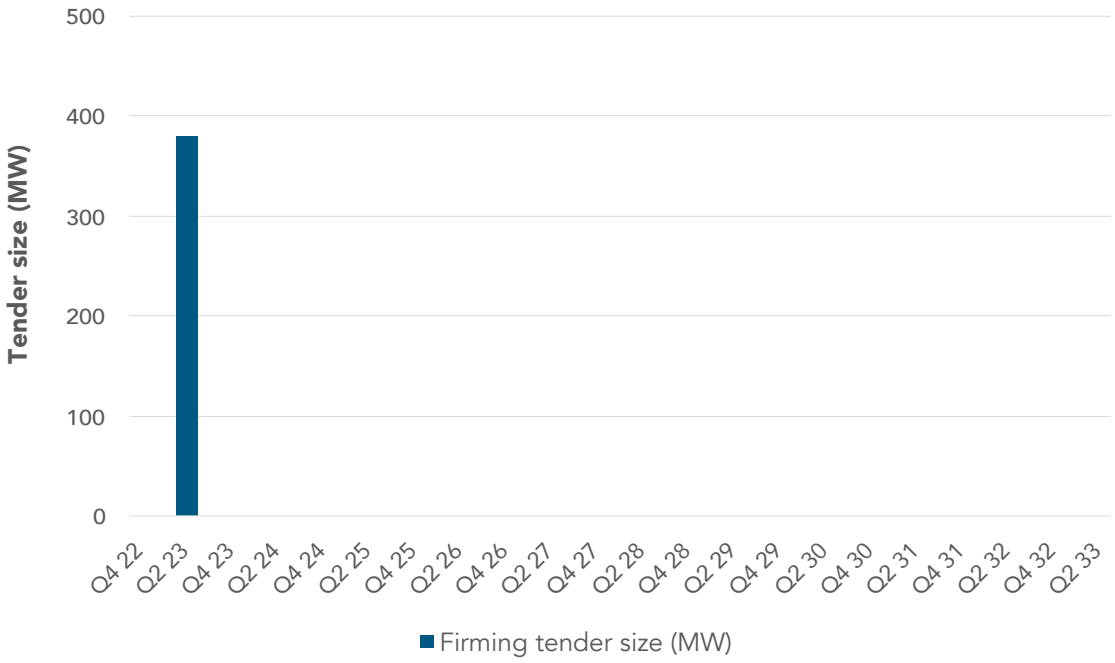
71 The current Tender Rules and Tender Guidelines, which set out the eligibility and merit criteria for competitive tenders, are available on the Consumer Trustee's website: https://aemoservices.com.au/tenders/tender-pack.

4.2 Firming tenders

The timing and indicative size for the competitive tender for firming infrastructure is shown in Figure 16.

Consistent with the Firming Direction to the Consumer Trustee, the 10-Year Plan consists of a single tender, which the Consumer Trustee has determined should commence in Q2 2023. The indicative size of the tender is 380 MW, and the firming infrastructure must be located within the Sydney-Newcastle-Wollongong sub-region (or in close proximity to this sub-region, provided it can demonstrate its contribution to meeting the energy security target), which is consistent with the Development Pathway detailed in section 3.3. To meet the Development Pathway, the recommended projects are required to be commissioned by December 2025.

Figure 16: 10-Year Plan (Firming)



4.3 Generation tenders

The timing and indicative size (in terms of amount of generation) for competitive tenders for generation infrastructure over the next 10 years is shown in Figure 17.

The volume of annual generation enabled by this schedule closely aligns to the Development Pathway, noting that the schedule of tenders accounts for a nominal two-year development lag.[72]

Figure 17: 10-Year Plan (Generation)

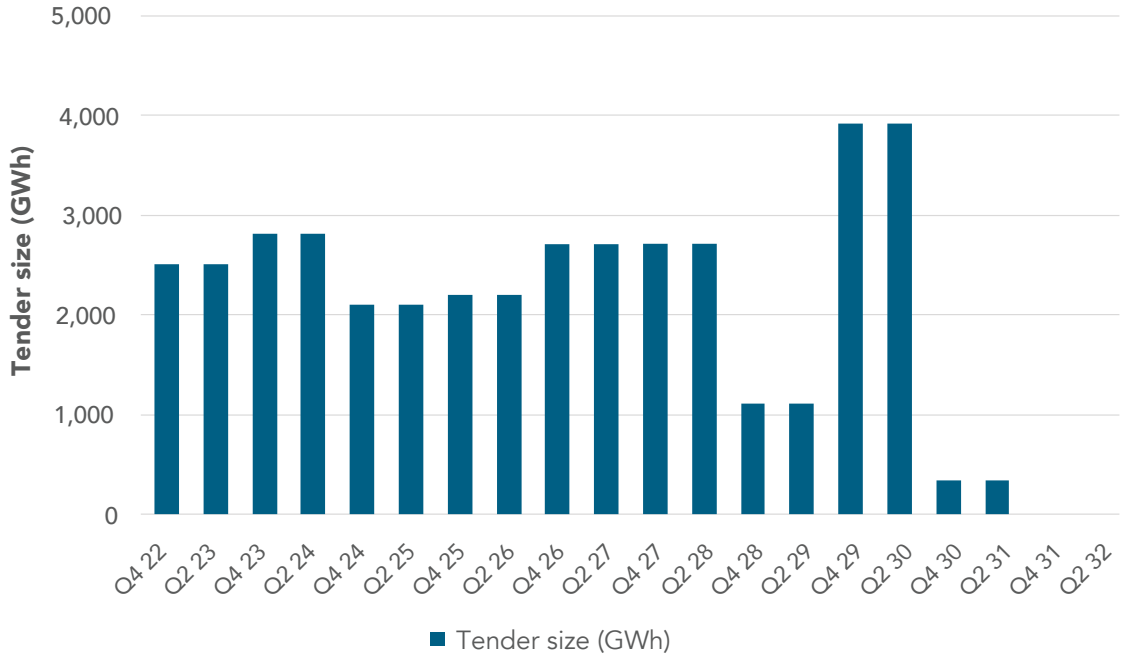


Figure 17 updates the 10-Year Plan in section 4.1 of the 2021 IIO Report.

The 10-Year Plan commences with the tender in Q4 2022, with an indicative size of 2,500 GWh per annum. This is consistent with the announcement made by AEMO Services on 7 April 2022 which set out the indicative amount for the Q4 2022 tender which is currently underway.[73] To reflect the passage of time, an additional year has been added to the 10-Year Plan. However, there are no tenders scheduled after Q2 2031 given the Development Pathway does not add any generation during the mid-2030s.

72 These lead times assume that the projects have already progressed through preparatory steps in the development process.

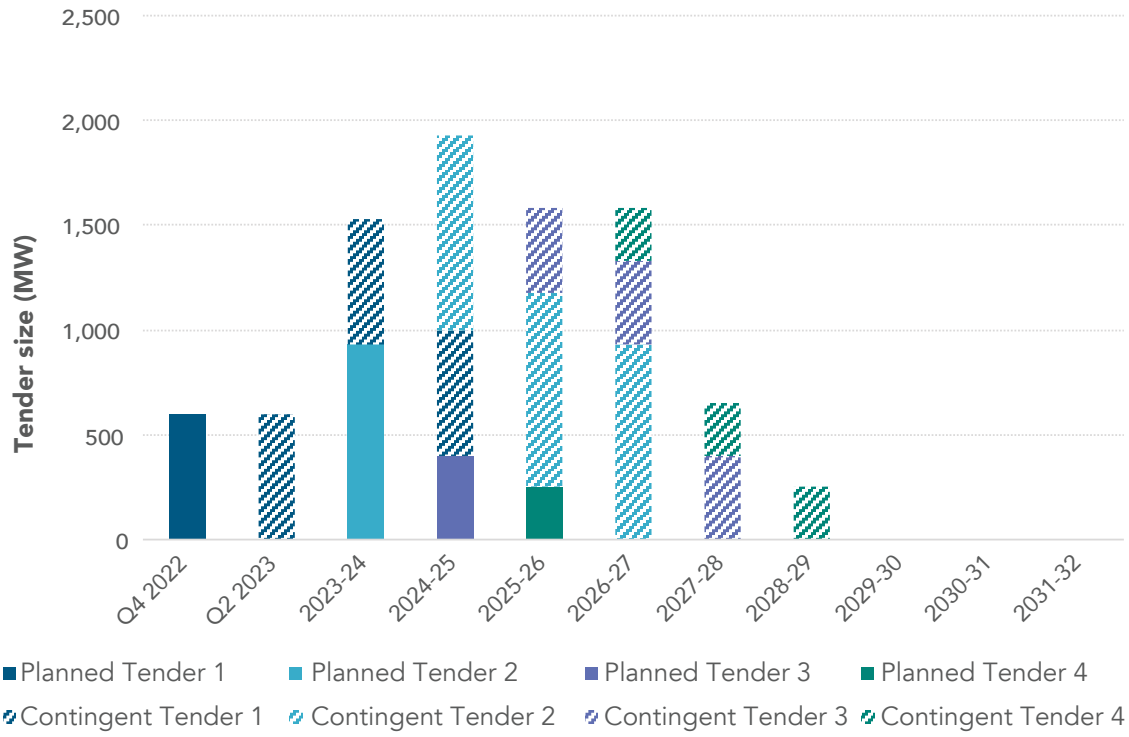
73 AEMO Services (April 2022), *Update to implementation of the plan for competitive tenders in the December 2021 Infrastructure Investment Objectives Report*, https://aemoservices.com.au/-/media/services/files/publications/update-to-tender-plan-implementation.pdf?la=en.

4.4 Long-duration storage tenders

The timing and indicative sizing for competitive tenders for long-duration storage infrastructure over the next 10-year period is shown in Figure 18.

These are based on the build trajectory of long-duration storage infrastructure needed to meet the Development Pathway with at least a four-year lead time to enable long lead-time technologies, including pumped hydro, to participate.

Figure 18: 10-Year Plan for Long-Duration Storage



As noted in the 2021 IIO Report, the Consumer Trustee has planned for 'contingent tenders' for long-duration storage infrastructure each year, including in years where the Development Pathway does not indicate a need for additional long-duration storage capacity (see Figure 18). Whether a tender proceeds in a given year is subject to the Consumer Trustee's assessment that it is in the long-term financial interests of NSW electricity customers for this to occur, for example, having regard to information derived from the outcomes of preceding tenders. It will only proceed if sufficient long-duration storage capacity is not recommended by the Consumer Trustee in preceding tenders. Any unallocated capacity from a tender round will also be rolled into the next round, as seen by the dotted lines in Figure 18.

The indicative capacity for the previous 2021-22 tender (0.6 GW) has been scheduled for Q4 2022, consistent with the announcement by AEMO Services on 7 April 2022.[74]

Figure 18 updates the 10-Year Plan in section 4.2 of the 2021 IIO Report as follows:

- A tender has been added in Q2 2023, with an indicative size of 0.6 GW contingent on the outcomes of the Q4 2022 tender (the rationale for this is discussed below).
- No tender has been added in 2031-2032 given the Development Pathway remains constant during the mid-2030s.

The Consumer Trustee has scheduled a contingent tender for long-duration storage be held in Q2 2023 to coincide with the tender for firming infrastructure set out in section 4.2. This will bolster the information available to the Consumer Trustee in its decision-making for both tenders. Because long-duration storage projects meet the definitional requirements for firming infrastructure,[75] and given the EII Act establishes a minimum objective with respect to the construction of long-duration storage infrastructure, there may be efficiencies in recommending long-duration storage projects that also meet firming needs (though this would be subject to the lead-times for the relevant projects). This could potentially reduce the amount of other types of firming infrastructure required to meet the energy security target gap from 2025-26.

As explained in Figure 8, it is important to note that, for the purposes of the Q2 2023 firming tender, firming infrastructure must be located in the Sydney-Newcastle-Wollongong sub-region. However, projects located outside (but in close proximity to) this sub-region may also be eligible if they are able to demonstrate their contribution to meeting the energy security target. For long-duration storage to replace the need for firming, it would also need to meet these locational requirements. However, long-duration storage located anywhere in NSW may participate in the Q2 2023 long-duration storage tender or any other long-duration storage tender.

74 AEMO Services (April 2022), *Update to implementation of the plan for competitive tenders in the December 2021 Infrastructure Investment Objectives Report*, https://aemoservices.com.au/-/media/services/files/publications/update-to-tender-plan-implementation.pdf?la=en.

75 See EII Act, sections 43(1)(b) and (c).

5. Methodology

This section outlines the modelling methodology and process used to design the Development Pathway for firming infrastructure set out in section 3.3.

The modelling methodology and approach to selecting the generation and long-duration storage infrastructure elements of the Development Pathway are set out in sections 5 and 6 of the 2021 IIO Report.

5.1 Overview

The Consumer Trustee uses electricity market modelling to inform the Development Pathway. This market modelling involves considering a range of forecast inputs and assumptions over a 20-year period – including existing and planned supply, forecast demand, fuel costs, the transmission network configuration and the expected costs and attributes of new candidate infrastructure – to produce an optimal (consumer least-cost) trajectory for the development of new infrastructure (including generation, storage, firming and network infrastructure). Given the multitude of variables, it is impossible to accurately forecast precise market conditions over a 20-year period. Rather, the purpose of the market modelling is to inform the Consumer Trustee's decisions about timing and need for new infrastructure to best achieve outcomes for NSW electricity customers.

The Consumer Trustee engaged AEMO to undertake market modelling to inform the development of the Development Pathway for firming infrastructure. The preparation of this report relied on use of AEMO's in-house models[76] and, except where otherwise noted in this report, use of inputs and assumptions consistent with AEMO's Integrated System Plan modelling.

The overarching approach to the Development Pathway is represented in Figure 19 below.

In order to identify the indicative size of the firming tender, the Consumer Trustee undertook analysis to ensure the Development Pathway contained sufficient firming infrastructure to meet the energy security target and the reliability standard. In accordance with the EII Act,[77] the analysis assessed whether the energy security target is met over a period of 10 years.

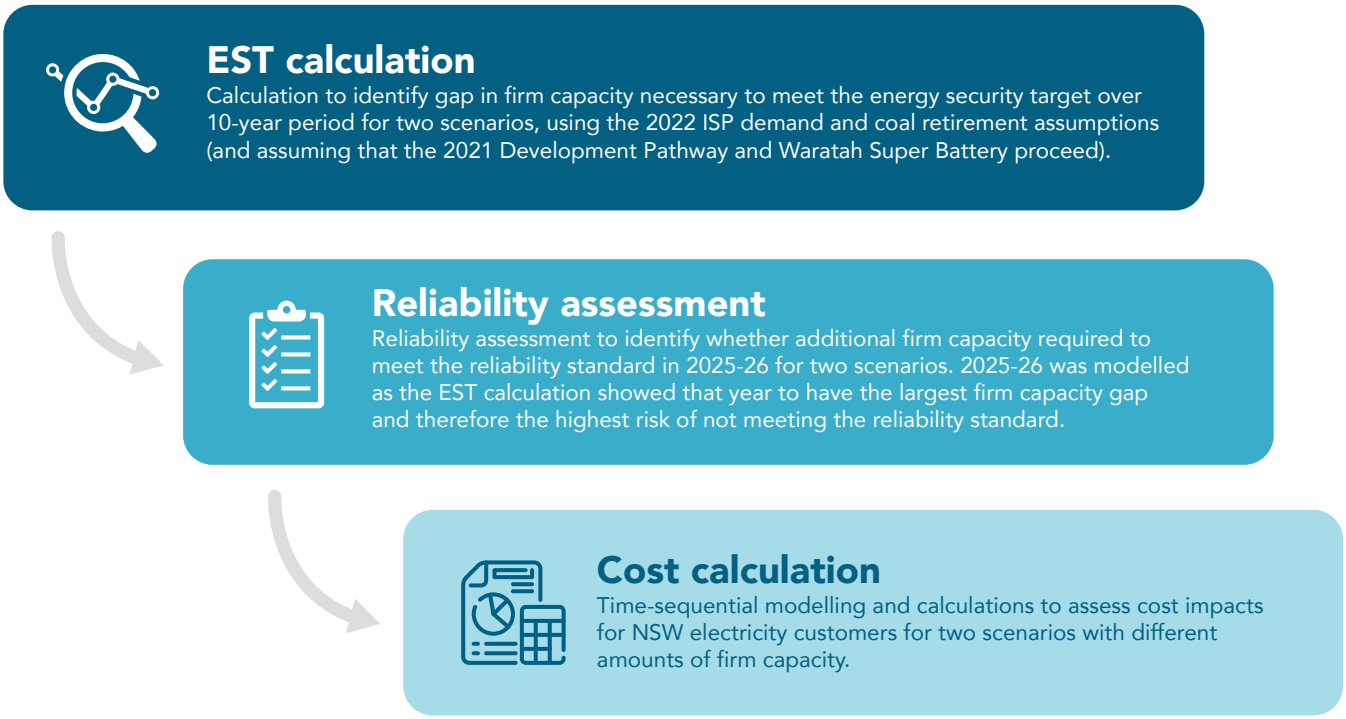
The Consumer Trustee also undertook a reliability assessment in respect of 2025-26, as the energy security target calculations showed this year had the largest firm capacity deficit across the 10-year horizon and the largest potential for a reliability breach, assuming the generation and long-duration storage elements of the Development Pathway eventuate.

The energy security target and reliability assessments each considered two primary scenarios. The scenarios (which were different for each assessment) are described in sections 5.3 and 5.4 below, respectively. The energy security target and reliability assessments considered more narrow sets of scenarios compared to the 2021 IIO Report, because the Consumer Trustee decided to retain the build trajectories for generation and long-duration storage infrastructure from the 2021 IIO Report (for the reasons described in section 3 above).

76 This approach differed to the approach to the 2021 IIO Report, where AEMO engaged a third-party consultant to develop a market model and assist generally with modelling activities.

77 EII Act, section 12(1).

Figure 19: Overview of modelling approach for firming Development Pathway



The assumptions used in, and results of, the cost calculations are set out in Appendix A. There was no material difference in cost outcomes between the three modelled scenarios owing to the relatively small amount of capacity added in the context of the overall NSW electricity system.

5.2 Assumptions for energy security target and reliability assessments

5.2.1 Core Assumptions

The following core assumptions underpin the modelling for the Development Pathway for firming infrastructure:

- The 2021 IIO Report's Development Pathways for generation and long-duration storage infrastructure pathway were maintained.
- Demand and coal retirement timing assumptions align with AEMO's 2022 Integrated System Plan (2022 ISP) Step Change scenario.[78]
- Network augmentation timings aligned with AEMO's Draft 2022 Integrated System Plan (Draft 2022 ISP) Step Change scenario.[79] These assumptions are set out in Table 2 below.

Table 2 Network Augmentation Timing Assumptions for Firming Assessment

Network augmentation	Modelled timing
Queensland to NSW (QNI) Minor	Before 1/7/2023
Victoria to NSW (VNI) Minor	Before 1/7/2023
Central-West Orana REZ	1/7/2024
Project EnergyConnect	1/7/2025
Waratah Super Battery*	1/7/2025[80]
New England REZ Transmission Link	1/7/2027
Hunter Transmission Project	1/7/2027
HumeLink	1/7/2028
VNI West (via Kerang)	1/7/2031
QNI Connect	1/7/2032
New England REZ Extension	1/7/2035

*Waratah Super Battery is not included in the 2022 ISP Step Change scenario.

78 AEMO (June 2022), *2022 Integrated System Plan*, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en.

79 AEMO (December 2021), *Draft 2022 Integrated System Plan*, https://aemo.com.au/-/media/files/major-publications/isp/2022/draft-2022-integrated-system-plan.pdf?la=en.

80 For the purposes of the energy security target and reliability assessments, the Waratah Super Battery was assumed to enter by 2025-26 in time for the Eraring retirement, however the Consumer Trustee understands it may be constructed in the 2024-25 financial year. However, this difference in timing does not affect the firm capacity gap in the energy security target calculation.

For both the energy security target calculations and the reliability assessment, the 2021 IIO Report's Development Pathway for generation was maintained. It was assumed, for the purposes of determining a firming infrastructure requirement, that the 600 MW of long-duration storage capacity that is commissioned in 2025-26 as part of the 2021 Development Pathway is commissioned at the end of 2025-26, and therefore is not available in time to address the forecast breach of the energy security target. This was regarded as a conservative assumption to reflect the uncertainties in the timing of long-duration storage project development.

5.2.2 Differences to Energy Security Target Monitor Report

The direction to the Consumer Trustee to conduct a tender for firming infrastructure followed the identification of a breach of the energy security target in the May 2022 Further ESTM Report.

The Further ESTM Report identified a 2025-26 EST breach of 1,250 MW, but this did not factor in the Waratah Super Battery. The OECC indicated that it anticipated that at least 350 MW of firming infrastructure will be required in the Sydney-Newcastle-Wollongong sub-region.

The Consumer Trustee's own calculations in respect of the energy target security target contain the following key differences in assumptions to the Further ESTM Report:

- The inclusion of the 2021 Development Pathway in respect of generation and long-duration storage.[81]
- The inclusion of New England Transmission Link (2027-28), Hunter Transmission Project (2027-28) and HumeLink (2028-29) as per the 2022 ISP Step Change Scenario outcomes.
- The inclusion of the Waratah Super Battery (2025-26).

5.2.3 Differences to the 2022 Electricity Statement of Opportunities

AEMO, in its 2022 ESOO, identified a reliability gap in respect of the reliability standard in NSW from 2025-26, unless further investments are made. However, the modelling undertaken by AEMO for the Central scenario in the ESOO only incorporates existing and committed generation projects and does not take account of the additional generation and long-duration storage included in the Consumer Trustee's Development Pathway (or the additional network infrastructure that is expected to be constructed in NSW under the Roadmap). The 2022 ESOO noted that, in NSW, the reliability forecast would be improved by the achievement of the 2021 Development Pathway, the HumeLink augmentation and the Hunter Transmission Project (which, in AEMO's modelling, includes the Waratah Super Battery).

In preparing this IIO Report, the Consumer Trustee conducted its own reliability assessment to assess whether the Development Pathway meets the reliability standard. The key differences between this reliability modelling and that undertaken by AEMO for the 2022 ESOO are the same as those listed in section 5.2.2 above for the energy security target assessment.

5.3 Energy security target assessment

An energy security target assessment compares forecast firm capacity in NSW to the energy security target to identify any potential shortfall (or 'breach'). For the purposes of this report, the energy security target assessment was consistent with the methodology used by the Energy Security Target Monitor, but with some updated assumptions (as detailed above).

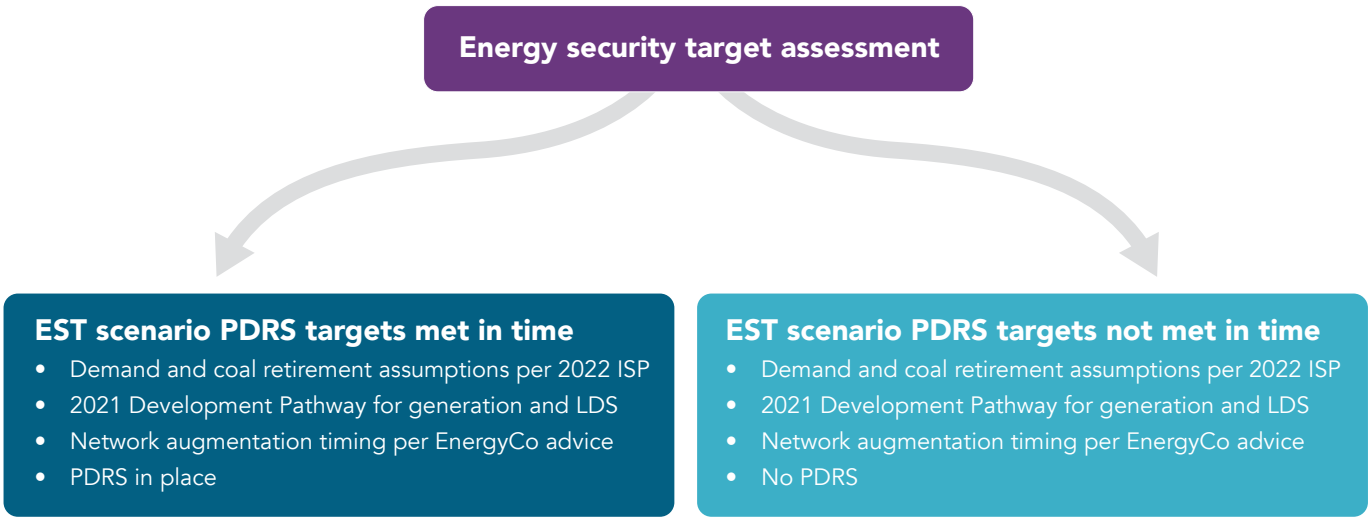
The energy security target is set at the capacity level needed to meet forecast maximum NSW summer demand while maintaining a reserve margin to account for the unexpected loss of two of NSW's largest available generators. Capacity includes scheduled, semi-scheduled and non-scheduled generation, interconnector capacity, demand response and demand-side participation (DSP) from existing and new sources. To determine the firm capacity, each of these capacity sources are discounted appropriately to a level which contributes to peak demand. The firm capacity is evaluated on a sub-regional basis and therefore is further reduced by major intra-regional transmission limits.

The energy security target assessment was performed on two scenarios, which tested the impact of the NSW Government's Peak Demand Reduction Scheme (PDRS) on the expected EST gap (assuming in both cases that the 2021 Development Pathway is delivered). These scenarios are shown in Figure 20.

81 For the purposes of the reliability assessment, the Consumer Trustee assumed that the 600 MW of long-duration storage infrastructure forecast for 2025-26 is not available until the end of that year.

As shown below, the PDRS, once fully implemented, is expected to go some way to addressing the forecast breach of the energy security target in 2025-26. However, given the scheme has not been tested in practice (it is planned to commence in the summer of 2022-23),[82] the Consumer Trustee has conservatively modelled the impacts of the PDRS not achieving its targets in the planned timeframes.

Figure 20: Scenarios for energy security target assessment



For each of these scenarios, a firming deficit was determined for the 2025-26 financial year. For both scenarios, network constraints between central NSW and the Sydney-Newcastle-Wollongong sub-region led to a shortfall of firm capacity in the Sydney-Newcastle-Wollongong sub-region necessary to meet the energy security target. No shortfalls were identified in other NSW sub-regions.

Table 3: Results of energy security target assessment

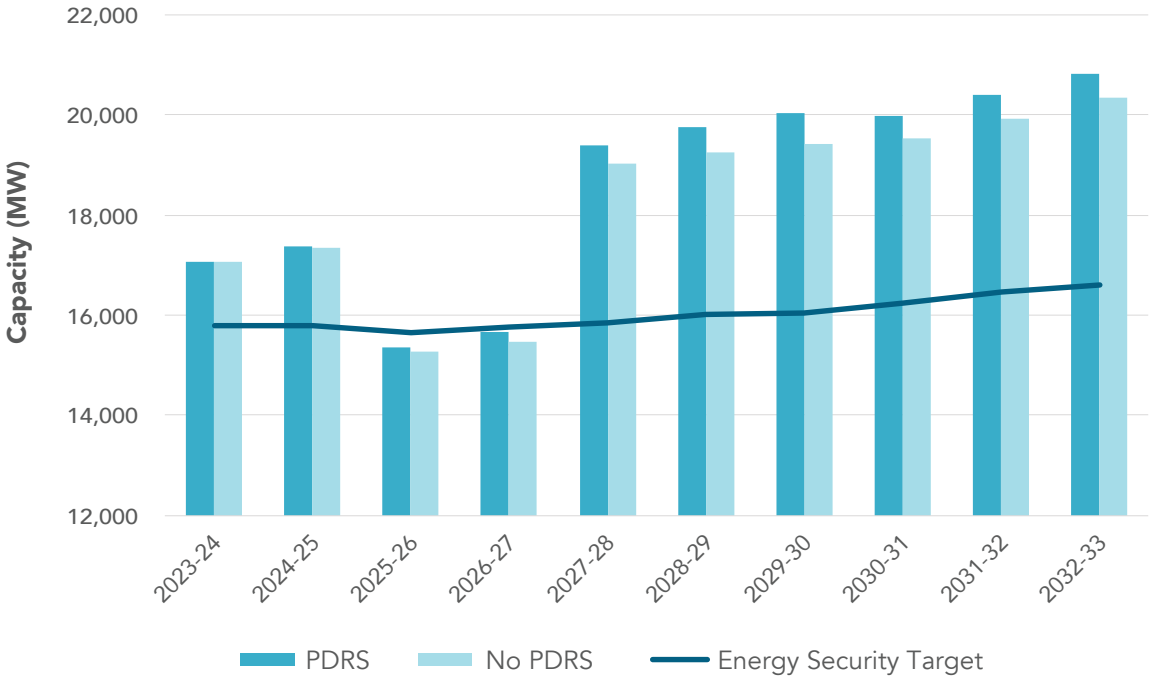
Scenario	2025-26 EST deficit
PDRS targets met in time	281 MW
PDRS targets not met in time	376 MW

Given the uncertainty associated with the timeliness of the PDRS achieving its targets, and the criticality of meeting the energy security target under the EII Act, the Consumer Trustee has used the second scenario as the basis for adding firming infrastructure to the Development Pathway. For the purposes of designing the Development Pathway and 10-Year Plan, the 376 MW figure was rounded up to 380 MW.

In addition to focusing on the 2025-26 year, the energy security target assessment was conducted for 10 forecast years. The results in Figure 21 show that in addition to 2025-26, there is a smaller EST breach identified in the 2026-27 year. In 2027-28 the EST breach is closed, primarily due to the development of Hunter Transmission Project and New England Transmission Link network augmentations.

82 See: https://www.energy.nsw.gov.au/nsw-plans-and-progress/regulation-and-policy/energy-security-safeguard/peak-demand-reduction-scheme#-find-out-more-about-the-pdrs-.

Figure 21: 10-Year EST assessment



The energy security target assessment was also conducted with only committed projects, to test the impact if the Development Pathway is not achieved. However, under that scenario, the 2025-26 breach was the same size at 376 MW. This is because none of the modelled generation in the Development Pathway is located in the Sydney-Newcastle-Wollongong sub-region, and so the Development Pathway does not address the breach.

5.4 Reliability assessment

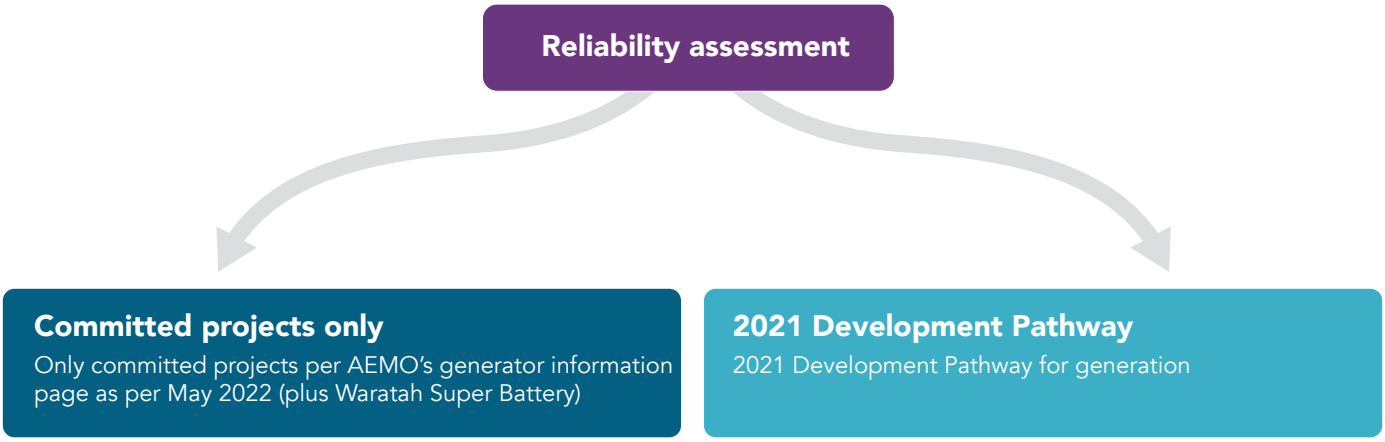
5.4.1 Primary reliability assessment

Because the overall objective for firming infrastructure under the EII Act involves meeting the reliability standard (as well as the energy security target), the Consumer Trustee also commissioned a reliability assessment. The reliability assessment forecasts the expected unserved energy (USE) through probabilistic, time-sequential modelling. The methodology involves Monte-Carlo simulations of a constrained optimal dispatch at an hourly level of granularity. A range of market conditions were forecast, including potential weather patterns and generator availability, with events weighted by likelihood of occurrence. The methodology for this assessment was consistent with that used by AEMO for its ESOO.

The reliability assessment was performed for 2025-26 on two scenarios, to test the impact of the 2021 Development Pathways for generation and long-duration storage infrastructure. These scenarios are shown in Figure 22, and described as below:

- The Committed projects only scenario includes the existing and committed developments from AEMO's May 2022 Generation Information publication, and the development of the Waratah Super Battery and associated minor transmission line upgrades.
- The 2021 Development Pathway scenario includes additional generation developments in accordance with the 2021 IIO Report, in addition to the infrastructure in the Committed projects only scenario. It has delayed investments in long-duration storage and does not include any additional firming infrastructure.

Figure 22: Scenarios for reliability assessment



The reliability standard for 2025-26 is the NEM-wide reliability standard under the National Electricity Rules of expected USE for a region not exceeding 0.002% of the total energy demanded in the relevant region for a given financial year. In both scenarios there was no breach of the reliability standard, as outlined in Table 4.

Table 4: Comparison of Reliability Assessment Scenarios for Unserved Energy and Reliability Standard

Scenario	2025-26 expected USE	Reliability standard
Full Development Pathway	0.0003%	0.002%
Only committed projects	0.0013%	0.002%

Having regard to this, the Consumer Trustee considers that no firming infrastructure is needed to meet the 0.002% USE reliability standard in 2025-26.

5.4.2 Reliability sensitivity

The EII Regulation provides that the reliability standard is the NEM interim reliability measure of expected USE not exceeding 0.0006% of NSW's total energy demand prior to July 2025.[83] The identified breach of the energy security target is forecast to occur in December 2025, shortly after the reliability standard has switched to the less onerous 0.002% standard. Due to the close proximity in timing, the Consumer Trustee investigated whether additional firming infrastructure would be required to meet the interim reliability measure.

The results of that analysis are set out in Table 5. Like the main reliability assessment described above, the analysis considered the two scenarios in Figure 22. The scenarios compare reliability outcomes between the Development Pathway being achieved and only committed projects being constructed prior to 2025-26. This differs from the scenarios for the energy security target assessment, where the energy security target gap in 2025-26 is not sensitive to the achievement of the Development Pathway. This is due to the model's sensitivity to projects being located in the Sydney-Newcastle-Wollongong sub-region to reduce the energy security target gap and the modelled Development Pathway's projects being located elsewhere in the NSW region. Accordingly, the likelihood of achieving the generation element[84] of the Development Pathway in 2025-26 is relevant to the reliability assessment but not the energy security target assessment.

83 EII Regulation, clause 23(a).

84 For the purposes of the reliability assessment, the entry of 600 MW of long-duration storage in 2025-26 under the Development Pathway was assumed to not be available until the end of that year.

In the absence of the full Development Pathway, an additional 150 MW of firming infrastructure located anywhere in NSW (in addition to the 380 MW located within the Sydney-Newcastle-Wollongong sub-region) would be required to meet the interim reliability measure in 2025-26.

Table 5 sets out the amount of firm capacity necessary to meet the interim reliability measure of 0.0006% USE and the reliability standard of 0.002% USE in 2025-26, depending on whether the full Development Pathway for generation infrastructure is or is not achieved in 2025-26. If the Development Pathway for generation infrastructure to 2025-26 is achieved, the interim reliability measure would be met.

Table 5: Results of reliability sensitivity

Measure	Committed projects only (including Waratah Super Battery)	2021 Development Pathway (for generation)
	2025-26 gap	2025-26 gap
Interim reliability measure (0.0006% USE)	532 MW*[85]	None
Reliability standard (0.002% USE)	None	None

*This includes the 380 MW of firming infrastructure required to meet the energy security target. Firming infrastructure to meet the forecast gap in the energy security target must be located in (or in close proximity to) the Sydney-Newcastle-Wollongong sub-region, whereas firming infrastructure necessary to meet the reliability standard may be located in or outside this sub-region.

85 The capacity required to close the interim reliability measure gap is equivalent to different capacity-duration combinations determined by the reliability assessment. For example, this interim reliability measure gap could be addressed with a 615 MW, 2-hour storage project, a 367 MW, 4-hour storage project or a 326 MW, 8-hour storage project.

Appendix A: Cost Calculations

The EII Regulations provide that an IIO Report must contain a forecast of wholesale electricity costs and costs for NSW electricity customers that are due to contributions required to be paid by distribution network service providers under section 58 of the EII Act.[86]

The forecast costs set out in this Appendix A are calculated using the results of the market modelling detailed in section 5. These calculations were undertaken by AEMO as part of its engagement by the Consumer Trustee for the market modelling. The approach to the cost calculations, and the inputs and assumptions used to derive them (primarily based on AEMO's 2021 Inputs, Assumptions and Scenarios Report unless stated otherwise), are outlined below.

As noted in section 5, given the multitude of variables inherent in the modelling and calculations underpinning this report, it is impossible to accurately forecast precise market conditions and resulting consumer costs over a 10-year period. Rather, consumer cost outcomes are calculated and compared across multiple scenarios so that decision-making can be informed by an understanding of the relative cost impacts of different development trajectories. Further, as noted below, some of the input assumptions around the costs of transmission projects in particular are likely to be outdated. While this was not material to the setting of the Development Pathway in this report, it has likely impacted the accuracy of the wholesale cost forecasts. This will be updated in the draft 2023 IIO Report once further information (about transmission projects in particular) becomes available.

Approach

The forecast costs for NSW electricity customers associated with the contribution determination process are modelled as consisting of 'scheme costs' (a proxy for LTESA costs) and network build costs (i.e., for REZ network infrastructure projects and priority transmission infrastructure projects).[87] Scheme costs are calculated as the difference between total levelised cost of energy for each unit, and the wholesale market revenues achieved by that unit. This is effectively a representation of the 'missing money' required by the unit to breakeven on its costs, and a proxy for payments required from the LTESA. These costs are added to wholesale costs, to determine an aggregated cost forecast.

Time-sequential modelling has been used to support the calculation of wholesale and scheme costs. Time-sequential modelling mimics the dispatch process used by AEMO's NEM dispatch engine, optimising electricity dispatch for every half-hourly interval. This is intended to reflect participant behaviour, including generation outages, to reveal performance metrics for both generation and transmission.

The below three scenarios were modelled, based on the outcomes of the energy security target assessment:

Table 6 Scenarios for cost calculations

#	Name	Capacity (MW) added in 2025-26	Location
1	No Firming	0 MW	N/A
2	EST Scenario – PDRS targets met in time	281 MW	Sydney-Newcastle-Wollongong sub-region
3	EST Scenario – PDRS targets not met in time	376 MW	Sydney-Newcastle-Wollongong sub-region

86 EII Regulation, clause 24(1)(d).

87 This cost forecast is not directly comparable to the contribution determination process, which also includes administrative costs associated with certain of the Roadmap entities and consideration of matters such as the minimum prudent balance to be maintained by the scheme financial vehicle.

Inputs and assumptions

For all three scenarios, it was assumed as follows:

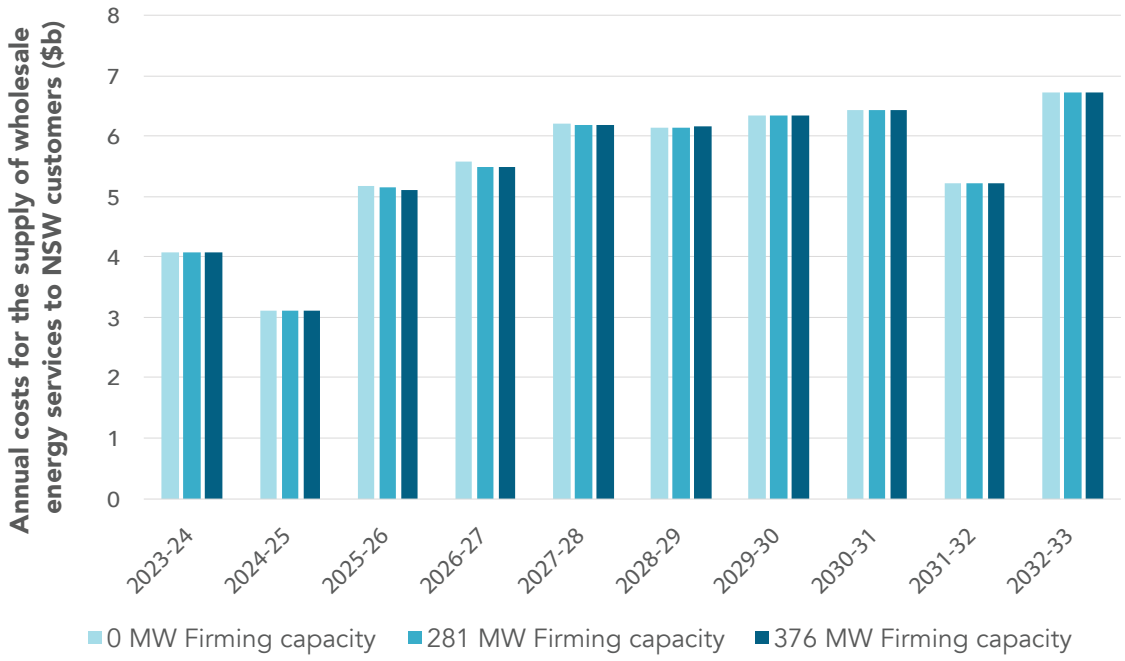
- The 2021 IIO Report's Development Pathway for generation and long-duration storage eventuate.
- Demand and coal retirement timing assumptions align with the 2022 ISP Step Change scenario.
- The firming infrastructure was assumed to consist of 1-hour batteries. This technology was chosen because it has the lowest build cost in 2025-26 in AEMO's 2021 Inputs, Assumptions and Scenarios Report (2021 IASR).
- Transmission augmentation timing assumptions align with the Draft 2022 ISP Step Change scenario, however, where relevant, transmission augmentation assumptions were updated on advice from EnergyCo and align with the final 2022 ISP Step Change scenario.
- Transmission cost assumptions align with the 2021 IASR, except for the Central-West Orana REZ and Waratah Super Battery projects (as the 2021 IASR did not include a cost estimate for these projects). [88] [89]

Given the 2021 IIO Development Pathway was maintained, capacity expansion modelling was not conducted.

Calculation results

As can be seen in Figure 23, there was no material difference in cost outcomes between the three modelled scenarios owing to the relatively small amount of capacity added in the context of the overall NSW electricity system.

Figure 23: Comparison of forecast costs for the supply of wholesale energy services to NSW customers across three scenarios



88 The cost forecast includes an estimate for these two projects provided by EnergyCo, which was based on assumptions regarding technology costs from AEMO's Transmission Cost Database and using the 2021 IASR methodology. For the Waratah Super Battery, the cost of the project was assumed to be recovered over 15 years (but with only the first 5 years of this recovered via the EII Act and therefore included in the cost forecast for this report). At the time of modelling, the procurement processes for both projects were still underway and, given the observable increases in construction costs since the 2021 IASR was published in July 2021, it is expected that the costs of these projects will ultimately be higher than the estimate considered for this report.

89 The modelling and consumer cost calculations underpinning this report are based on inputs and assumptions consistent with AEMO's 2021 IASR (except where otherwise noted). These assumptions do not include recent developments, such as the NSW Government's strategic benefit payment scheme. As the NSW Government proceeds with the planning and development of new network projects, this is expected to produce more accurate cost estimates for these projects. It is expected that such estimates will be reflected in the 2023 IIO Report.

The results for the third scenario (reflecting the amount of firming infrastructure which the Consumer Trustee has included in the Development Pathway) for the next 10 years are set out in Figure 24. In addition, Table 7 sets out the present value of each cost component over 10 years, using a 5.5% (real, pre-tax) discount rate in line with the Central assumption in AEMO's 2021 IASR. These forecasts reflect the total costs of supplying wholesale energy services to NSW customers over a 10-year period. 2022 has seen significant increases in wholesale electricity costs across the NEM due to a combination of factors, including unplanned outages of coal-fired generation and supply chain issues for coal and gas. The below results indicate that wholesale costs will continue to make up the majority of costs for the supply of energy services to NSW customers. Moreover, previous modelling undertaken when the Roadmap was established has demonstrated that the Roadmap would provide an overall net benefit to NSW customers. It is expected that updated modelling regarding the benefits of the Roadmap to NSW customers will be available from the NSW Government for the draft 2023 IIO Report in Q1 2023.

Figure 24: Forecast of annual costs for the supply of wholesale energy services to NSW customers

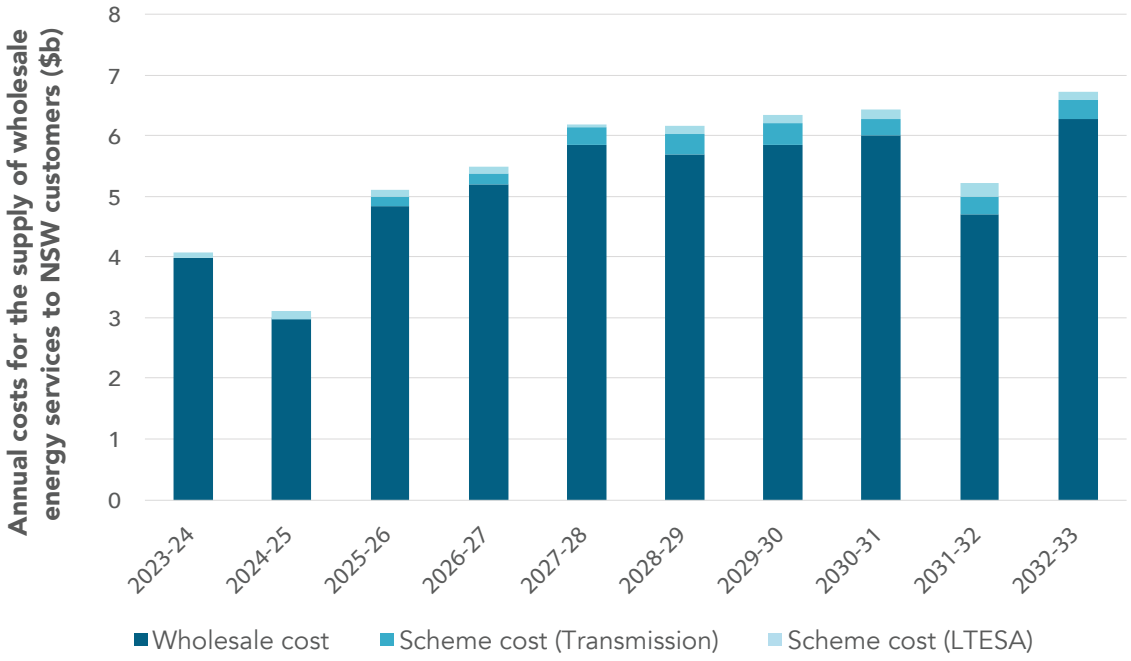


Table 7: Present value of forecast costs over 10 years

Present value of forecast costs over 10 years ($b)	
Wholesale costs	40.08
Scheme costs (Transmission)	1.47
Scheme costs (LTESA)	0.99
Total cost	**42.54**

As shown in Figure 24, costs are expected to vary over time. Higher wholesale costs are generally associated with generator retirements and/or higher demand. Lower wholesale costs are generally associated with new investment in generation and/or transmission capacity. Scheme costs associated with LTESAs and transmission investment are expected to increase over time as infrastructure is added incrementally, but be offset by lower costs in the wholesale market.

Limitations

The Consumer Trustee notes that these forecasts do not reflect the outcomes of various procurement processes currently underway (or underway at the time of modelling), and that the assumptions regarding costs and timeframes for built energy infrastructure have not been tested in the market, given the first tender is currently in progress. The 2023 IIO Report is expected to include an updated Development Pathway, taking into account this new information.

Appendix B: Resilience to Variable Renewable Energy Source Lulls

Legislative requirement

The EII Regulations provide that an IIO Report must contain an assessment of the resilience of the NSW electricity system in relation to lulls in variable renewable energy (VRE) sources, as it relates to the Development Pathway, including by reference to climate modelling.[90]

As set out below, the Consumer Trustee's assessment indicates that the Development Pathway is resilient to wind and solar lulls.

The analysis in this report approached the elements of this requirement as follows:

- **Climate modelling**: There is minimal substantive literature on the topic of modelling in relation to future impacts to the frequency and severity of wind and solar lulls due to climate change.[91] A historical analysis of 40 years of wind speeds and solar irradiance in NSW REZ regions was conducted to inform the resilience assessment.
- **Lull**: The historical analysis used hourly wind speed (m/s) and solar irradiance (kJ/m^2) data across NSW REZs at a cell granularity of ~31 x 31 km. A lull threshold was defined as the 5th percentile of this weather data across all NSW REZs from 1979 to 2020. A lull was defined to occur when the 24-hr rolling average falls below the lull threshold for at least half of the geographical area within a REZ.
- **Resilience**: In this assessment, resilience is defined as the ability of NSW to minimise unserved energy (USE) during the extended wind and solar lulls.

Methodology

The methodology ensures that the Development Pathway is resilient to historical VRE lulls which occurred between 1979 and 2020. The most significant VRE lulls from this dataset were identified and the ability of the system to minimise unserved energy (USE) in each year of the Development Pathway was assessed. If the analysis indicated that USE occurred, the Consumer Trustee would have considered adjusting the Development Pathway.

A four-step methodology was used:

- Step 1: Assessment of underrepresentation of lulls from historical data
- Step 2: Assessment of the underrepresentation of lulls given in the Development Pathway
- Step 3: Assessment of the resilience of the Development Pathway to a lull extension
- Step 4: Consideration of adjustment to the Development Pathway

These steps are discussed further below.

Step 1

The historical climate analysis was undertaken by the University of New South Wales (UNSW) and the OECC. Their analysis formed Step 1 of the resilience assessment. Their analysis assessed the underrepresentation of VRE lulls within the modelling dataset used to create the Development Pathway (2011 to 2020) relative to a larger dataset (1979 to 2020). The maximum duration (hours) of VRE lulls were compared between the two datasets, including combined wind and solar lulls and combined REZ lulls.

90 EII Regulation, clause 24(2)(e).

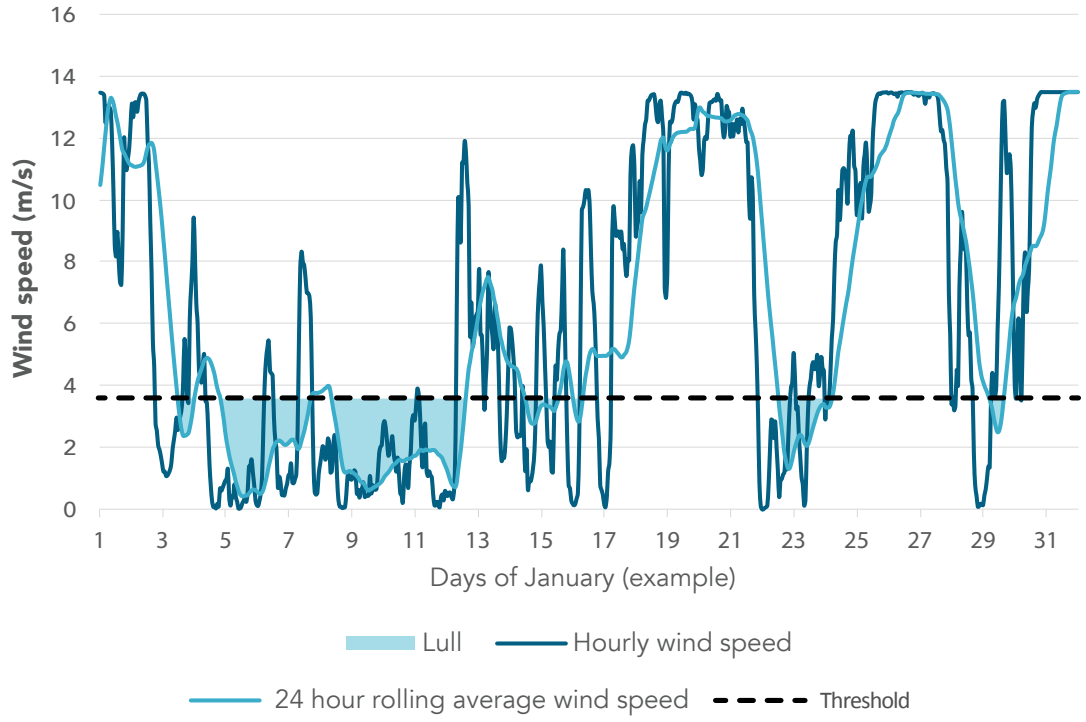
91 The CSIRO, BOM and NARCLiM, among other groups, have led initiatives that generated a range of future climate projections. However, there has been little to no quantitative research specifically on the impact of climate change towards the frequency and duration of VRE lulls.

Step 1.1: Lull definition

The universal wind speed threshold was defined to be the 5th percentile of the long-run distribution of 24-hour rolling mean wind speed data averaged across NSW REZs. A solar threshold was defined by the same definition using solar radiation data[92]. Across NSW REZs and using the larger dataset (1979 to 2020), this method yielded a 3.58 m/s wind speed threshold and a 341.9 kJ/m^2 solar radiation threshold.

A wind/solar lull is defined to have occurred if the 24-hour rolling mean value of the wind speed/solar radiation falls below these thresholds. Figure 25 shows a stylised example of wind speeds over a 31-day period. The 24-hour rolling mean value removes the brief fluctuations observed in the hourly wind speed data. The shaded area represents a wind lull, which occurs when the 24-hour rolling mean value falls below the threshold.

Figure 25: Lull definition example



The UNSW analysis calculated lulls at an individual 0.25° x 0.25° (~31 x 31 km) cell level. UNSW provided OECC with an hourly dataset spanning the period 1979 – 2020[93] with binary results for each grid cell across NSW indicating whether the cell is experiencing a solar lull (SL), wind lull (WL), or a combined wind and solar lull (CWL-SL).

92 Specifically, surface solar radiation downwards.

93 https://zenodo.org/record/6780614#.YvCUN3ZBxZd

OECC characterised lulls at a broader REZ level and defined a REZ to be in a lull if 50% or more of the individual cells in the REZ were simultaneously in a lull. This method was applied to all categories of lull such that a REZ-level combined wind and solar lull was defined as 50% or more of the individual cells being simultaneously in a combined wind and solar lull. A multiple REZ lull is then defined as the co-occurrence of a lull across the REZs of interest in the same time step.

The assignment and distribution of VRE lulls across REZs is shown in Figure 26 and Figure 27. The two VRE lull thresholds are geographically universal, leading to some REZs experiencing a higher frequency of lulls than others.

Figure 26: OECC assignment of grid cells to NSW REZs (n denotes the number of cells considered to be in REZ)

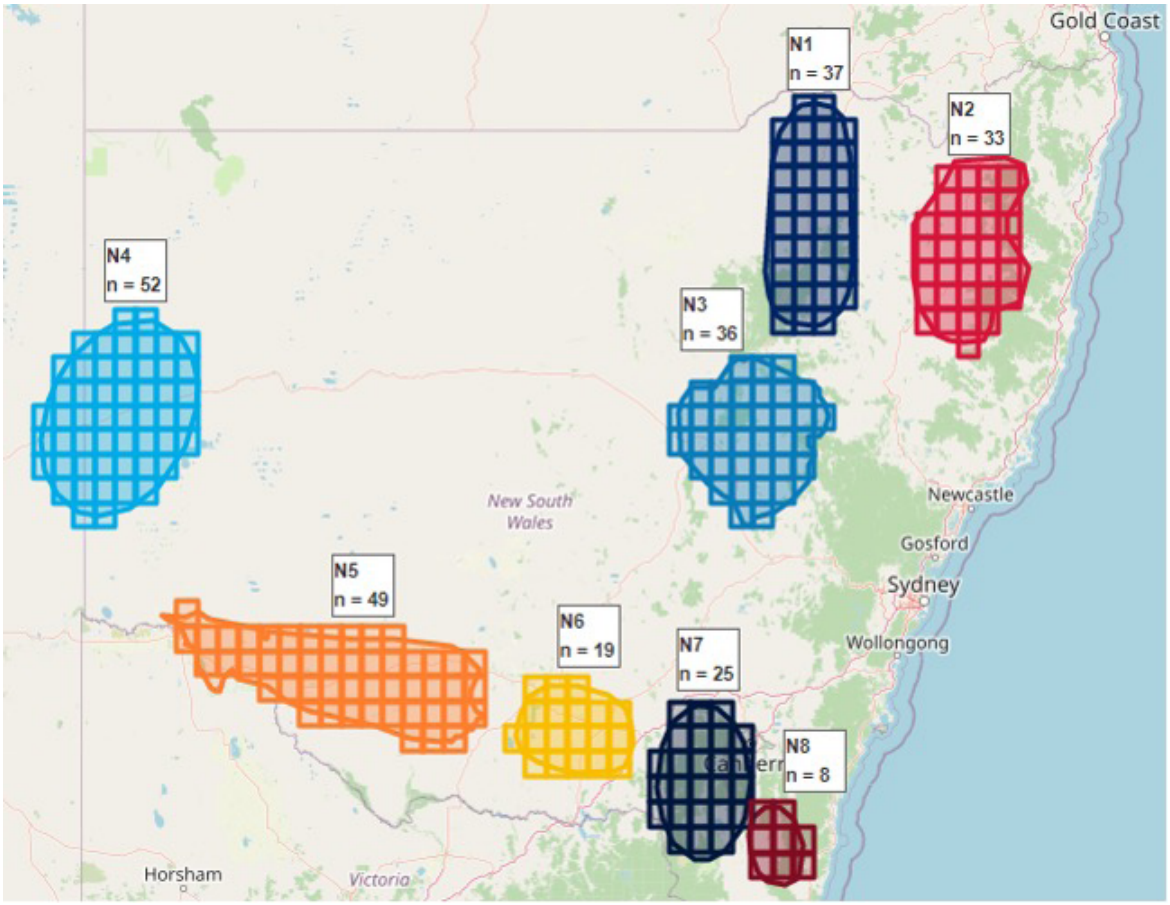
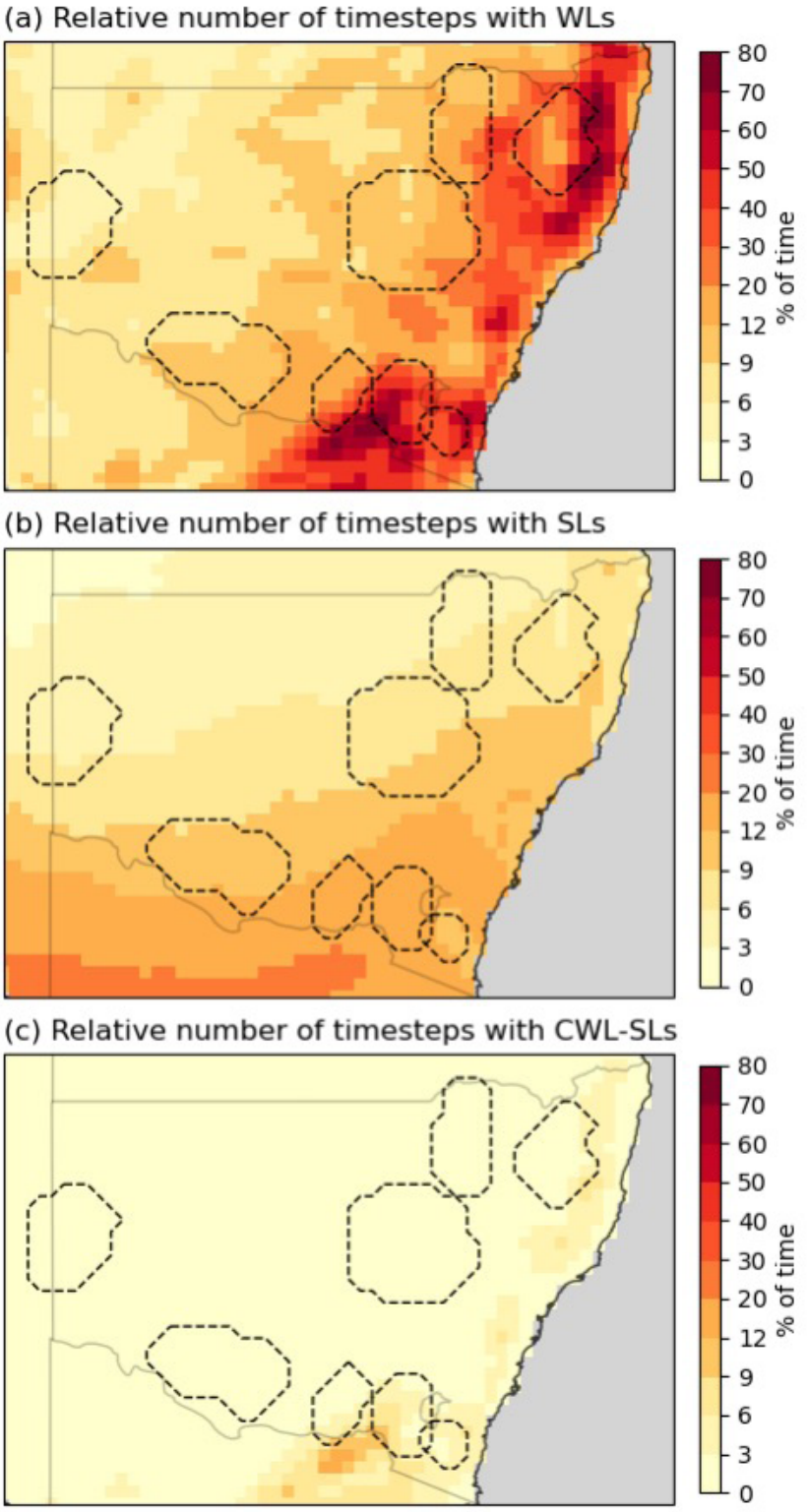


Figure 27: Geographic distribution of wind, solar and combined lulls, and their overall frequency as a proportion of time



Step 1.2: Historical analysis

OECC's analysis compared the maximum duration (hours) of VRE lulls between the two datasets. This was to assess whether and to what extent the lull durations in the modelling dataset are underrepresented relative to the larger dataset. The results are shown in Table 8.

Table 8: Maximum lull duration (hours) and the difference between datasets

REZ	Maximum lull duration (hours)								
	Larger dataset (1979-2020)			Modelling dataset (2011-2020)			Lull difference		
	WL	SL	CWL-SL	WL	SL	CWL-SL	WL	SL	CWL-SL
N1	146	169	71	146	169	60	0	0	11
N2	239	170	72	236	169	33	3	1	39
N3	196	232	86	196	215	50	0	17	36
N4	97	144	47	89	140	45	8	4	2
N5	160	311	108	126	173	108	34	138	0
N6	171	482	80	150	482	51	21	0	29
N7	495	410	86	476	316	80	19	94	6
N8	500	291	119	368	174	98	132	117	21
N2 + N3	139	144	26	139	144	19	0	0	7
N2 + N5	122	120	24	103	101	23	19	19	1
N3 + N5	90	209	35	55	124	23	35	85	12
N2 + N3 + N5	85	101	16	55	101	16	30	0	0

Step 2

Step 2.1: Incorporate the Development Pathway

Each of the lull underrepresentations identified in Step 1 (lull difference column of Table 8) are only significant if there are wind and solar projects developed within the REZ.

Step 2 multiplied the underrepresentation values (in hours) by the corresponding wind and solar capacity for each year of the Development Pathway to calculate the energy underrepresentation value (in GWh). The most significant VRE lull for each year of the Development Pathway was then selected to be the VRE lull which resulted in the largest energy underrepresentation between the two datasets.

The results showed that it was the 85-hour solar lull underrepresentation across both the Central-West Orana REZ (N3) and the South-West REZ (N5) that was the most significant given the Development Pathway from 2024 to 2028. It was the 30-hour wind lull underrepresentation across the New England REZ (N2), Central-West Orana REZ (N3) and South-West REZ (N5) that was the most significant given the Development Pathway from 2029 to 2044. The details of the two VRE lulls selected as the most significant are shown in Table 9.

Table 9: Selected VRE lulls

	Selected VRE lull #1	Selected VRE lull #2
Development Pathway years	2024 to 2028	2029 to 2044
Lull type	Solar lull	Wind lull
REZ	N3 & N5 simultaneously	N2, N3 & N5 simultaneously
Longest lull from larger dataset (1979-2020)	209 hours	85 hours
Longest lull from modelling dataset (2011-2020)	124 hours	55 hours
Lull duration underrepresentation	85 hours	30 hours
Lull energy underrepresentation	43 to 56 GWh	59 to 146 GWh

Step 3

Step 3.1: Lull identification and data extraction

The two selected lulls were artificially extended by their underrepresentation duration via post processing, referred to from here onwards as the 'lull extension'. The headroom on NSW generation, storage and interconnector import was extracted from the short-term dispatch modelling results during the lull extension period. Headroom was averaged over the lull extension period.

The total headroom was then compared to the lull energy underrepresentation for each year in the Development Pathway. If there was sufficient headroom to meet the energy lost from the extension of the VRE lull, then that year of the Development Pathway was deemed resilient. If there was no sufficient headroom to meeting the energy lost from the extension of the VRE lull, then that year of the Development Pathway was deemed to be not resilient.

Step 3.2: Resilience assessment

Firm headroom was defined as headroom on coal and gas generators, hydro, pumped hydro, batteries (subject to reservoir levels), NSW interconnector import (subject to dynamic import limits for NSW, Central NSW, and Sydney-Newcastle-Wollongong) and demand side participation (DSP).

The NSW operational demand during the lull extension period was increased to reflect the correlation between VRE lulls and higher operational demand (see box below). The headroom requirement for the assessment was equal to the lull energy underrepresentation plus the operational demand uplift.

Explainer: Correlation between operational demand and VRE lulls

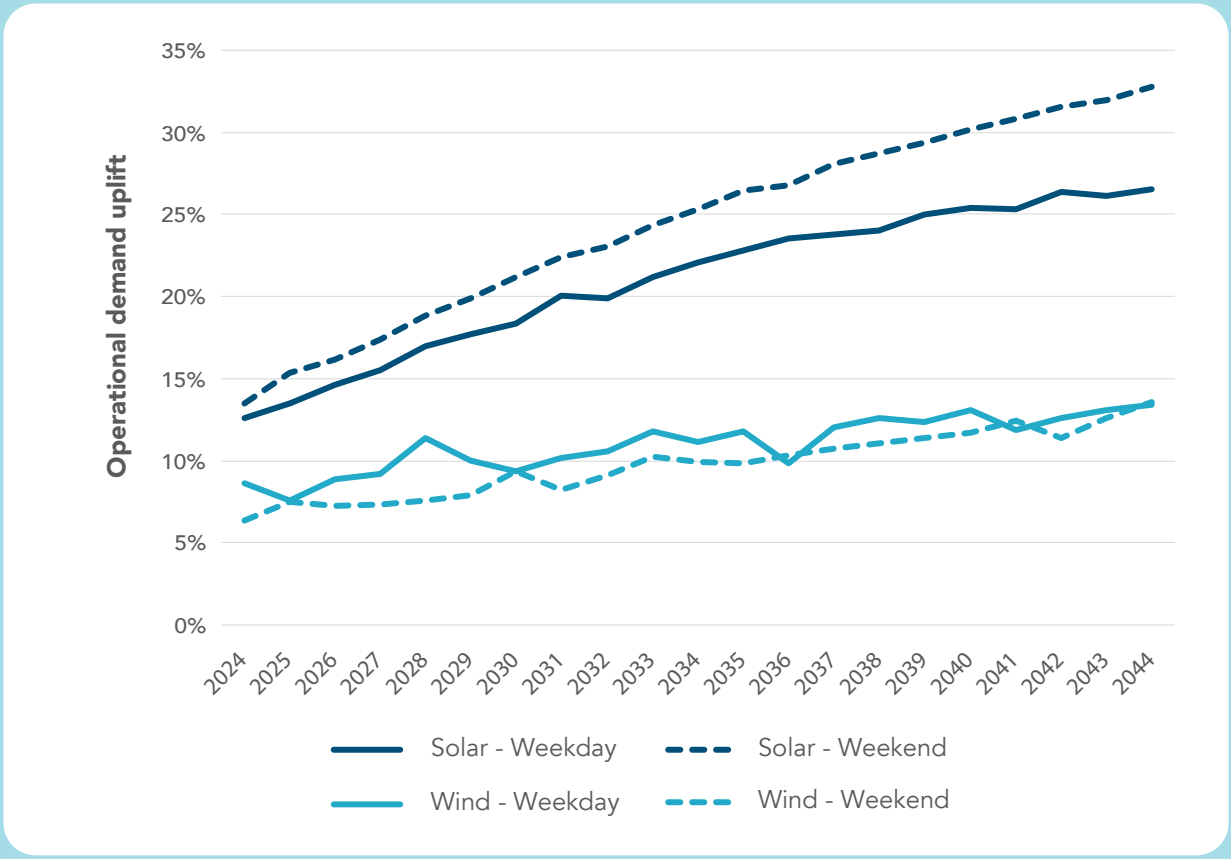
An analysis of the correlation between operational demand and wind and solar lulls was conducted using AEMO's historical wind, solar and demand data between 2011 and 2020.

The analysis concluded that operational demand is materially higher during both wind and solar lulls in AEMO's traces. This analysis also found distinct correlations when separating the data into weekday and weekend subsets, which are known to have distinct demand profiles.

This correlation can be attributed to how the weather patterns which accompany wind and solar lulls also influence operational demand. This is particularly intuitive for solar lulls whereby low rooftop PV output leads to higher operational demand.

Consequentially, an uplift has been applied to operational demand during the artificial extension of the lull. This uplift was equal to 6-15% for a wind lull and 10-34% for a solar lull, depending on the forecast year and occurrence on a weekday or weekend. This relationship is shown in Figure 28.

Figure 28: Operational demand uplift during lull extension



This analysis also explored whether there were significant trends when separating the data into other data subsets, such as REZs. Whilst there were some observable trends and reasonable contextual drivers for these (e.g., proximity of REZ to NSW load centre), the correlations were statistically insignificant (p value < 0.05).

Figure 29 and Figure 30 compare the energy needed if the VRE lull was extended against available headroom across NSW generators, storage, and interconnection. In each forecast year of the analysis for the 2022 IIO Report, there was sufficient average headroom during the lull extension period to meet the headroom requirement.

In the early years, coal and gas power stations are the largest contributors to headroom. The QNI Connect and VNI West interconnector upgrades in the early 2030s allow NSW interconnector import to contribute more headroom in the later years. Hydro power stations and demand side participation (DSP) provide material headroom throughout.

Figure 29: Headroom (GWh) during the 85-hour extension of a solar lull across Central-West Orana and South-West REZs against the headroom requirement

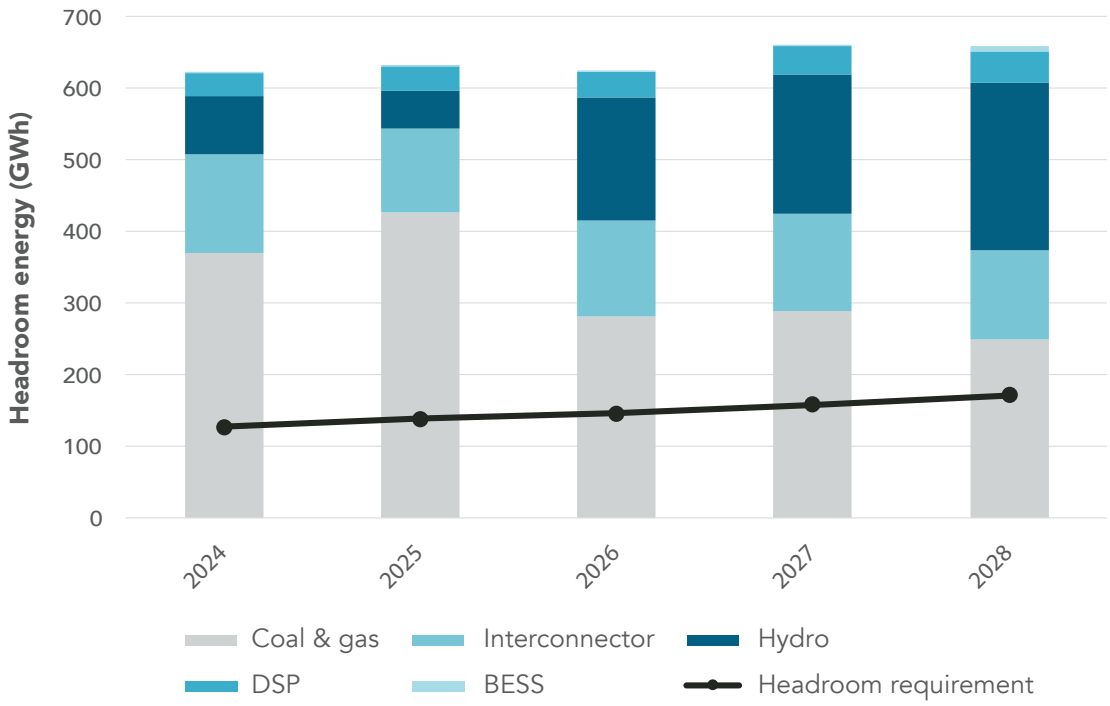
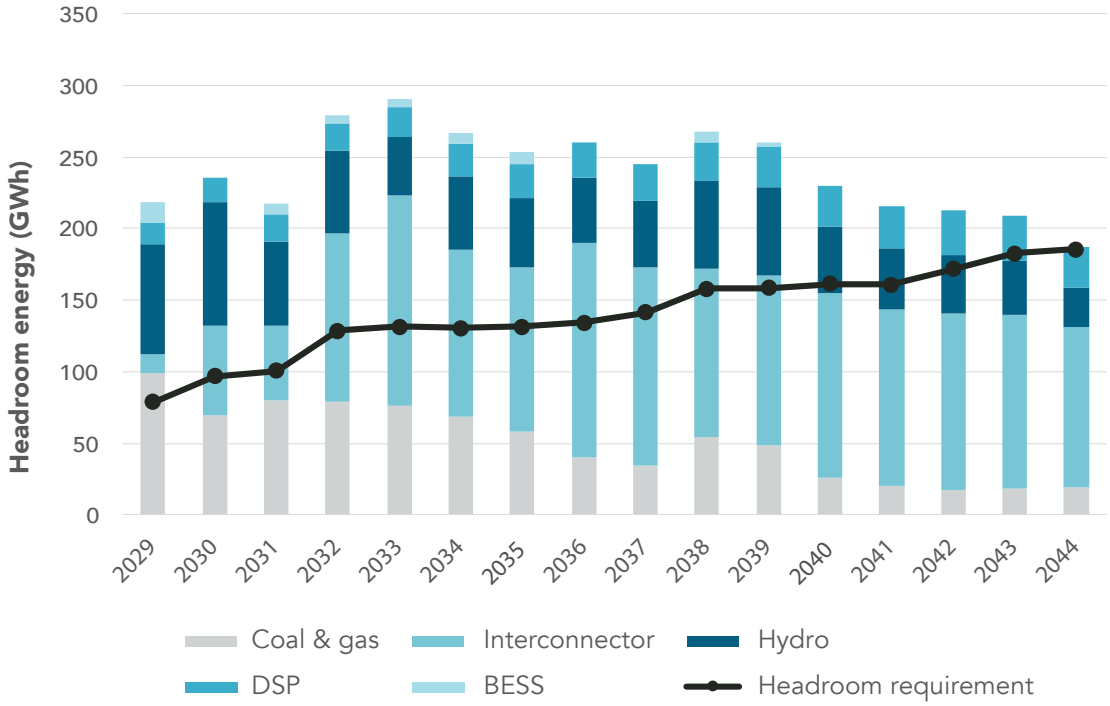


Figure 30: Headroom during the 30-hour extension of a wind lull across New England, Central-West Orana and South-West REZs against the headroom requirement



The analysis indicates that there is less headroom in the final years of the Development Pathway. As noted in section 1.4, the build trajectory in these years is influenced by forecast demand, which is subject to significant uncertainty in the 2030s. Accordingly, the scale of construction of generation needed in the 2030s is subject to a higher degree of uncertainty than the first half of the Development Pathway. Demand for electricity in this decade will be strongly impacted by trends in electrification and where these trends accelerate, greater demand is likely to require additional generation in this decade, beyond that included in the Development Pathway. This will be re-investigated as part of the 2023 IIO Report, a draft of which is expected to be available in Q1 2023.

Step 4

Step 4.1: Development Pathway adjustment

The resilience gap reflects the shortfall in energy which would occur during the largest VRE lull across the larger dataset (1979 and 2020). If a resilience gap were to arise, generation equal to the resilience gap would be introduced into the development pathway. Constructing infrastructure to mitigate resultant unserved energy during this 1 in 40-year event may not be a cost-effective outcome for NSW customers. Accordingly, the resilience gap would be probabilistically reduced to reflect the likelihood difference between the largest VRE lull event occurring over 10 years and 42 years.

For the purposes of the 2022 IIO Report, a resilience gap was not identified and therefore, this step was not required.