



Consumer
Trustee

2023 Infrastructure Investment Objectives Report

December 2023



Important notice

PURPOSE

AEMO Services Limited (AEMO Services) publishes the 2023 Infrastructure Investment Objectives Report (IIO Report) pursuant to its functions as Consumer Trustee under section 45(2) of the *Electricity Infrastructure Investment Act 2020* (NSW).

DISCLAIMER

The contents of this document are for information purposes only. This document is not intended to provide any advice or imply any recommendation or opinion and should not be relied upon as constituting advice. This document may include inputs and assumptions that are not necessarily current as at the date of publication.

AEMO Services has taken care in the preparation of the information contained or referred to in this document but cannot guarantee its accuracy or completeness. Accordingly, to the maximum extent permitted by law, AEMO Services and its officers, employees and consultants involved in the preparation of this document:

- do not give any warranty or make any representation, express or implied, as to the completeness, accuracy, adequacy or correctness of the information contained or referred to in this document; and
- expressly disclaim any and all liability relating to or resulting from: the use of, or reliance on, such information by any person; or the exercise of any discretion, or the making of any decision, by AEMO Services as the Consumer Trustee in relation to the information contained or referred to in this document.

VERSION CONTROL

Version	Release date	Changes
1.0	21 December 2023	

ACKNOWLEDGEMENT OF COUNTRY

AEMO Services acknowledges the Traditional Custodians of the lands, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander land. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country, and hope that our work can benefit both people and Country.

COPYRIGHT

© 2023 AEMO Services. The material in this publication may be used in accordance with the copyright permissions on AEMO's website.

Powering infrastructure investment for NSW electricity customers

AEMO Services' role under the NSW Electricity Infrastructure Roadmap is to enable the State's transformation to renewable energy generation and storage. Leveraging the deep pool of expertise within our organisation, we work to accelerate private investment to deliver the necessary energy at the right time and at the right cost.

Guiding this investment is the NSW Roadmap's central planning document: the Infrastructure Investment Objectives (IIO) Report, which sets out a 20-year Development Pathway for electricity infrastructure investment and a rolling, decade-long schedule for tenders which will identify where, when, and at what cost new energy generation, storage and firming infrastructure is needed.

A fundamental aim of this Report is to provide investors and other stakeholders with certainty around the expected progression of the energy transition in NSW. Each iteration of the document serves as a definitive picture at the time that it is published, of the Development Pathway and indicative tender schedule, reflecting the most up-to-date assessment of the state's energy needs, industry's capacity to meet them and the broader energy market context.

Our new Development Pathway generally represents adjustments, not large-scale revisions, to its predecessors. Our latest tender schedule reflects the approach adopted in the Draft 2023 IIO Report, with regular-sized tenders designed to deliver greater certainty to the market, as well as reflecting the tenders already completed and currently underway.

By providing this level of certainty and consistency, balanced with necessary flexibility to make decisions reflecting latest market information, each Report provides a useful tool for ongoing planning across the public and private sector.

The 2023 Report shows considerable progress has already been made towards meeting NSW's objectives, with 2,170 megawatts (MW) of renewable generation constructed in NSW since 2019, and a further 3,620 MW locked in – over 46 per cent of the minimum target for 2030 set in legislation.

Achieving the investment objectives of the Report while improving the sustainability and security of electricity supply requires an unprecedented level of investment. AEMO Services is committed to supporting this investment through recommending bankable products with financial value for customers at their core. We have already observed innovation and advances in technologies and commercial arrangements in bids for these products, and AEMO Services encourages the market to continue to innovate and bring forward a diversity of projects.

To date, our tenders for generation, storage and firming infrastructure have attracted over 10 gigawatts (GW) of high-quality projects. The 2023 IIO Report serves as a call for further investment to build on this success and enable the transition to cleaner, more affordable energy for NSW electricity customers.

AEMO Services is also working with government and industry to deliver investment in renewable energy in accordance with the Development Pathway. Achieving this goal requires close alignment between the NSW Government, AEMO Services and the Energy Corporation of NSW (EnergyCo), all working together to support EnergyCo's transmission infrastructure planning to unlock the State's renewable energy zones, and connect new generation and storage back to the national electricity grid.

Industry can be certain that the opportunities to invest are real and growing – policy is expanding and reinforcing targets across Australia and the National Electricity Market (NEM), and NSW has the frameworks to support investment in a competitive landscape. Stakeholders can be confident in our established governance arrangements to exercise our independent functions efficiently, effectively and with integrity.

AEMO Services gratefully acknowledges those who have participated in our planning and implementation to date, and thanks all those who have provided input to this 2023 IIO Report. We look forward to continuing to work with the public and private sector on this once-in-a-generation investment in infrastructure for the NSW energy system.



Paul Verschuer

Executive General Manager, AEMO Services



Guiding the energy transition in NSW

Issued every two years, the IIO Report is the central planning document that guides NSW's energy transformation under the Electricity Infrastructure Roadmap (Roadmap). It sets out the least-cost 20-year pathway for meeting NSW's legislated targets for renewable energy infrastructure, alongside a 10-year plan for conducting tenders for long-term energy service agreements (LTESAs).

The 2023 IIO Report has been informed by stakeholder feedback on the Draft 2023 IIO Report. Changes have been made to reflect market developments, additional sensitivity testing and methodology improvements to account for lulls in variable renewable energy availability.

We have considered how factors such as deliverability risks and costs may influence the trajectory for procuring built infrastructure to meet NSW's future energy needs. We will apply a pragmatic and flexible approach towards tendering, given the rapid pace of change, to encourage investment and deliver value to consumers.

To date, our tenders for generation, storage and firming infrastructure have attracted over 10 GW of high-quality projects. The 2023 IIO Report serves as a call for further investment for NSW electricity customers to build on this success.

“Significant progress has been made towards delivering electricity infrastructure to support NSW's electricity system transition in the interest of consumers, but continued strong investment is required to meet 2030 targets.”



Infrastructure Investment Objectives



The 2023 IIO Report shows **over 46% of the minimum objective has been achieved** for generation (15,600 GWh / 5,790 MW added since November 2019), tracking well towards 2030. After multiple successful tenders, the delivery of long-duration storage is also aligned with the planned trajectory of construction towards the end of the decade to minimise costs to consumers, with almost 600 MW secured to date.

20-Year Development Pathway



The Development Pathway sets out AEMO Services view for achieving the Infrastructure Investment Objectives in the long-term financial interest of NSW electricity customers. It shows:

The need for consistent renewable generation construction:

The IIO Report shows a need for generation infrastructure investment in NSW across a range of technologies at or near record levels to 2030 and beyond to meet the infrastructure investment objectives.

Substantial investment in long-duration storage is required:

The build trajectory requires balancing projects' cost to consumers with their ability to deliver to the 2030 minimum objective.

Firming infrastructure will help ensure reliability:

Over 1 GW of firming infrastructure supported through a successful tender will help meet reliability needs as the power system evolves.

10-Year Tender Plan



The 10-Year Plan sets out the schedule of competitive tenders for delivering the Development Pathway. It shows consistently sized tenders for generation and storage to meet 2030 objectives.

Generation: opportunities for projects every 6 months.

Long-duration storage: annual tenders up to 2028 until the 2 GW and 16 GWh objective is met.

Firming: tender recently completed, directed by the Minister.

2023 IIO Report consultation

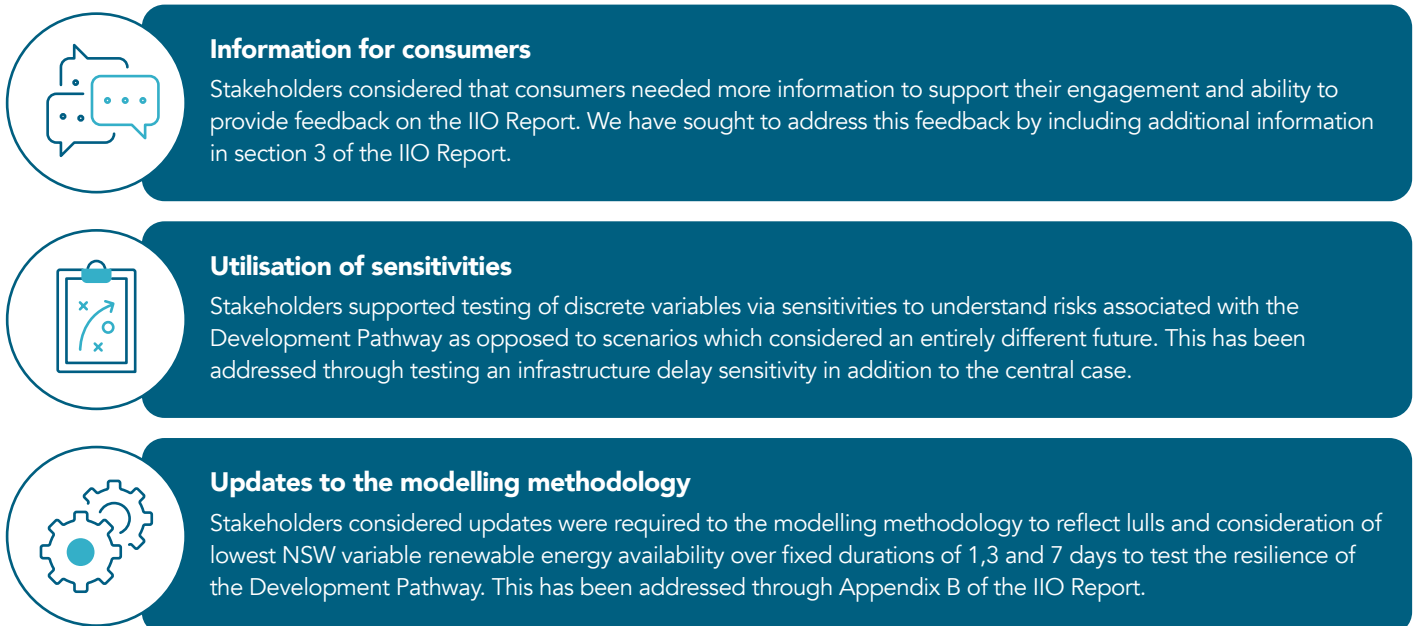
A draft of the 2023 IIO report was published in May 2023 for the purposes of consulting on the methodology in preparing this report. Consultation occurred across government, consumer and industry groups through webinars, deep dive sessions and written submissions. There was strong interest from stakeholders with 246 registrations for the webinars, fully subscribed deep dive sessions, and five written submissions. Consultation on the Draft 2023 IIO Report, is summarised in [Figure 1](#) below.

Figure 1: Timeline



The 2023 IIO Report incorporates feedback from this consultation where possible. The major themes from consultation are summarised in [Figure 2](#) below.

Figure 2: Summary of stakeholder feedback themes



Any issues raised by stakeholders and not captured in this report are intended to be addressed through ongoing continuous improvement in modelling approaches and where possible, adapting the information we publish in future, to meet our stakeholders' needs, focused on delivering customer value.

About AEMO Services

AEMO Services is a subsidiary of the Australian Energy Market Operator with an independent board and is a key partner in the implementation of the NSW Government's Electricity Infrastructure Roadmap (NSW Roadmap). We are trusted to plan, assess, and guide long-term investment to help transform the energy sector.

As the appointed Consumer Trustee under the NSW Roadmap, we have a mandate to act independently and in the long-term financial interests of NSW electricity customers. This responsibility is at the core of our work under the NSW Roadmap.

In this capacity we plan and co-ordinate long-term investment in built energy infrastructure, conducting competitive tenders to bring forward projects with the greatest potential to help the state meet its future energy needs.

We incentivise these new investments in electricity generation, storage and firming infrastructure through long-term energy services agreements (LTESAs) and network access rights in renewable energy zones (REZs) awarded through a series of rolling tenders to promote a collaborative, yet competitive environment where the best projects are supported to construction and operation as early as possible.

A rolling schedule of competitive tenders and coordinated investment planning is set out in the IIO Report. The IIO Report is our plan for meeting NSW's future electricity needs and is a central planning document of the NSW Roadmap. The IIO identifies the timing and scale for renewable energy generation and storage investment, building in flexibility to support a future NSW energy system that delivers quality energy, where and when it is needed while ensuring the interests of electricity customers are prioritised.

Under the NSW Roadmap, AEMO Services also authorises REZ network infrastructure project recommendations and provides financial risk management advice. By independently reviewing REZs network infrastructure project recommendations, we help to ensure NSW energy customers benefit from the projects going ahead.

Contents

Definitions	9
Executive Summary	10
1. Introduction	18
1.1 What is the Infrastructure Investment Objectives (IIO) Report.....	18
1.2 Overview of IIO Report contents	20
1.3 Interaction with other planning documents	21
1.4 Market developments since previous report.....	23
1.5 Limitations.....	24
2. Infrastructure Investment Objectives	25
2.1 Overview	25
2.2 Explaining the minimum objectives	26
2.2.1 Generation infrastructure	26
2.2.2 Long-duration storage infrastructure	26
2.2.3 Firming infrastructure.....	27
2.3 Explaining the overall objectives	27
2.3.1 Minimising costs to NSW customers	27
2.3.2 Meeting the reliability standard.....	28
2.3.3 Meeting the energy security target	28
2.4 Tracking the infrastructure investment objectives.....	29
2.4.1 Progress toward achieving the minimum objectives	29
2.4.3 The energy security target.....	30
2.5 The contribution of tenders since the previous report.....	31
3. 20-Year Development Pathway	34
3.1 Overview and considerations	34
3.2 Modelling process overview	34
3.2.1 Modelling Steps.....	34
3.2.2 Scenarios Considered.....	35
3.3 Generation infrastructure pathway.....	36
3.4 Long-duration storage infrastructure pathway.....	40
3.5 Firming infrastructure pathway.....	43
3.6 Network infrastructure to support the pathways.....	45
3.6.1 New network infrastructure.....	45
3.6.2 Existing Network Infrastructure.....	48
3.7 Testing the Development Pathway	49
3.7.1 Costs of the pathway for NSW electricity customers.....	49
3.7.2 Reliability assessment	54
3.7.3 Resilience to VRE lulls	54

3.8	Alternative infrastructure delay scenario	55
3.8.1	Scenario descriptions.....	55
3.8.2	Scenario outcomes	56
4.	10-Year Plan	64
4.1	Overview	64
4.2	Tender plan for generation infrastructure	65
4.3	Tender plan for long-duration storage infrastructure.....	66
4.4	Tender plan for firming infrastructure.....	67
4.5	How the 10-Year Tender Plan can be adjusted between reports.....	67
5.	Preparing the Development Pathway	68
5.1	Setting up the model	68
5.1.1	Objective Functions.....	68
5.1.2	Modelling inputs and forecast outputs.....	68
5.2	Modelling assumptions.....	69
5.2.1	Modified assumptions used to model infrastructure delay scenario	73
Appendix A – Reliability Assessment		74
A1.	The reliability standard	74
A1.1.	Risks to meeting the reliability standard.....	75
A2.	The energy security target	76
A2.1.	Risks to meeting the energy security target	77
Appendix B – Resilience to variable renewable energy lulls		78
B1.	Summary	78
B2.	Legislative requirement and interpretation.....	78
B3.	Results.....	79
B4.	Discussion	83
B5.	Approach	83
B5.1.	Evolution of the VRE lull analysis	83
B5.2.	2023 IIO Report VRE lulls method	84
B5.3.	Limitations.....	86
Appendix C – Regulatory requirements.....		87
List of tables and figures.....		88

Definitions

Term	Meaning
AEMO	Australian Energy Market Operator
CER	Consumer Energy Resources
CO2-e	Carbon dioxide equivalent
CWO	Central-West Orana
Development Pathway	Infrastructure required to be constructed over the following 20 years
10-Year Plan	Tenders to be conducted during the following 10 years
EII Regulations	Electricity Infrastructure Investment Regulation 2021 (NSW)
EII Act	Electricity Infrastructure Investment Act 2020 (NSW)
EnergyCo	Energy Corporation of NSW
ESOO	AEMO's 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
HCC	Hunter-Central Coast
IASR	Inputs, Assumptions and Scenarios Report
IIO Report	Infrastructure Investment Objective Report
ISP	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
NIS	Network Infrastructure Strategy
OECC	NSW Office of Energy and Climate Change
Overall objectives	The overall infrastructure investment objectives established by section 44(2) of the EII Act
QED	Quarterly Energy Dynamics
QNI	Queensland to NSW Interconnector
RES Board Plan	Renewable Energy Sector Board Plan
REZs	Renewable Energy Zones
NSW Roadmap	NSW Electricity Infrastructure Roadmap
USE	Unserviced energy
VNI	Victoria to NSW interconnector
VRE	Variable renewable energy
WACC	Weighted Average Cost of Capital

Executive Summary

Since our appointment in October 2021 as Consumer Trustee under the NSW Electricity Infrastructure Roadmap (NSW Roadmap), AEMO Services has planned and incentivised private investment to transition the state's electricity network to one driven primarily by renewable forms of generation.

Although necessary, given the urgent need to respond to climate change and the imminent retirement of the existing fleet of coal-fired power stations, the task is complex. Our challenge, as NSW Consumer Trustee, is to manage these complexities in a dynamic environment to deliver against the infrastructure investment objectives set out in the Electricity Infrastructure Investment Act 2020 (EII Act) in the long-term financial interest of the state's electricity customers.

The infrastructure investment objectives specify minimum amounts of renewable generation infrastructure and long-duration storage infrastructure to be constructed by the end of 2029, as well as additional infrastructure necessary over a 20-year period to minimise costs to NSW electricity customers and meet the NSW energy security target and reliability standard.

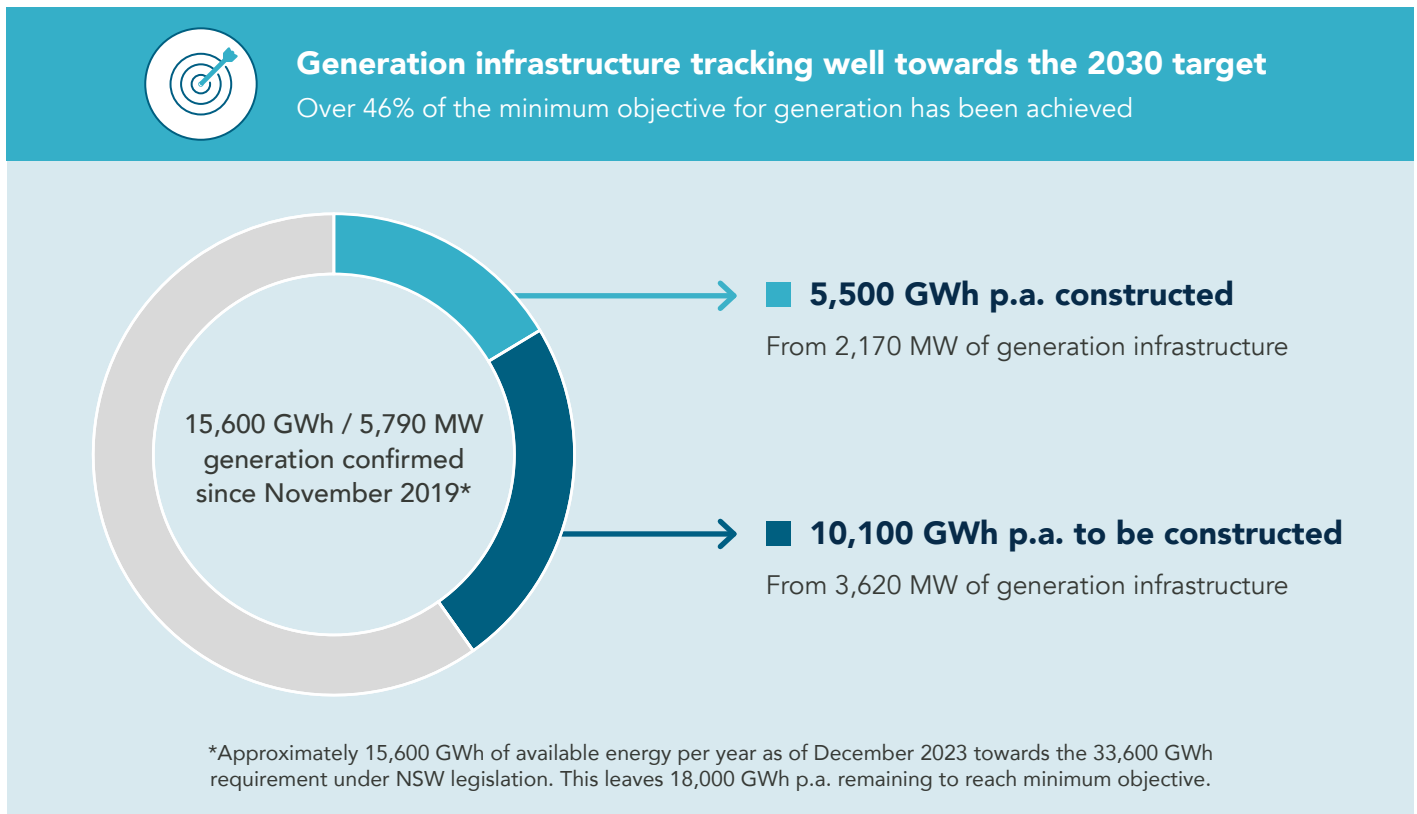
This 2023 Infrastructure Investment Objectives (IIO) Report, our third, updates our 20-year Development Pathway for the construction of electricity infrastructure in NSW to achieve the infrastructure investment objectives and our 10-year competitive tender schedule for Long-term Energy Service Agreements (LTESAs) to give effect to the development pathway.

The process of revising the IIO Report provides an opportunity for AEMO Services to consider the progress of the infrastructure procurement program against the capacity of the market and the state's future energy needs. The Development Pathway to 2030 in this report is similar to previous reports, reflecting that there are few degrees of freedom to meet the minimum objectives for renewable generation and long-duration storage in these timeframes. However, this update includes adjustments to the development pathway from previous reports particularly beyond 2030, reflecting latest market information, and identifies further amendments that may be made in response to external delays – including those relating to transmission availability.

A credible pathway to deliver large investment opportunities in NSW

In the first year of tenders, significant progress has already been made against the infrastructure investment objectives. Outcomes from Tenders 1 and 3 have helped in securing over 5.7 GW of the 12 GW target for new generation infrastructure ([Figure 3](#)), along with almost 600 MW of the 2 GW required for long-duration storage. Both categories are aligned with the trajectories set out in the Development Pathway. Separately Tender 2 has secured 1 GW of new firming capacity, which increases reliability, particularly in the short term.

Figure 3: Progress made to date toward achieving the minimum objective for generation



Notwithstanding, significant new investment is still required to keep pace with the Development Pathway, including investment in the enabling network infrastructure projects.

The updated 20-year Development Pathway and 10-Year Plan included in this report take into account these outcomes and market feedback received during the first twelve months of tenders.

Renewable generation infrastructure investment at or near record levels

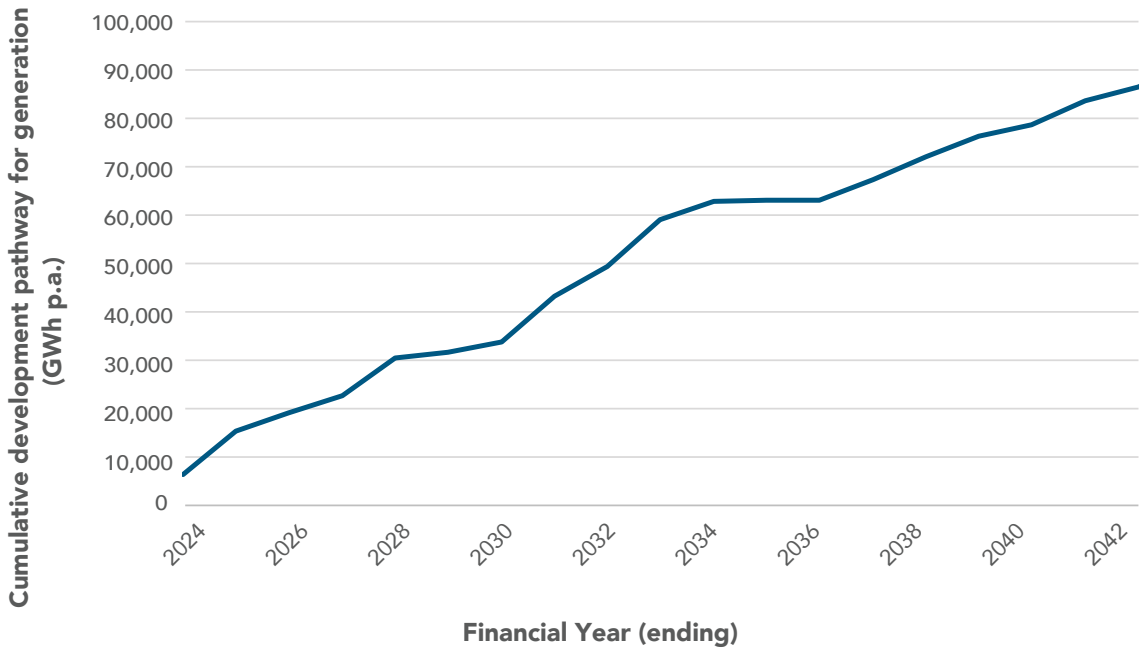
The EII Act requires the construction of sufficient generation infrastructure in the state to minimise costs for NSW electricity customers, and the Development Pathway shows the construction trajectory necessary to achieve this objective. This includes meeting a minimum objective for renewable energy generation by 2030, estimated by AEMO Services to be 33,600 GWh per annum.

The Development Pathway for generation infrastructure

The generation element of the Development Pathway set out in [Figure 4](#) shows the cumulative annual available energy from renewable generation infrastructure constructed in NSW after 2019, for the period 2024 to 2043.¹ The final 2023 Development Pathway identifies an approximate linear trajectory for new generation to 2030, by which point it will marginally exceed the minimum objective to minimise costs to NSW customers. Beyond 2030 generation capacity grows at a slightly slower rate.

¹ In this report, references to years in relation to the Development Pathway, network infrastructure timing or other modelling results are to financial years (ending) – for example, 2024 under the Development Pathway means the year starting July 2023 and ending June 2024.

Figure 4: NSW Development Pathway (Generation)



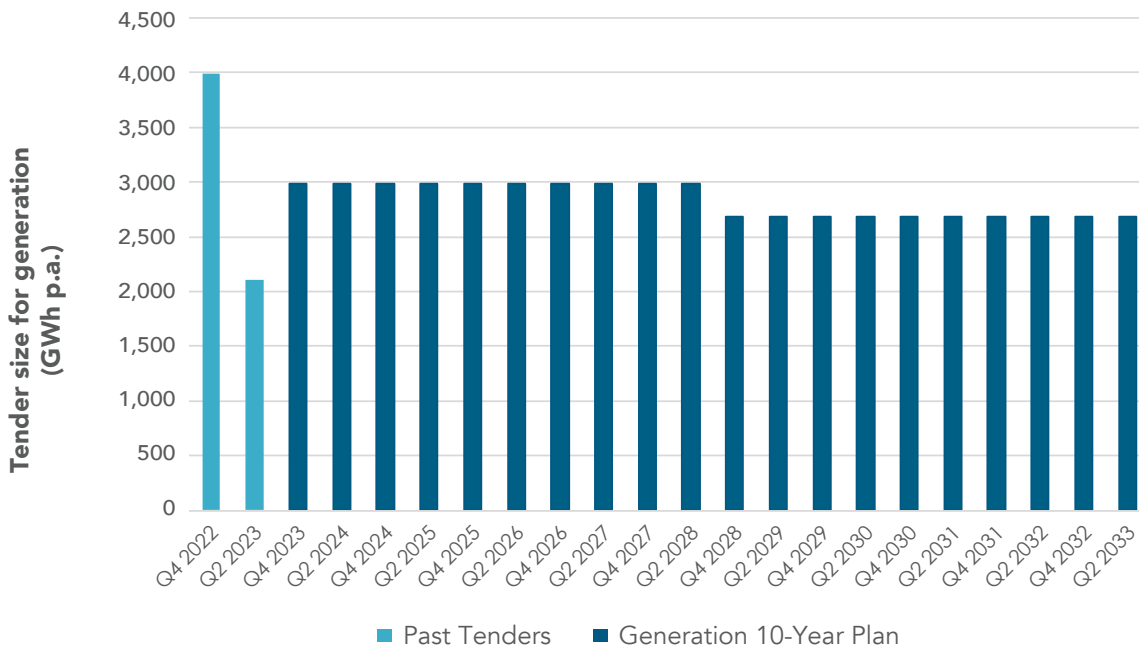
The Development Pathway is largely consistent with the Draft 2023 IIO Report to 2030, reflecting there are few alternatives to meet the minimum objective by 2030. Driven by higher Weighted Average Cost of Capital (WACC) assumptions in this report, the Development Pathway builds less after the mid-2030s than previously modelled in the Draft 2023 IIO Report.

In optimising the Development Pathway, the model balances a preference for complementary generation profiles from wind with the potential for early deliverability of solar. This reflects latest market information about the limited availability of wind projects in the near-term development pipeline and the application of a supply chain constraint in the model across the NEM.

The 10-Year Plan for generation infrastructure

As the NSW Consumer Trustee, AEMO Services intends to conduct consistently sized tenders over the next ten years to give effect to the Development Pathway for generation. The 10-Year Plan to tender for generation LTESAs is set out in [Figure 5](#). AEMO Services is planning for a steady build of capacity to 2030, consistent with the ability of industry to deliver, which has previously been observed in the NEM and through early tenders.

Figure 5: 10-Year Plan (Generation)



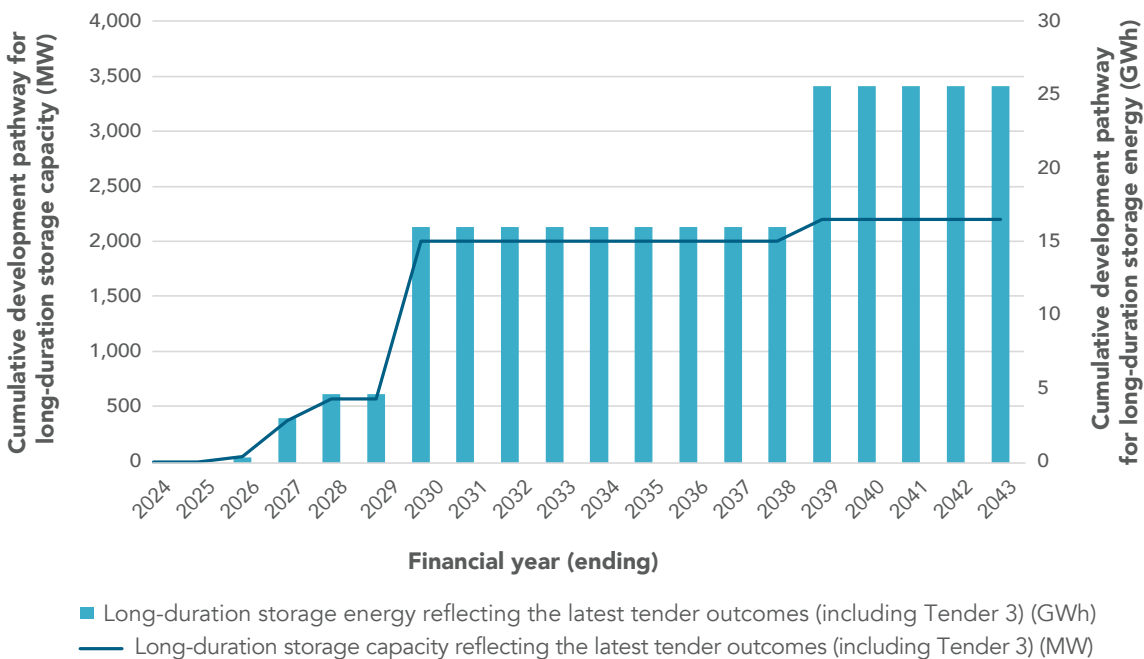
Substantial investment in long-duration storage infrastructure in time for 2030

NSW legislation requires the construction of 2 GW and 16 GWh of long-duration storage infrastructure (can be dispatched for at least 8 hours) in NSW by 2030, and any additional infrastructure necessary to meet the reliability standard.

The Development Pathway for long-duration storage infrastructure

The long-duration storage element of the Development Pathway is set out in [Figure 6](#), which shows the cumulative capacity installed over the period 2024 to 2043. The build trajectory is driven by costs and lead times associated with long-duration storage technologies, with the model showing a preference for later lower-cost projects, balanced by shorter delivery lead time projects to achieve the minimum objective of 2 GW and 16 GWh by 2030.

Figure 6: NSW Development Pathway Long-duration storage reflecting the latest tender outcomes²



² The long-duration storage development pathway was modelled prior to results from Tender 3 being available. The results have subsequently been included into this figure.

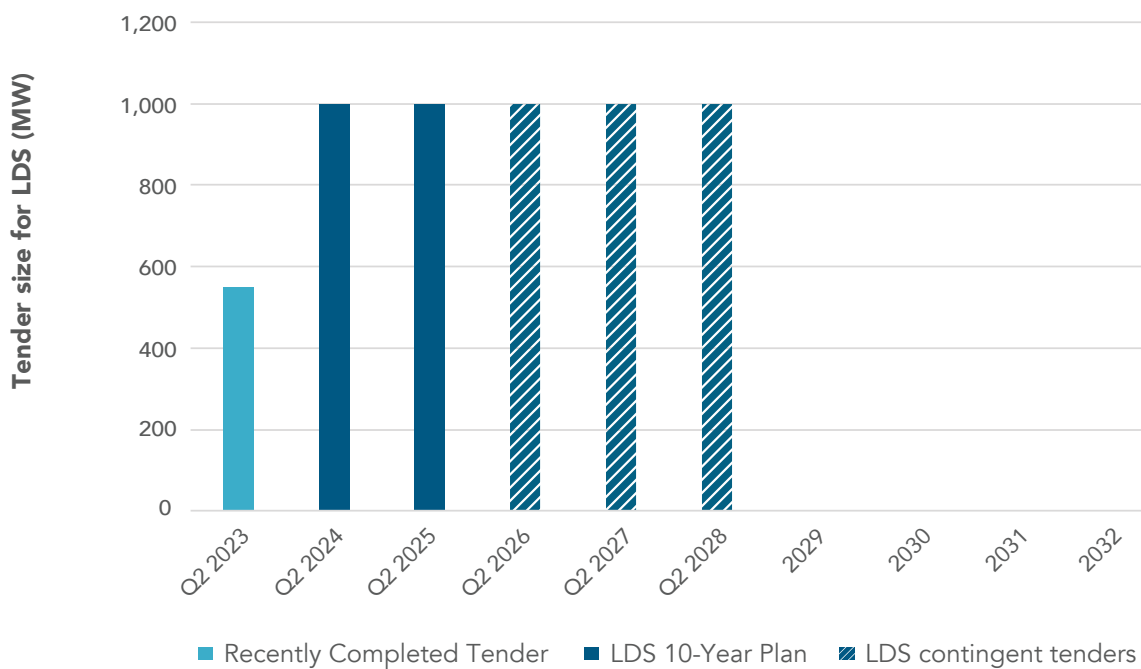
The Development Pathway captures the 50 MW Limondale battery entering in 2026 as a result of a successful bid in the first long-duration tender completed by AEMO Services. Additional storage enters in 2027 and 2028 in line with announcements from Tender 3. The majority of long-duration storage follows in 2030 to meet the 2 GW and 16 GWh minimum objective.

AEMO Services has considered the deliverability risk associated with this pathway and has tested the impact of assumptions using a sensitivity for this 2023 IIO Report. An infrastructure delay scenario brings forward construction with shorter delivery lead-time projects to meet the 2030 minimum objective. AEMO Services will continue to assess the development of long-duration storage technologies through tenders, and future analysis to be reported in subsequent IIO Reports.

The 10-Year Plan for long-duration storage infrastructure

AEMO Services intends to conduct annual tenders for long-duration storage in line with the schedule set out in the 10-Year Plan, shown in [Figure 7](#). The recently completed Tender 3 delivered 524 MW of long-duration storage. Subsequent tenders, as shown in the 10-Year plan for 2024 and 2025, are both sized at 1 GW.

Figure 7: 10-Year Plan (Long-duration storage)



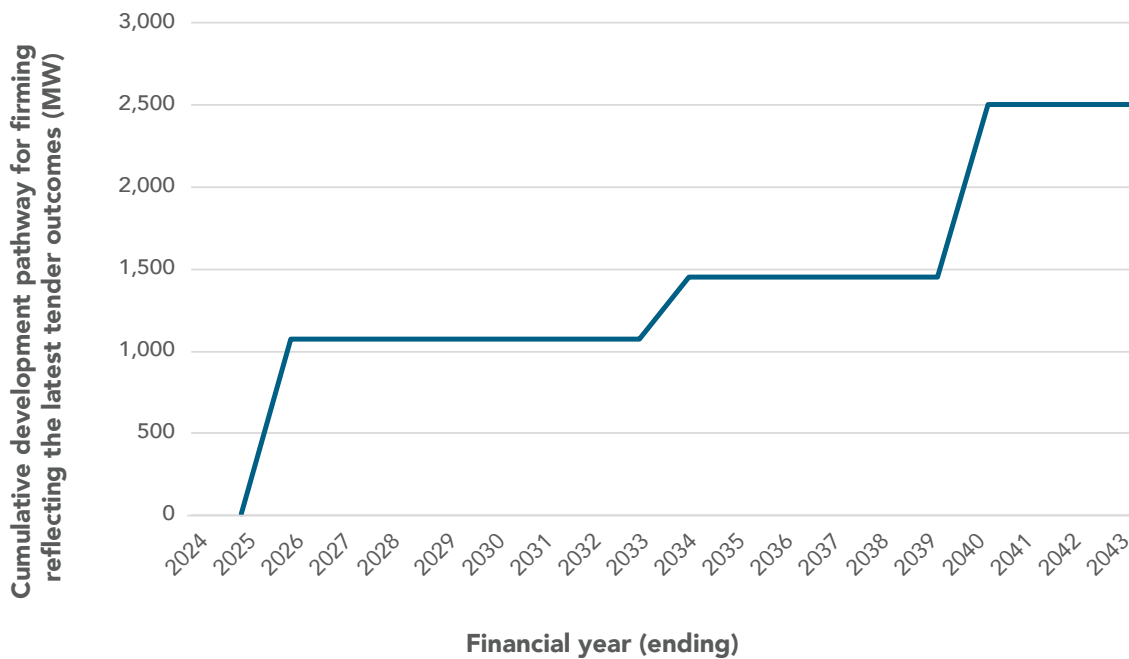
Ensuring reliability as the system evolves

NSW legislation requires that firming infrastructure is constructed as necessary to meet the energy security target and the reliability standard.

The Development Pathway for firming infrastructure

The firming element of the Development Pathway is set out in [Figure 8](#), which shows the cumulative annual capacity installed over the period 2024 to 2043. The Development Pathway shown captures announced outcomes of the Tender 2, with successful projects accounting for an estimated firming capacity of 1,075 MW. No further firming tenders are planned at this stage, however further capacity may be required under certain delay scenarios. If this were to be the case, AEMO Services would only conduct a firming tender if directed by the Minister to do so.

Figure 8: NSW Development Pathway Firming reflecting the latest tender outcomes (including Tender 2)³



Planning for reliability with customer participation and coal-fired power station retirements

The timing and volume of long-duration storage and firming infrastructure capacity construction required to meet reliability objectives is sensitive to key inputs and assumptions. These include the retirement dates of existing coal-fired generation, as well as the participation of customers and their energy resources in the energy system. These, and other considerations, will continue to be assessed by AEMO Services, and may impact the conduct of future tenders.

It is likely that coal-fired power station retirement dates will change as the market continues to evolve, and it is possible they may be earlier than assumed for in the modelling for this 2023 IIO Report. Where closure timings are brought forward these may lead to a need for additional long-duration storage and/or firming infrastructure.

The 2022 Integrated System Plan (ISP) flagged that there is a role for embedded energy storage (use of batteries in managing consumer demand) in responding to market conditions and these have an important role in maintaining system reliability. Projections for the uptake of embedded energy storage in the Draft 2024 ISP have recently been revised down (and are not captured in this report). This may also lead to a need for additional long-duration storage and/or firming infrastructure.

Balancing certainty for investors with flexibility in decision-making

The IIO Report considers a number of factors that may influence the trajectory for procuring the necessary built infrastructure to provide affordable electricity to NSW electricity customers through to 2030 and beyond. This changing landscape requires pragmatism and adaptive planning, and AEMO Services will retain flexibility in decision-making to ensure that we deliver our objectives at the least cost and risk to customers.

Indicative pathway in the interest of customers

For all Consumer Trustee tenders, the target volumes are indicative only. AEMO Services may recommend more or less than the indicative size, depending on its assessment of projects during tenders based on real market information. AEMO Services may also adjust tender sizes to respond to changes that occur prior to the publication of the next IIO Report, where an alternative development pathway and corresponding tender plan is considered more beneficial to the long-term financial interests of NSW electricity customers.

³ The firming development pathway was modelled prior to results from Tender 2 being available. The results have subsequently been included into this figure.

Considering an alternative scenario for infrastructure timing

The task of co-ordinating investment in new generation, storage and network infrastructure is ongoing. The 2023 IIO Report outlines an additional scenario, alongside the central scenario, under which the Development Pathway might be further modified in response to external developments, including changes to project lead-times and completion dates for important transmission infrastructure.

Financial value for NSW electricity customers

The long-term financial interest of NSW electricity customers is a guiding principle of the IIO Report and the critical decisions AEMO Services makes to shape NSW's energy future.

Innovations in technology and commercial arrangements

AEMO Services support the necessary investment in electricity infrastructure to give effect to the Development Pathway through bankable products with financial value for customers at their core. The tender process and products incentivise technological and commercial innovation to capture further value for customers.

Costs for the supply of wholesale electricity services

The modelling undertaken for this IIO Report has identified that the implementation of the Development Pathway and underpinning network projects is forecast to be \$49.6 billion in total costs (in real 2022 dollars)⁴ for the supply of wholesale energy services to NSW electricity customers over the 10-year horizon to 2033. Costs beyond the 10-year horizon AEMO Services use for tender planning are subject to high levels of uncertainty.

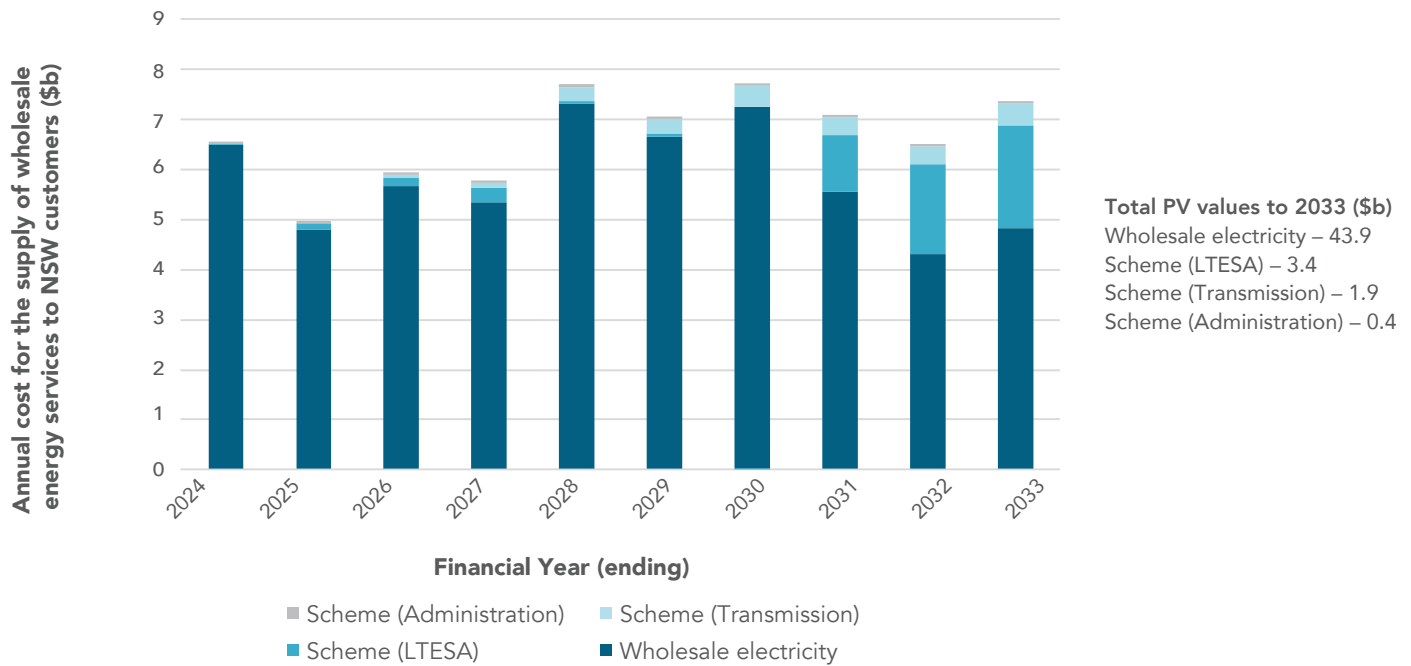
It is important to note that the cost forecasts contained in this and other IIO Reports are modelled forecasts. Actual costs for NSW electricity customers are determined on an annual basis by the Australian Energy Regulator Contribution Determination process. For more information on this process please visit: <https://www.aer.gov.au/industry/networks/cost-pass-throughs/nsw-electricity-infrastructure-fund-2023-24-contribution-determination/decision>

An annual breakdown of forecast wholesale and scheme costs, in real terms is set out in [Figure 9](#). This shows scheme costs related to LTESA payments becoming material as they help to drive down wholesale electricity costs. These costs present a proxy estimate for a simplified contractual mechanism that does not represent the innovative design and use of the LTESA that is emerging from our tender processes. Due to a simplified approach, annual costs are subject to a high degree of uncertainty but the total forecast costs over 10 years is expected to represent a reasonable estimate.

The forecast costs need to be compared to the costs that would have otherwise been borne by customers in the absence of the NSW Electricity Infrastructure Roadmap. The NSW Government is undertaking modelling to provide an update on customer benefits of the infrastructure that is planned to be enabled by the Roadmap.

⁴ The present value of the cost forecast is in real 2022 dollars, calculated by discounting costs to the first modelling year (2023-24) at a real discount rate of 7% (consistent with the discount rate in AEMO's 2023 IASR).

Figure 9: Forecast of annual costs for the supply of wholesale energy services to NSW electricity customers (2024-2033 total \$b)



Planning in a dynamic and evolving context

This 2023 IIO Report reflects AEMO Services’ most recent view of the generation, long-duration storage and firming infrastructure required to meet the requirements of the EII Act in NSW. It is being published in a dynamic market and policy context.

Notably, the Australian Government recently announced an expanded Capacity Investment Scheme (CIS). Through partnerships with State and Territories, the Commonwealth will target 32 GW of new dispatchable and variable capacity. This will be delivered alongside state policies, including the Roadmap in NSW through tenders for LTESAs conducted by AEMO Services. Further, in the week leading up to the publication of this report AEMO released its Draft 2024 Integrated System Plan (ISP) and the NSW Minister published the 2023 Energy Security Target Monitor Report.

The modelling that underpins this report reflects the latest information at the time that modelling commenced and therefore does not capture all recent developments. In a rapidly evolving context, AEMO Services will continue to be adaptive to ensure that its planning for tenders reflects the latest market and policy information as this becomes certain.

What’s changed since the Draft 2023 IIO Report?

The Draft 2023 IIO Report was published in May 2023. While inputs and assumptions have changed with market developments since that time, the modelled pathway for the construction of electricity infrastructure has not changed substantially over the planning period.

- **Generation: The equivalent of 3,000 GWh of annual generation every six months:** the final Development Pathway for generation is similar to the draft. The modelled construction of generation infrastructure shows a linear trajectory from now to 2030, and the 10-Year Plan continues to show the investment opportunity with consistent tenders for long-term energy service agreements for generation.
- **Long-duration storage infrastructure:** the final Development Pathway for long-duration storage is similar to the draft. The modelled construction of long-duration storage infrastructure is back-ended to 2030, and the 10-Year Plan shows that AEMO Services will tender earlier to test cost assumptions and mitigate delivery risk associated with lead times.
- **Firming infrastructure:** the final Development Pathway for firming has changed compared to the draft. Consistent with notice to market associated with Tender Round 2, the firming target increased from 375 MW to 930 MW, with 1,075 MW ultimately awarded. There is now no additional firming modelled to meet the requirement until the mid-2030s.

1. Introduction

1.1 What is the Infrastructure Investment Objectives (IIO) Report

The NSW Roadmap is a plan to transform the NSW electricity system into one that is clean, reliable, and affordable. An essential element of the NSW Roadmap and its supporting legislation is the IIO Report, prepared by AEMO Services in its foundational role as the NSW Consumer Trustee.

The IIO Report is the central planning document to guide the state's energy transformation by setting out a Development Pathway for the next 20 years and a tender plan for the next 10 years. Together, the Development Pathway and 10-Year Plan identify indicative timing and scale for electricity infrastructure investment in NSW, with an appropriate level of flexibility to ensure AEMO Services can prioritise the interests of NSW energy customers as we give effect to the plan. The IIO Report is the only planning document legislated to be produced under the EII Act. It is required to be updated every two years,⁵ to capture market changes and progress towards the State's renewable energy goals. The defining features of the IIO Report⁶ are summarised in [Figure 10](#) below.

Figure 10: Defining features of the Infrastructure Investment Objectives Report

Defining features



Provides stakeholders with certainty

The 20-year Development Pathway provides certainty to industry, consumers, and the community, on required levels of investment to transition the NSW electricity system to one that is cheap, clean and reliable.



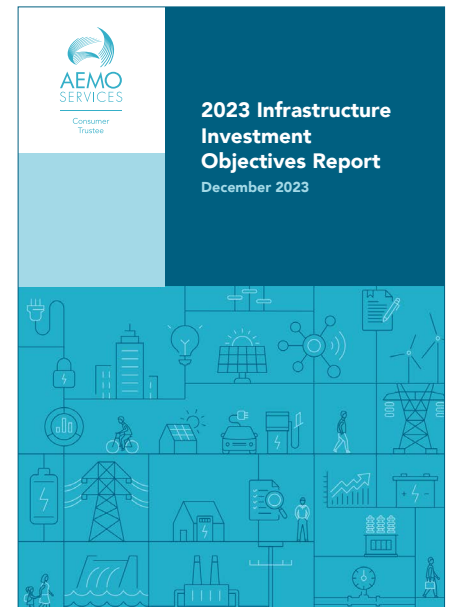
Promotes real outcomes

AEMO Services conducts tenders on the basis of the IIO Report to support the construction of infrastructure to deliver outcomes for consumers. The IIO Report is a call for investors to come forward with projects to deliver the Development Pathway.



Focuses on the long-term interests of consumers

AEMO Services seeks to deliver the Development Pathway and 10-Year Plan in a manner that optimises energy system needs whilst safeguarding the future financial interests of NSW electricity customers.



As the NSW Consumer Trustee, we consider both the energy system needs and the value to NSW electricity customers. This is the backbone of the report and is paramount to the decisions we make as the NSW Consumer Trustee that shape NSW's energy future. This includes decisions regarding the size and cadence at which we carry out competitive tenders for LTESAs and Renewable Energy Zone Access Rights. Indicative timing and volumes for these tenders are set out in this report through the 10-Year Plan to give effect to the Development Pathway.

⁵ AEMO Services must also prepare an IIO Report as soon as practicable after being directed by the NSW Minister for Energy (Minister) under section 47(2) of the EII Act to conduct a tender for LTESAs in respect of firming infrastructure. The 2022 IIO Report was prepared and published in response to such a direction.

⁶ The Electricity Infrastructure Investment Regulation 2021 (EII Regulation), clauses 24 and 25 set out items that the report must contain or matters that AEMO Services must have regard to in preparing the report. Appendix C sets out where these requirements are addressed in this report.

Explainer: Long Term Energy Service Agreements (LTESAs)

AEMO Services has developed and introduced a unique new financial instrument – the LTESA – which directly addresses electricity price risk to bring forward investment in new energy infrastructure.

LTESA's are a series of option contracts, offering storage or generation projects the rights to access cash flows for distinct periods, over a long contract term. In this way, they can be thought of as an insurance product, reducing price uncertainty for investors and subsequently bringing forward investment in new sources of renewable generation and storage, resulting in more affordable energy for consumers.

Project proponents across NSW compete for LTESA's through AEMO Services' rolling tender process. Projects can be inside or outside a Renewable Energy Zone. Our tenders are designed to identify bidders that have balanced price-competitive energy delivery with investments in other initiatives that contribute to broader community and economic benefits for host regions.

To date there have been three IIO Reports released,⁷ as summarised by [Figure 11](#) below.

Figure 11: Summary of IIO Reports released to date



The energy transition in NSW continues to occur at a rapid pace, with significant developments and announcements occurring frequently in the market. The IIO report is intended to provide guidance, increase confidence and provide a level of certainty for investors, broader industry and customers in the face of this rapidly evolving industry. This 2023 IIO Report seeks to mitigate the impact of future uncertainties, by presenting analysis and adopting an approach to planning and implementing tenders that will support AEMO Services to pivot quickly to respond to developments in the market.

⁷ Previous IIO Reports are available on AEMO Services' website. [Infrastructure Investment Objectives Report \(aemoservices.com.au\)](https://aemoservices.com.au)

1.2 Overview of IIO Report contents

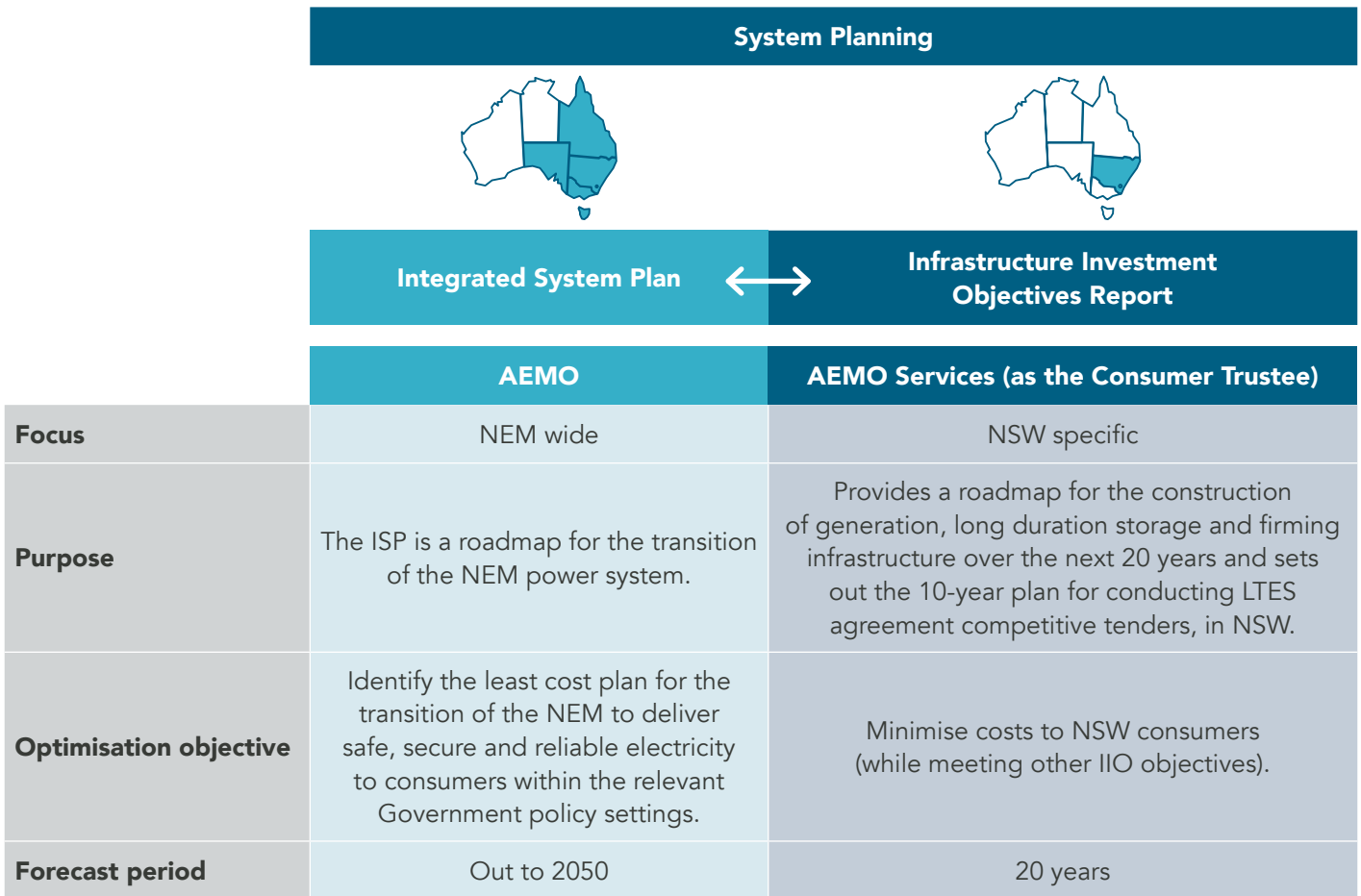
This 2023 IIO Report is broken down into 5 sections, with additional supporting material provided in the report's appendices:

- [Section 1](#) introduces the report and helps establish the purpose of the report, its relationship with other planning documents and limitations.
- [Section 2](#) outlines the minimum and overall objectives that the report is seeking to address, and the progress being made to date in their achievement.
- [Section 3](#) presents the 20-year Development Pathway which provides a view on how the energy system could transform over the coming decades.
- [Section 4](#) uses the 20-Year Development Pathway to set out the 10-Year Plan for tenders for generation, long-duration storage and firming LTEAs.
- [Section 5](#) provides more detailed information on the modelling completed to inform the preparation of the development pathway.
- [Appendix A](#) provides additional information on reliability assessment.
- [Appendix B](#) provides additional information on variable renewable energy lulls analysis.
- [Appendix C](#) provides a full list of regulatory requirements the report must have consideration for and provides references to where they are documented.

1.3 Interaction with other planning documents

The IIO Report forms part of a broader planning framework, with linkages between other key planning documents, such as AEMO's Integrated System Plan (ISP) ([Figure 12](#)).

Figure 12: The IIO Report as part of a broader planning framework



Relationship between AEMO's ISP and the IIO Report

The IIO Report is an input into AEMO's ISP process, in the same way any State or Territory policy that meets certain National Electricity Rules (NER) criteria is an input to the ISP. Both reports serve critical, and distinct, purposes.

AEMO's ISP is a NEM wide plan that is produced under the NER. The ISP finds alignment between jurisdictional plans and seeks to minimise costs across the energy system as a whole. The ISP considers multiple scenarios and determines an optimal development pathway across all scenarios which guides transmission development planning. The long lead times and large investments inherent in transmission projects makes it difficult to pivot plans where circumstances change. This makes a least worst regrets approach appropriate, with consideration of multiple alternate scenarios.

In contrast, the purpose of the IIO Report is to set out a plan for the development of generation, long-duration storage and firming infrastructure in NSW that meets the infrastructure investment objectives set out in the EII Act, with a primary focus on minimising costs to NSW electricity customers. The IIO Report also seeks to operationalise this plan by setting a schedule of tenders for LTESAs to support the delivery of built infrastructure. The shorter lead times and smaller investments associated with generation and long-duration storage, compared to transmission infrastructure, means it is easier to pivot the Development Pathway if circumstances change. This has informed AEMO Services' approach to preparing a resilient Development Pathway which, together with the corresponding 10-Year Tender Plan, provides for managing risks over the medium-term and uses AEMO's 2023 Inputs, Assumptions and Scenarios Report (IASR).⁸

AEMO Services' modelling diverges from AEMO on various matters including investment costs and industry constraints consistent with the objects of the EII Act. The modelling methodology and inputs and assumptions underpinning this report are detailed further in [Section 5](#).

⁸ AEMO (July 2023), *2023 Inputs, Assumptions and Scenarios Report*. Available at [AEMO | Current inputs, assumptions and scenarios](#).

Relationship between the work of the Infrastructure Planner and the IIO Report

EnergyCo, in its role as Infrastructure Planner under the EII Act, is responsible for leading the delivery of Renewable Energy Zones (REZs) as part of the NSW Government's Electricity Infrastructure Roadmap.

AEMO Services seeks to utilise information from, and help inform, transmission planning considerations in NSW through its interaction with the Infrastructure Planner. The interaction between the Consumer Trustee and the Infrastructure Planner helps improve the coordination of investment in renewable energy generation, electricity networks and storage infrastructure in REZs for the long-term benefit of electricity customers, local communities and industry in NSW.

AEMO Services provides information to EnergyCo on the modelled optimal combination and sequence of network infrastructure projects under different conditions for EnergyCo's consideration. This information can assist EnergyCo in its design and recommendation of network infrastructure projects as well as its ongoing engagement with communities, investors and industry. For example, modelling completed for the Draft 2023 IIO Report assisted in the development of EnergyCo's Network Infrastructure Strategy, a coordination exercise intended to complement AEMO Services' independent planning.⁹

AEMO Services intends to consider the best and latest information from EnergyCo as a key input to its IIO Reports. This includes EnergyCo planning information in relation to the size and timing of network infrastructure that may be required to facilitate or otherwise affect the Development Pathway. The co-optimisation of the delivery of NSW REZs network infrastructure with the build of generation, storage and firming infrastructure enables AEMO Services to determine a Development Pathway that improves cost outcomes for NSW customers.

This co-optimisation exercise has been enabled by new information from EnergyCo regarding options for NSW REZs network infrastructure and downstream augmentations, provided in August 2023. This includes updated information in relation to the costs of transmission infrastructure. However, the transmission costs are based on AEMO's Transmission Cost Database and do not reflect latest market information on transmission infrastructure costs from the Central-West Orana REZ network operator tender, which is still being finalised.

This 2023 IIO Report includes information from EnergyCo on network infrastructure options updated since EnergyCo's Network Infrastructure Strategy and the Draft 2023 IIO Report. The updated co-optimised modelled view of the network infrastructure required to deliver the Development Pathway presented in this and future IIO Reports will inform EnergyCo's ongoing planning of network infrastructure under the NSW Roadmap.

Energy Security Target Monitor Reports

The EII Act and associated regulations require the Energy Security Target Monitor (ESTM) 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.¹⁰ The various matters that the ESTM must take into account when calculating the energy security target and preparing its reports,¹¹ including inter-regional network constraints, are also regulated.

ESTM Reports show the amount of reliable capacity needed in NSW to service maximum customer demand. The ESTM forecasts any anticipated shortfalls and, in the event of any shortfalls, recommends actions to take over the medium term. AEMO Services takes into account any target breaches identified in the most recent ESTM Report in preparing an IIO Report.¹²

The Minister originally appointed AEMO as the ESTM, however the NSW Government has announced that it intends to appoint the Department of Climate Change, Energy, the Environment and Water as ESTM.¹³ The Minister may decide what action to take in response to a report received from the ESTM. Such a response can include the Minister directing AEMO Services to conduct a competitive tender for LTESAs in respect of firming infrastructure, as was made in 2022.

Electricity Statement of Opportunities

The Electricity Statement of Opportunities (ESOO) provides data for the NEM over a 10-year period to inform the planning and decision-making of market participants, new investors, and jurisdictional bodies. This includes technical and market data, and the 2023 ESoo presents AEMO's outlook of supply adequacy to 2032-33. It incorporates AEMO's Reliability Forecast, and the 2023 Energy Adequacy Assessment Projection (EAAP). Reliability is a key consideration for the NSW infrastructure investment objectives, and this information is considered in preparing an IIO Report.¹⁴

⁹ This advice was requested and provided under clause 18(1) of the EII Regulations.

¹⁰ EII Act, sections 12 - 14.

¹¹ *EII Infrastructure Investment Regulation 2021 (EII Regulation)*, Part 3.

¹² *Electricity Infrastructure Investment Regulation 2021*, regulation 25.

¹³ EII Act, section 15.

¹⁴ *Electricity Infrastructure Investment Regulation 2021*, regulation 25 requires that the Consumer Trustee take into account the forecast of unserved energy in the most recent ESoo published by AEMO.

1.4 Market developments since previous report

There have been significant developments in the NSW energy market in recent years, driven by broader changes in the Australian and global economy. This included impacts from global commodity price swings associated with a tightening supply-demand balance, which put significant upward pressure on electricity prices. While there have been subsequent declines in energy prices from their record levels in 2022, supply and demand continue to evolve, with impacts on electricity prices for NSW electricity customers.¹⁵

This context has influenced AEMO Services consideration and selection of the assumptions and the sensitivity used in this report, to understand the impacts of uncertainty, risk and potential future market developments for NSW electricity customers.

Infrastructure development challenges

In addition to high electricity prices, key infrastructure projects have faced development challenges throughout 2023. The transition facing Australia represents a major infrastructure program and supply chain constraints have brought delays for projects across the NEM. Later delivery dates are being seen for transmission and generation infrastructure countrywide, with a range of factors including social licence and planning approvals as well as network connections impacting timelines.

AEMO, in their 2023 ES00,¹⁶ noted that it is now applying delays to reflect observed development and delivery risks of new projects to ensure the accuracy of its reliability outlook. These delays act to further limit the choice available in delivering a Development Pathway that meets the minimum objectives (outlined in [Section 2.2](#)).

In addition to time delays, project costs are also increasing. The release of AEMO's 2023 Inputs, Assumptions and Scenarios Report (IASR) demonstrated that project costs are increasing for different technologies.

Response from governments

These challenges have been acknowledged by Governments and market bodies, and there has also been a range of positive announcements in response, designed to help deliver on infrastructure investment objectives whilst ensuring the interests of NSW electricity customers are prioritised.

The Australian Government's recent announcement about an expanded Capacity Investment Scheme (CIS) is one such example.¹⁷ Through partnerships with states and territories, the Commonwealth will target 32 GW of new dispatchable and variable capacity. CIS investment will continue to be delivered working with state systems, including the NSW Electricity Infrastructure Roadmap (Long Term Energy Service Agreements).¹⁸

This support from the Australian Government to underwrite new renewable generation and storage using federal funding mechanisms is already delivering results. The indicative size of the NSW firming tender was increased from 380 MW to 930 MW through a partnership with the CIS, to ultimately deliver 1,075 MW of reliable capacity.¹⁹ Options to help further accelerate the transition underway in NSW have been released by the NSW Government in their response to the Electricity Supply and Reliability Check Up.²⁰

The NSW Roadmap, including the IIO Report, will continue to provide a mechanism to mitigate the impact of the challenges associated with the transition. The NSW Roadmap establishes a comprehensive framework to support investment for the long-term, with decision making to take into account changing circumstances. As detailed throughout this report, AEMO Services considers many factors that may influence the trajectory for procuring the built infrastructure necessary to make energy available to NSW electricity customers. This informs the Development Pathway, and the 10-Year Plan for regular tenders to unlock the necessary investment through bankable products.

15 AEMO's Quarterly Energy Dynamics reports provide further insights on market dynamics, trends and outcomes in Australia's electricity and gas markets. Available at: aemo.com.au/energy-systems/major-publications/quarterly-energy-dynamics-qed

16 See AEMO (August 2023), 2023 Electricity Statement of Opportunities August 2023 Quarterly Energy Dynamics Q2 2023, page 4. Available at: [AEMO | NEM Electricity Statement of Opportunities \(ESOO\)](https://aemo.com.au/nem-electricity-statement-of-opportunities-esoo).

17 Announcement from Minister Bowen on 23 November 2023. Available at: minister.dccew.gov.au/bowen/media-releases/delivering-more-reliable-energy-all-australians

18 The allocation of capacity between jurisdictions that will be supported by the expanded Capacity Investment Scheme, and the role of AEMO Services in tendering for that capacity, had remains to be decided as of the date of publication of this report.

19 Joint announcement from Ministers Bowen and Sharpe on 22 November 2023. Available at: minister.dccew.gov.au/bowen/media-releases/joint-media-release-capacity-investment-scheme-supports-nsw-deliver-1gw-cleaner-cheaper-more-reliable-energy-nsw

20 See NSW Government (September 2023) Electricity Supply and Reliability Check Up NSW Government response [Electricity Supply and Reliability Check Up \(nsw.gov.au\)](https://www.nsw.gov.au/electricity-supply-and-reliability-check-up)

1.5 Limitations

The 2023 IIO Report is informed by modelling which makes simplifications to represent investment and bidding behaviour. The modelling seeks to leverage key inputs and assumptions from AEMO's 2023 IASR and key assumptions for NSW REZ network infrastructure options from EnergyCo, both of which represent updates from the Draft 2023 IIO Report. To commence the modelling exercise, inputs reflecting the best available information known at a certain point in time need to be used. As with any modelling exercise, there are uncertainties associated with these inputs and the assumptions they make about the future, with their accuracy only being revealed over time.

AEMO Services recognise that market actors may make different decisions or have access to more accurate and specific information. Accordingly, AEMO Services intends to be informed by the market via LTESA tenders when making decisions within tender processes. Information received via tender processes is taken into consideration when updating future development pathways and 10-year tender plans.

A more detailed description of the modelling process and inputs used is provided in [Section 3](#) and [5](#) of this report. Information from events or publications after the modelling commenced has not been directly incorporated into the modelling but may be referred to in the content of this 2023 IIO Report. A summary of information not directly considered in the modelling is outlined in [Table 1](#) below.

Table 1: Information excluded from IIO Report modelling

Information	Rationale
Announcements of changes to generator closure dates from July 2023 onwards.	Modelling for this report commenced in early August and was not able to capture announcements made after July.
Announcements on delayed project timings and additional investment commitments from July 2023 onwards.	Modelling for this report commenced in early August and was not able to capture announcements made after July.
Recommendations made by the NSW government in its response to the Electricity Supply and Reliability Check Up.	The Government response was released in September after modelling commenced and with recommendation still to be implemented.
Authorisation for CWO REZ network infrastructure.	A decision on authorisation is still under consideration. For the purposes of this modelling exercise the CWO REZ was assumed to be available and able to enter as part of the modelling co-optimisation process.
AEMO Services tender outcomes for firming infrastructure (tender 2).	Modelling assumed a firming tender size of 930 MW, reflective of the announced indicative tender size at the time work commenced.
AEMO Services tender outcomes for generation and long-duration storage LTESAs (tender 3).	Tender 3 remained in progress at the time modelling for this report commenced.
Outputs from the Draft 2024 ISP modelling including updates to the optimal timing of key transmission projects and forecast coal retirements. ²¹	The Draft 2024 ISP was released on 15 December 2023.
Updates to demand associated with the release of the 2023 ESOO.	Modelling for this report commenced in early August and was not able to capture ESOO data which was released on 31 August 2023. This Report utilised demand forecasts from the 2022 ESOO, which have materially lower operational consumption projections than the Draft 2024 ISP.
Any updates from the final 2023 IASR that required a significant model re-configuration including generator reliability settings.	The final 2023 IASR was released on 28 July. Updates were able to be captured where they were most relevant for the purpose of this report and did not involve any significant re-configurations to the model setup.

²¹ Reflecting optimised timing to achieve emissions budgets and economic retirement decisions.

2. Infrastructure Investment Objectives

This section explains the infrastructure investment objectives, which the Development Pathway in the IIO Report must plan to meet, and outlines NSW's significant progress to meeting these infrastructure investment objectives to date.




2.1 Overview

The infrastructure investment objectives to be considered by this report are set out in the EII Act.²² The objectives 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, beyond 31 December 2029.²³

The Development Pathway sets out how infrastructure could be constructed over 20 years to achieve both the minimum and overall objectives. These objectives are summarised in [Figure 13](#) below.

Figure 13: Infrastructure investment objectives and eligible infrastructure

Definitions		Minimum objectives	Overall objectives		
		(volume/capacity target)	Minimise costs for NSW Electricity customers	Meet reliability standard	Meet the energy security target
Generation 	Generation from a renewable energy source ≥ 30 MW	At least the same amount as 12 GW (~33,600 GWh p.a) constructed by the end of 2029	✓	N/A	N/A
Long-duration storage 	Storage able to be dispatched at registered capacity for ≥ 8 hrs, and scheduled by AEMO in the central dispatch process under the NER	2 GW and 16 GWh 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	✓	✓

²² EII Act, section 44.

²³ EII Act, section 44(2).

2.2 Explaining the minimum objectives

The Development Pathway must meet the minimum objectives for specified amounts of generation and long-duration storage infrastructure to be constructed by the end of 2029. Generation and long-duration storage infrastructure constructed since 14 November 2019 (regardless of whether it has been awarded an LTESA) can contribute towards the minimum objective targets of 33,600 GWh of annual renewable energy generation and 2 GW and 16 GWh of long-duration storage.

The EII Act does not establish a minimum objective for the construction of firming infrastructure. Rather, the Minister may direct AEMO Services to conduct a competitive tender for LTESAs to support firming infrastructure as necessary.

2.2.1 Generation infrastructure

The EII Act establishes a minimum objective for the construction of new generation infrastructure by 31 December 2029 that generates at least the *same amount of electricity* in a year as:

- 8 GW of generation capacity from the New England REZ,
- 3 GW of generation capacity from the Central-West Orana REZ, and
- additional 1 GW of generation capacity from elsewhere.²⁴

This objective is effectively an annual available energy generation volume (GWh per year) target rather than a target for capacity at a point in time. AEMO Services estimates that this volumetric available energy target equates to 33,600 GWh of generation. As explained in the 2021 IIO Report,²⁵ the amount of available energy is based on assumptions of technology capacity mix and capacity factor estimates. The renewable technologies' capacity mix was taken from the 'Step Change' scenario in AEMO's 2020 ISP, at the earliest period in which new build of renewable generation in NSW (post-November 2019) reaches 12 GW of capacity. The capacity mix and capacity factors are multiplied and summed to gain the final energy target in GWh per year.

The EII Act requires that the generation infrastructure is comprised of renewable energy generators in NSW, each with generation capacity of at least 30 MW.²⁶

2.2.2 Long-duration storage infrastructure

The EII Act establishes a minimum objective for the construction of a total of 2 GW and 16 GWh of long-duration storage infrastructure by 31 December 2029.²⁷

This infrastructure must:

- provide for the storage of electricity,
- consist of storage units with a registered capacity that can be dispatched for at least 8 hours, and
- be scheduled by AEMO in the central dispatch process under the NER.²⁸

The *Energy Legislation Amendment Bill 2023*, which passed NSW Parliament on 28 November 2023, added that this infrastructure must also consist of at least 16 GWh of storage. This clarifies the connection between the capacity objective and the definition of minimum duration, and hence does not represent a substantive change in policy.

²⁴ EII Act, section 44(3)(a).

²⁵ AEMO Services (December 2021), 2021 Infrastructure Investment Objectives Report, box 3.

²⁶ EII Act, section 43(1)(a).

²⁷ EII Act, section 44(3)(b).

²⁸ EII Act, section 43(1)(b).

2.2.3 Firming infrastructure

There is no specific legislated minimum objective for firming infrastructure. A Ministerial direction was received by AEMO Services in August 2022 to conduct a firming tender to meet future forecast reliability needs. The firming tender, subsequently scheduled via the 2022 IIO Report, has been delivered with projects totalling 1,075 MW being announced to help address future reliability needs.

Generally, firming infrastructure refers to flexible capacity that can be dispatched when there is a sharp 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 NER (which can include wholesale demand response).²⁹

2.3 Explaining the overall objectives

In addition to the minimum objectives, AEMO Services' Development Pathway must also plan to meet the overall objectives of:

- minimising costs to NSW electricity customers,³⁰
- meeting the NSW energy security target,³¹ and
- meeting reliability standard.³²

2.3.1 Minimising costs to NSW customers

In minimising electricity costs for NSW electricity customers, AEMO Services must consider whether additional generation infrastructure beyond the minimum infrastructure investment objective is required both before and after 2029. Modelling is used to inform this consideration.

As explained further in [Section 3.2](#), AEMO Services sets an objective function in the model used for IIO Reports to minimise costs for NSW electricity customers across the 20-year horizon. The modelling exercise is able to forecast the likely impacts of the Development Pathway on wholesale electricity costs, and the costs of LTESAs. The costs of EII Act network infrastructure and scheme administration are also added at the third stage where the cost forecast is calculated.

[Section 3.7.1](#) provides a forecast of costs for the provision of wholesale energy services to NSW electricity customers under the Development Pathway.

²⁹ The Wholesale Demand Response (WDR) mechanism allows demand side (or customer) participation in the wholesale electricity market. More information is available at: aemo.com.au/initiatives/trials-and-initiatives/wholesale-demand-response-mechanism

³⁰ EII Act, section 44(2)(a).

³¹ EII Act, section 44(2)(c).

³² EII Act, section 44(2)(b) and (c).

2.3.2 Meeting the reliability standard

An overall objective exists for both the construction of long-duration storage and firming infrastructure that is necessary to meet the reliability standard.

The reliability standard, for the purposes of the Roadmap and the IIO Report, is defined as:³³

- until 30 June 2028, the NEM interim reliability measure of expected unserved energy in a region not exceeding 0.0006% of the total energy demanded in that region for a given financial year, and
- from 1 July 2028, the NEM reliability standard of expected unserved energy in a region not exceeding 0.002% of the total energy demanded in that region for a given financial year.

This above definition represents a change since the Draft 2023 IIO Report. This is because, on 25 May 2023, the Australian Energy Market Commission (AEMC) released a final report from a completed review into the interim reliability measure which recommended that the application of interim reliability measure be extended to 30 June 2028. The *Electricity Infrastructure Investment Regulation 2021* (EII Regulation) was then subsequently revised on 30 June 2023 to align with the AEMC recommendations.

The minimum objective for the construction of 2 GW and 16 GWh of long-duration storage by the end of 2029 is expected to make a significant contribution to meeting the reliability standard over time. AEMO Services may also plan for additional long-duration storage if required.

The reliability standard may also be met through the construction of firming infrastructure, noting that AEMO Services may only conduct an LTESA tender for this infrastructure when the Minister directs AEMO Services to do so.

2.3.3 Meeting the energy security target

Meeting the energy security target (as well as the reliability standard) is the overall objective for firming infrastructure under the EII Act.

The energy security target sets the target of firm capacity required to meet NSW's maximum customer demand, with a reserve margin to account for the unexpected loss of the two largest generating units in the state.³⁴

³³ 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.

³⁴ EII Act, section 12.

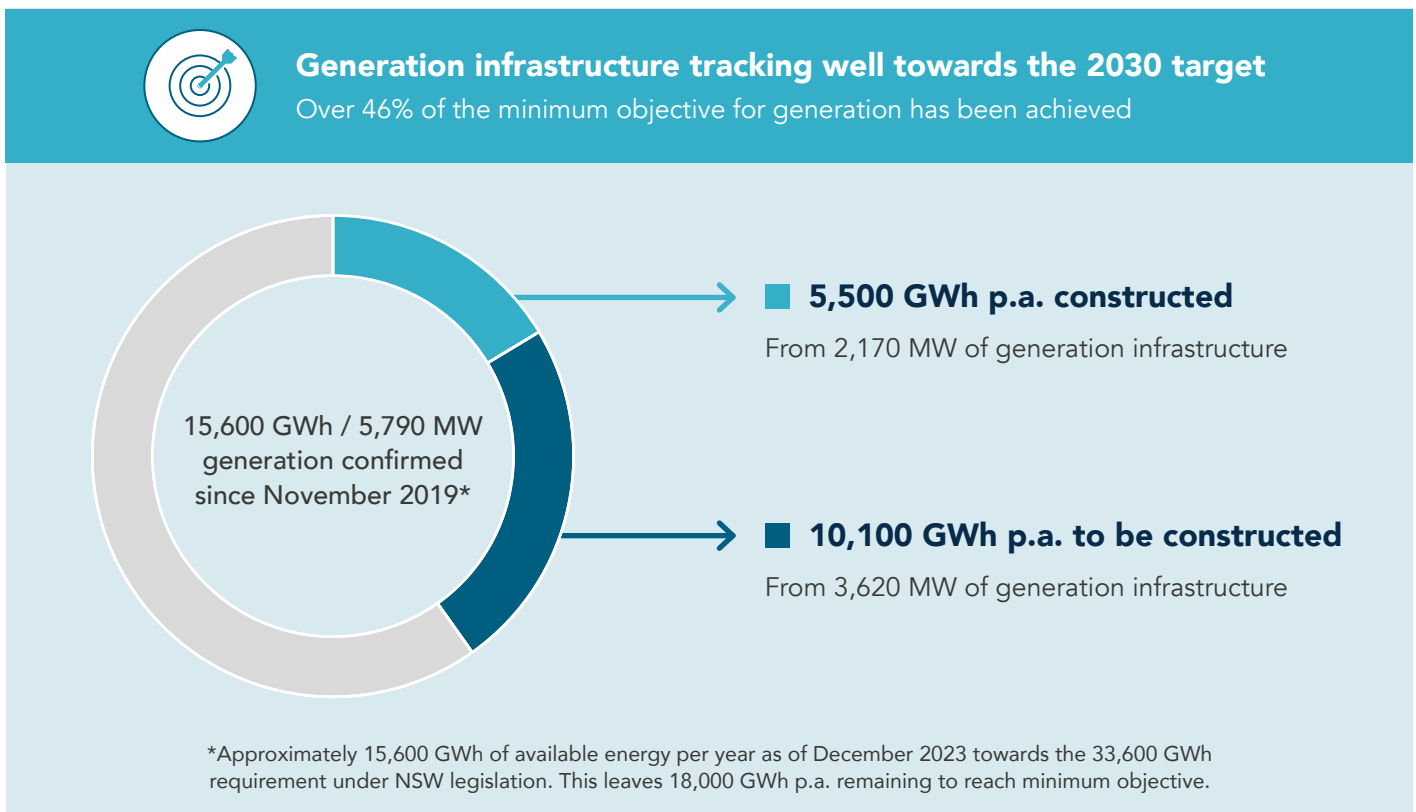
2.4 Tracking the infrastructure investment objectives

2.4.1 Progress toward achieving the minimum objectives

AEMO Services monitors progress in achieving the minimum objectives using information from AEMO's generation information page.³⁵ AEMO Services uses information regarding AEMO's 'existing' and 'committed' project status as 'constructed' and 'to be constructed' infrastructure for the purposes of tracking progress against the infrastructure objectives. Any project with an LTESA is also included and is allocated to a category based on whether it has been constructed or not. The total capacity of projects is the sum of the projects 'constructed' and 'to be constructed'.

Since 14 November 2019, and as of December 2023, an indicative total of 5,790 MW of capacity has been secured in NSW towards the 2030 objective, as shown in [Figure 14](#) below. This constructed or to be constructed infrastructure is estimated to generate approximately 15,600 GWh of available energy per year or just over 46% of the minimum objective for generation infrastructure.

Figure 14: Progress made to date toward achieving the minimum objective for generation



For long-duration storage, 574 MW has been classified as 'to be constructed' with a further 1,426 MW being required to achieve the minimum objective of 2 GW and 16 GWh by 2030. Most of this type of infrastructure is expected to be constructed toward the end of the decade.

³⁵ AEMO Generation Information available at: aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information. October 2023 Generation Information (released on 2 November 2023) used for this progress update.

2.4.2 The reliability standard

AEMO's 2023 ESOO, identified gaps in meeting the reliability standard in NSW starting in 2025-26. This is principally a result of the potential early retirement of the Eraring Power Station in August 2025, as announced by Origin Energy as its owner.

The modelling undertaken by AEMO for its central scenario in the 2023 ESOO incorporates existing, committed and anticipated generation projects (with both committed and anticipated projects being subject to commissioning delays).³⁶ It therefore does not take into account additional generation and long-duration storage included in a broader pipeline of projects, or the additional network infrastructure that is expected to be constructed in NSW under the NSW Roadmap. The 2023 ESOO did, however, note that developments in NSW associated with both federal and state schemes are effective in addressing reliability risks, provided they occur in alignment with their proposed schedule and scope.³⁷

AEMO Services has undertaken a reliability assessment to test the Development Pathway set out in this report which is described in [Appendix A](#). Consistent with the 2023 ESOO it found that the Development Pathway is able to achieve the reliability standard across the assessed period to 2033.

2.4.3 The energy security target

The latest ESTM Report was published in December 2023.³⁸ The 2023 ESTM Report forecast a breach of the energy security target under its central scenario from 2025-26 (following the potential early retirement of the Eraring Power Station).

AEMO's modelling of its central scenario for the 2023 ESTM Report only included existing projects and committed projects and applied an assumed delay in delivery for committed projects.

As outlined in [Appendix A](#), where generation projects that are anticipated by AEMO are included in the forecast per the 2023 ESOO approach, and where projects that have received an LTESA from an announced tender are operational by their targeted date, there is no longer a breach in the energy security target. This indicates that the Development Pathway in this Report, which includes anticipated projects and additional generation, storage and transmission infrastructure developments, is able to meet the energy security target over the 10-year assessment horizon. Where this a delay to the delivery of projects which have received an LTESA, this analysis shows a gap in 2025-26.

36 Commissioning delays are applied based on observed trends. Committed projects are assumed to become fully available six months after the full commercial use date provided by the developer anticipated projects which have provided an expected commissioning date are assumed to become fully available at the latest date of either one year after the full commercial use date provided by the developer, or the first day after the T-1 year for Retailer Reliability Obligation purposes.

37 2023 Electricity Statement of Opportunities, page 124.

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

2.5 The contribution of tenders since the previous report

Tendering for LTESAs on the basis of the IIO Reports is a key function of AEMO Services in its foundational role as the NSW Consumer Trustee. The projects supported by LTESAs seek to improve affordability, reliability, security and sustainability of electricity supply in addition to other objects of the EII Act. The tender rounds delivered according to the 10-Year Plan are designed to foster competition and support the highest merit projects in the long-term financial interests of NSW electricity customers to meet the infrastructure investment objectives.

Three tenders have been completed since the 2022 IIO Report:

- **Tender Round 1** for generation and long duration storage LTESAs,
- **Tender Round 2** for firming infrastructure LTESAs following direction by the Minister, and
- **Tender Round 3** for generation and long duration storage LTESAs.

AEMO Services observes that each of the three tenders conducted so far have been substantially over-subscribed, indicating an appreciation by project proponents for the uniqueness of AEMO Services' LTESA design which aims to reduce market risk while retaining market upside. LTESAs are pioneering an approach to incentivising the market to bring forward new energy infrastructure investment. Their design is intended to overcome market barriers to investment, such as unexpectedly low market prices or a 'missing money' issue for longer duration storage (i.e. the prices for energy may not fully reflect the value of investment to electricity customers), whilst seeking to limit cost to NSW electricity customers. Under the Generation LTESA, consumers will only subsidise a project when prices are already low due to increases in supply of cheaper firmed renewable energy.

In May 2023, AEMO Services announced the award of LTESAs to three generation projects, representing a capacity of 1,390 MW, alongside one long-duration storage lithium-ion battery project. Tender Round 2, announced in November 2023, identified six firming projects (consisting of two 2-hour duration lithium-ion batteries, one 4-hour duration lithium-ion battery and three firming demand response/VPP projects) with highly competitive prices. This was followed in December 2023 by the announcement of two generation and three storage projects following completion of Tender Round 3. This brings the total of projects awarded to 15.

The LTESA has been designed with a high degree of flexibility to allow for innovation and tailoring of the product to a Project's requirements – to the benefit of both the proponent and long-term financial interests of NSW electricity customers. Successful projects have used this flexibility to improve their competitiveness in a tender. For example, as part of their bid, proponents have committed to not exercising the option in certain periods, which eliminates the risk of any payouts under the LTESA by NSW consumers during that period.

The LTESAs have also supported projects with a diversity of technology from solar, wind, and BESS (including a hybrid project) to advanced compressed air energy storage and demand response projects. This reflects AEMO Services' aim to facilitate competition between eligible technologies, which it considers to be in the long-term financial interests of NSW electricity customers. Collectively, these successful projects will represent a total of 3,789 MW of new energy infrastructure which will deliver approximately 6,100 GWh p.a. from generation projects and 1,649 MW and 7,572 MWh of energy storage from firming and long duration storage projects. The successful projects from these three tenders are captured in [Table 2](#) below.

Table 2: Tender projects

Project name	Company	Infrastructure type	Capacity MW	Storage Capacity	Available GWh p.a.	REZ
Tender Round 1³⁹						
Stubbo Solar Farm	ACEN Australia	Generation	400 MW		1,130 GWh p.a.	Central West Orana
Coppabella Wind Farm	Goldwind Australia	Generation	275 MW		870 GWh p.a.	Non REZ
New England Solar Farm	ACEN Australia	Generation	720 MW		2,000 GWh p.a.	New England
Limondale BESS	RWE Renewables Australia	Long Duration Storage	50 MW	400 MWh+		South West REZ
Tender Round 2⁴⁰						
Liddell BESS	AGL Energy	Firming	500 MW	1,000 MWh		NA
Orana BESS	Akaysha Energy	Firming	415 MW	1,660 MWh		Central West Orana
Smithfield BESS	Iberdrola Australia	Firming	65 MW	130 MWh		Non REZ
Virtual Power Plant (VPP)	Enel X Australia	Firming	95 MW, comprised of three separate projects VPP 1: 50 MW VPP 2: 20 MW VPP 3: 25 MW	2 hours minimum ⁴¹		NA
Tender Round 3⁴²						
Uungala Wind Farm	Squadron Energy	Generation – Wind	400 MW		1,190 GWh p.a.	Central West Orana
Culcairn Solar Farm	Neoen Australia	Generation – Solar	350 MW		909 GWh p.a.	NA
Silver City Energy Storage Centre	A-CAES	Long duration Storage – Compressed Air	200 MW	1600 MWh		NA
Goulburn River BESS	Lightsource bp	Long duration Storage – BESS	49 MW	392 MWh+		NA
Richmond Valley BESS	Ark Energy	Long duration Storage – BESS	275 MW	2200 MWh+		NA

39 Tender Round 1 projects were announced on 1 May 2023.

40 Tender Round 2 projects were announced on 22 November 2023.

41 Minimum dispatch duration of 2 hours, which will be maintained throughout the LTESA term.

42 Tender Round 3 projects were announced on 19 December 2023.

There was strong market interest in our first two tenders and the broader tender schedule:

- Projects in Tender Round 1 represented a combined capacity of more than 5 GW of generation and 5 GW of long duration storage,
- Projects in Tender Round 2 represented a combined capacity of more than 3.3 GW of firming infrastructure, and
- Projects in Tender Round 3 represented a combined capacity of more than 3.1 GW Generation and 1.6 GW of long duration storage.

[Table 3](#) provides more detail on tender participation.⁴³

Table 3: Tender Participation

Tender Round	1	2	3		
Total bids	33	18	18		
Proponents	23	10	10		
Capacity bid into tender	Generation	5.5 GW	3.3 GW	Generation	3.2 GW
	LDS	2.5 GW		LDS	1.6 GW
	Generation	578% ⁴⁴	868% ⁴⁵	Generation	332%
Proportion of capacity bid to indicative tender size	LDS	416%		LDS	296%
Eligible bids	26	17	17		
Ineligible bids	7	1	1		
LTESAs recommended	4	6	5		
LTESAs awarded	4	6	5		

43 As required by EII Reg 24(2)(b).

44 Using 950 MW as the indicative tender size, which approximates the 2500 GWh indicative tender size.

45 This is based on the initial indicative tender size of 380 MW. This was increased to 930 MW, in which case this figure is 354%.

3. 20-Year Development Pathway

3.1 Overview and considerations

IIO Reports publish a Development Pathway for infrastructure required to be constructed over the following 20 years to achieve the minimum and overall infrastructure investment objectives. This section sets out the Development Pathway for generation, long-duration storage and firming infrastructure types over the 20-year period from 2023-24 to 2042-43.

The Development Pathway represents AEMO Services' view of the pathway for achieving the infrastructure investment objectives that is in the long-term financial interests of customers and helps guide AEMO Services in conducting competitive tenders. It is the outcome of electricity market modelling, using a methodology that is explained briefly in [Section 3.2](#) below and in more detail in [Section 5](#).

The Development Pathway is primarily intended to meet the infrastructure investment objectives in a way that minimises cost to NSW electricity customers. AEMO Services has also considered how the design of the Development Pathway might mitigate against a range of future risks, ranging from supply chain constraints (see [Section 3.3](#)) to lulls in wind and solar resources (see [Section 3.7.3](#)).

The complex interplay of broader energy system factors creates uncertainties when seeking to model a future Development Pathway based on assumptions from a point in time. As such, the Development Pathway presented in this report is indicative and may be subject to change. A sensitivity is presented below at [Section 3.8](#) showing how it may change in the case of infrastructure delays.

3.2 Modelling process overview

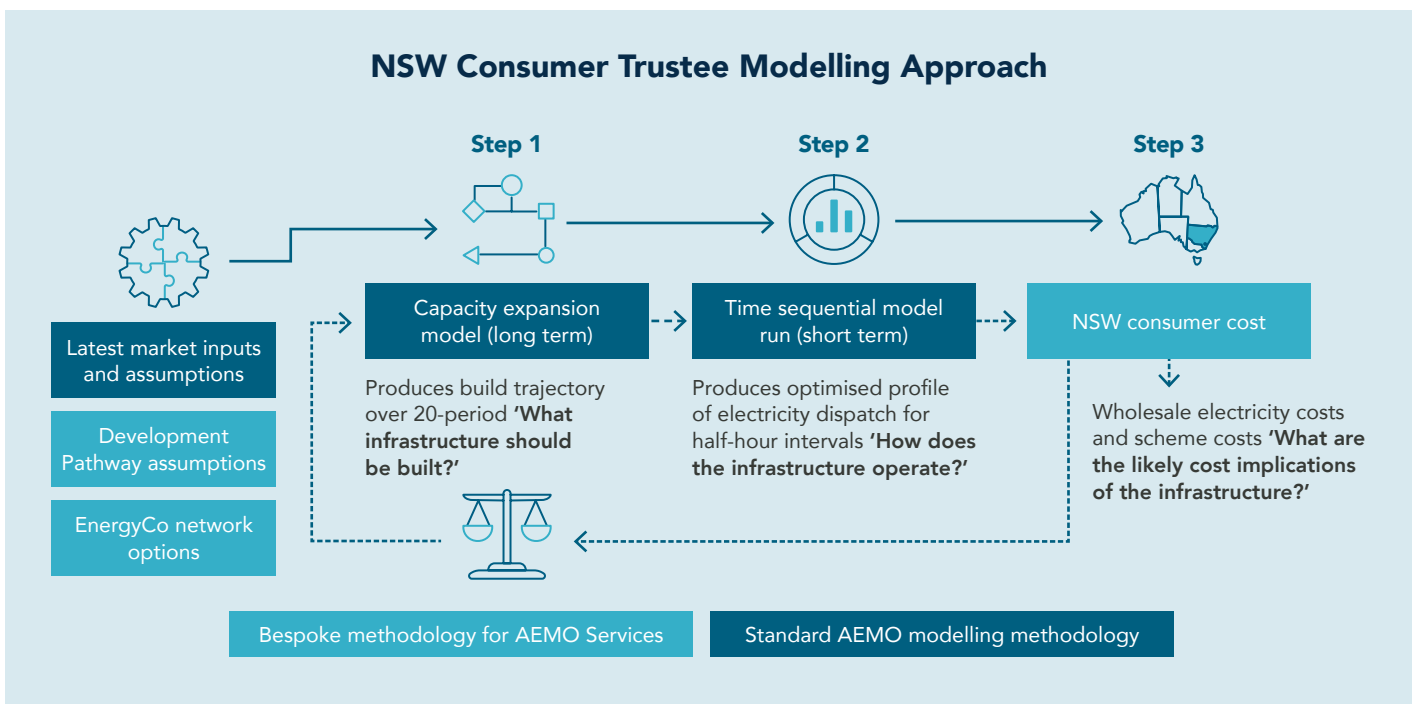
AEMO Services uses electricity market modelling, commissioned and funded by AEMO Services and undertaken by AEMO, to inform the Development Pathway.

3.2.1 Modelling Steps

Key steps in this modelling, including bespoke aspects of the methodology focussing on cost to NSW electricity customers, are shown in [Figure 15](#) below and explored in this section of the report.

Further detailed explanation about the approach AEMO Services follows is provided in [Section 5](#).

Figure 15: Overview of IIO Report modelling steps



In addition to those steps set out in the figure, AEMO Services then undertakes two further modelling exercises to test the development pathway:

- **Reliability assessment:** The co-optimised modelling described in these steps adopts a proxy approach to ensure there is sufficient infrastructure to meet the reliability standard. AEMO Services then undertakes a further detailed probabilistic reliability assessment to confirm whether the Development Pathway meets the reliability standard and a further analysis of whether the Development Pathway meets the energy security target, and
- **VRE lulls assessment:** The Development Pathway is re-simulated in time-sequential modelling with additional extreme VRE lull events. These are 1-day, 3-day and 7-day periods with low aggregate NSW availability and are reflective of historical events over the last 43 years. Resilience of the Development Pathway is analysed by metrics including the sufficiency of generation to meet NSW demand and the impact on NSW wholesale price.

3.2.2 Scenarios Considered

AEMO Services has applied the above modelling steps to two scenarios as shown in [Figure 16](#) to inform the 2023 IIO Report.

Figure 16: Overview of scenarios considered



The results from the central scenario are adopted as the Development Pathway. This scenario produces a mix of infrastructure that meets the infrastructure investment objectives at the lowest cost to customers. This scenario does not include a number of announced policies from federal and state governments, which are reflected in AEMO's Draft 2024 ISP 'Step Change' scenario. This is because AEMO Services considers that to do so would be inconsistent with the Consumer Trustee's legislative role under the EII Act and policy context, which is to plan for infrastructure investment that is in the long-term financial interests of NSW electricity customers, through the conduct of tenders for LTESAs. Under the EII Act, NSW electricity customers pay the costs which arise under these LTESAs.

There is remaining uncertainty as to how the excluded jurisdictional policies will be implemented. As such AEMO Services did not consider that setting a development pathway and 10-year plan that included additional capacity to meet these policies was consistent with its legislative role and overarching policy objectives.

The Infrastructure Delay scenario reflects changes to assumptions around infrastructure delivery timeframes in the central scenario to enable AEMO Services to identify the discrete implications of these changes in a way that can support it to pivot its planning if required. It provides valuable information regarding the resilience of the Development Pathway.

3.3 Generation infrastructure pathway

The generation element of the Development Pathway shows a need for generation infrastructure investment across a range of technologies at or near record levels to 2030 and beyond to meet the infrastructure investment objectives.

The generation element of the Development Pathway is set out in [Figure 17](#) and [Figure 18](#), which show the annual and cumulative annual output of the infrastructure for NSW over the period 2024 to 2043, respectively. It is designed to meet the minimum objective of 33,600 GWh p.a. of renewable energy generation by 2030 and the overall objective of minimising costs to NSW electricity customers.

Figure 17: NSW Development Pathway - Annual (Generation)

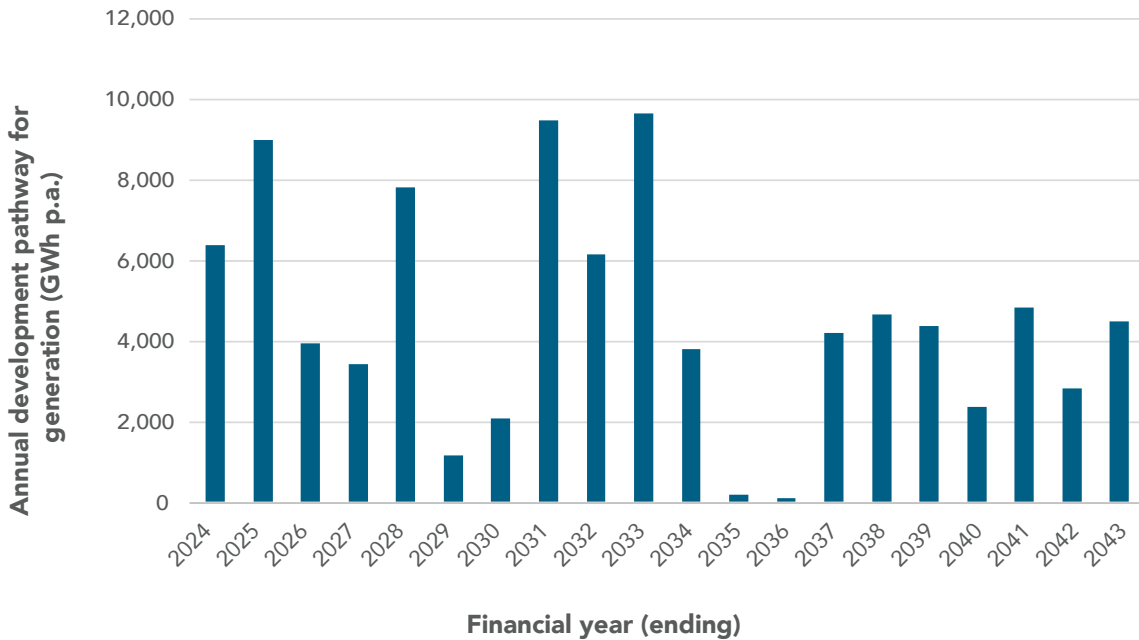
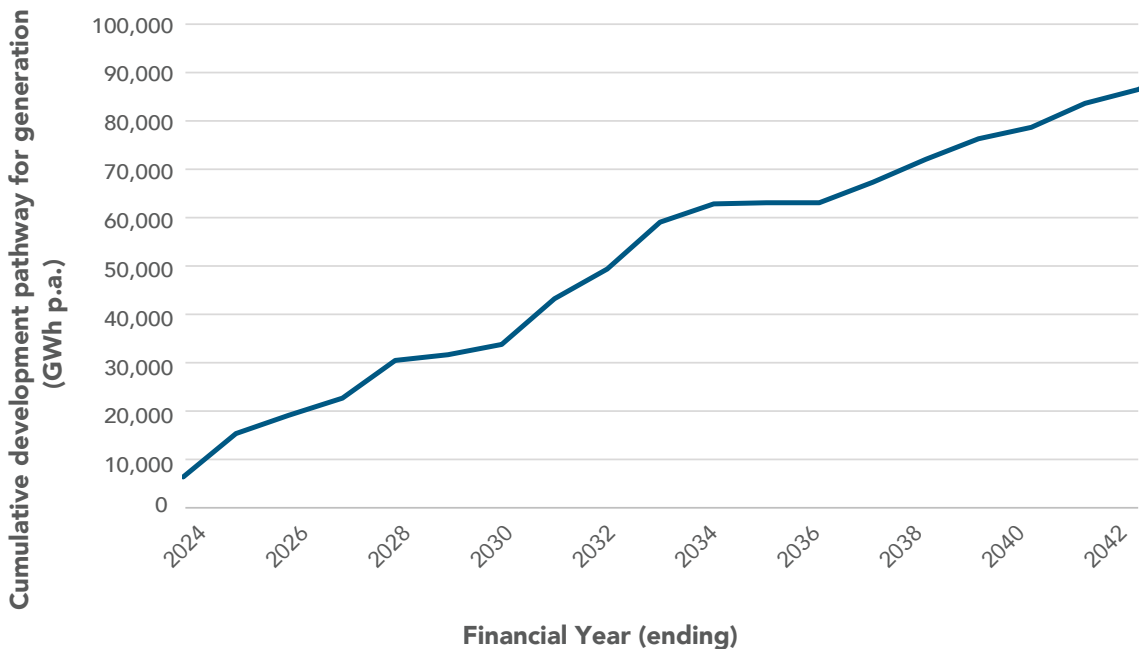


Figure 18: NSW Development Pathway - Cumulative (Generation)



The generation infrastructure element of the Development Pathway sees the minimum objective for the construction of generation infrastructure being achieved by 2029-2030 with just over 34,000 GWh of annual generation. To achieve the legislated minimum construction objective of 33,600 GWh of annual generation from renewables by 2030, there is very little choice in the development pathway to 2030, and the trajectory to this date largely aligns with the 4 GW NEM-wide build limit AEMO Services has applied in the modelling (see explainer below) with this limit being reached or slightly exceeded over the period 2026 to 2030.

The Development Pathway then continues to grow beyond 2030 at a slower rate for the purpose of minimising electricity costs to NSW electricity customers. There is a high degree of uncertainty in the long-term view of generation needs and the best mix of technologies. The ongoing maturing of technologies and how they complement one another along with firming infrastructure will be important considerations in shaping the generation mix in the future. In addition to the technologies themselves, the location of projects, availability of resources, and the need for social licence along with necessary development and planning approvals will all influence the amount and speed of generation that can be built as the energy transition continues to progress.

Explainer: Supply-chain and development pipeline build limits

Consistent with previous IIO Reports, a supply chain constraint has been incorporated into the modelling to limit the amount of generation being constructed in any given year. In this IIO Report, a NEM wide constraint has been adopted, replacing a NSW-specific constraint (as presented in previous reports).⁴⁶ This updated approach reflects the fact that commodity, manufacturing and labour needs associated with these large infrastructure builds in NSW are also in demand in other jurisdictions to achieve their targets.

The annual build limit for new entrant NEM generation and storage has been set at 4 GW⁴⁷ for all technologies up until 2029-30. From 2030-31 onwards the limit is relaxed and increased construction can take place without penalty. The limit of 4 GW was selected based on historical build of all large-scale technologies in the NEM from the last 10 years. This occurred across 2020-2021 and was comprised of mostly wind and solar with some Battery Energy Storage Systems (BESS). The removal of the constraint from 2030 onwards is designed to represent further maturing of the market, improved capability, increased skills and easing global supply limitations.

In considering supply chain constraints, AEMO Services has had regard to the plan prepared by the NSW Renewable Energy Sector Board (**RES Board Plan**), published in September 2022.⁴⁸ The RES Board Plan sets out how local workers, communities and industries can benefit from the economic opportunities presented by the Roadmap. The RES Board Plan also identifies barriers, such as skill and labour shortages, that result from a large general infrastructure pipeline combined with low levels of unemployment in renewable energy zones and shortages in key occupations (e.g., electricians).⁴⁹

The modelling for this IIO Report also adopts a NSW specific build limit. This applies in the first few years of the modelling horizon. It seeks to reflect the existing pipeline of projects and takes into consideration those projects which could be reasonably expected to be constructed above and beyond those projects already committed and anticipated.

AEMO Services' modelling for this IIO Report adopts these assumptions, that limit the investment in renewable generation to that which has already been achieved in Australia, to ensure there can be the highest level of confidence that the generation infrastructure pathway can be delivered.

46 See 2021 IIO Report, Appendix D.

47 Limit applies to new entrant projects and excludes those projects already committed and anticipated within AEMOs Generation Information [AEMO | Generation information](#)

48 Available at <https://www.energy.nsw.gov.au/nsw-plans-and-progress/major-state-projects/electricity-infrastructure-roadmap/entities-delivering#renewable-energy-sector-board>.

49 RES Board Plan, page 25.

Generation development pathway technology mix

The generation development pathway is technology neutral and AEMO Services' investment decisions will be informed by real-market information received through tenders to recommend projects for LTESAs that are in the long-term financial interests of customers.

While not definitive in AEMO Services LTESA tender decision-making, the technology mix preferred by AEMO Services' model in the generation infrastructure pathway provides useful insights into how different technologies may contribute to meeting the infrastructure investment objectives.

Wind offers a generation profile that minimises costs to customers through its complementarity with demand. However, latest market information suggests that the development pipeline of wind projects in NSW is limited in the near term, and the trajectory of wind and solar investment from the model, as shown in [Figure 19](#) below, reflects this. The model is forced to select solar early in the horizon to reflect the concentration of solar technology in the development pipeline that can be delivered by 2025, and to help ensure the minimum objectives are met by 2030. The model preferences wind from the late 2020's when development pipeline constraints ease, from which point the proportion of wind to solar selected by the model grows.

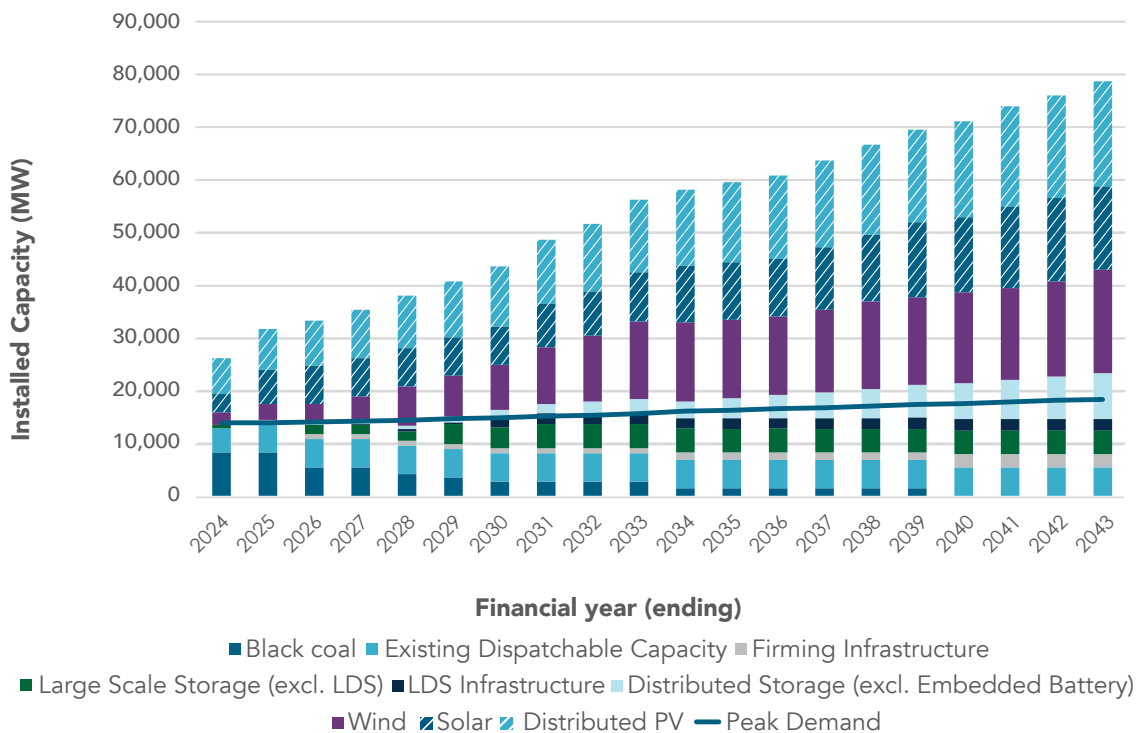
Other generation supply infrastructure

The Development Pathway for generation infrastructure assumes that other generation supply infrastructure including coal and gas fired power plants and consumer energy resources (CER) complements large scale generation infrastructure supported via AEMO Services' tenders. The mix of other generation supply infrastructure is dependent on a range of factors and uncertainties around coal closures and the uptake and operation of CER. These uncertainties could lead to changes in the composition of the NSW energy system from that forecast below. For example, lower projections for distributed storage uptake to 2030 have become available since this modelling exercise commenced.

This mix of NSW generation is considered within the context of the NEM wide transformation that is taking place. The ambitions of, and generation in, other NEM jurisdictions is considered in AEMO Services' central case where the implementation mechanisms for these targets has been settled, by factoring in these policy targets and associated technology mixes overtime.

An indicative forecast of the different types of infrastructure (by technology type) for the supply of electricity in NSW from the central scenario over the next 20 years is set out in [Figure 19](#).

Figure 19: Forecast installed capacity in NSW over time



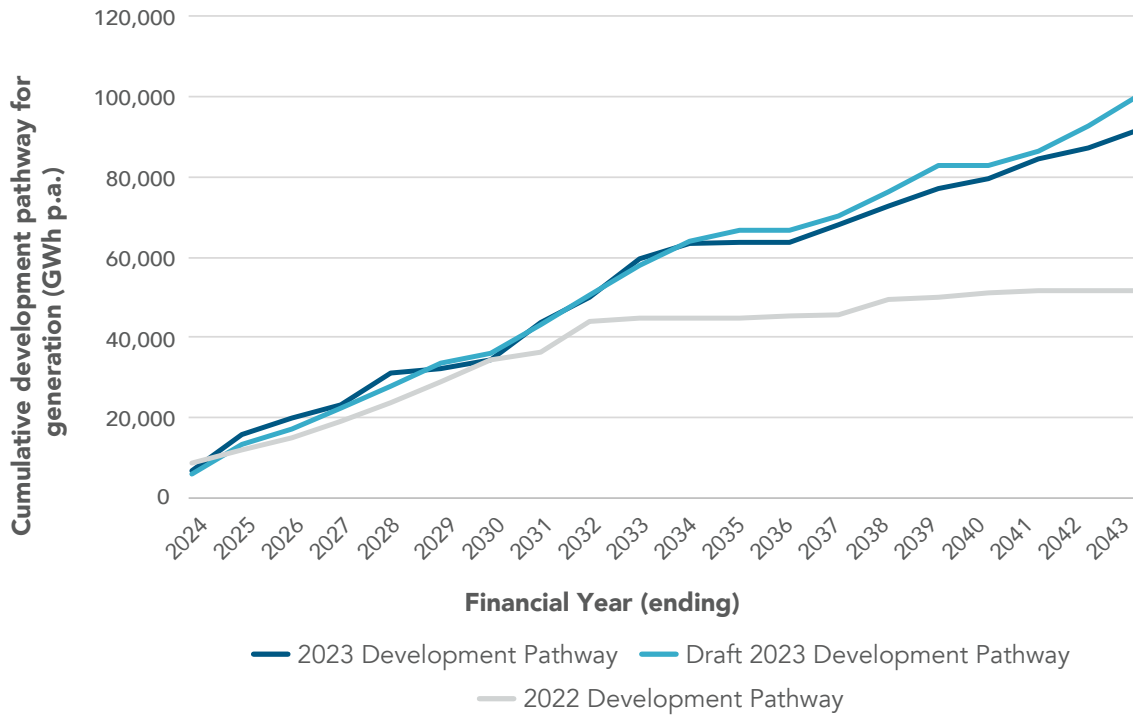
Comparison to previous IIO Reports

Figure 20 compares the generation element of the Development Pathway to the previous Development Pathway in the Draft 2023 IIO Report and the 2022 IIO Report. The Development Pathway trajectory is closely aligned with the Draft 2023 Development Pathway. The projected build is similar to meet the 2030 minimum objective, reflecting the few degrees of freedom available to meet this objective at this time, and then from the mid 2030's a lower build trajectory is observed.

The similar, though slightly lower, projected build of generation infrastructure for the remainder of the modelled period from the mid 2030's onwards occurs because of higher costs of capital assumed in this IIO Report and additional state based renewable targets delivering increased generation in the NEM outside of NSW.

The Development Pathway is significantly higher when compared to the 2022 Development Pathway because of several factors, including increased electricity demand and assumed earlier NSW coal-fired generator retirements.

Figure 20: Comparison of Development Pathway to 2023 Draft and 2022 Development Pathways (Generation)

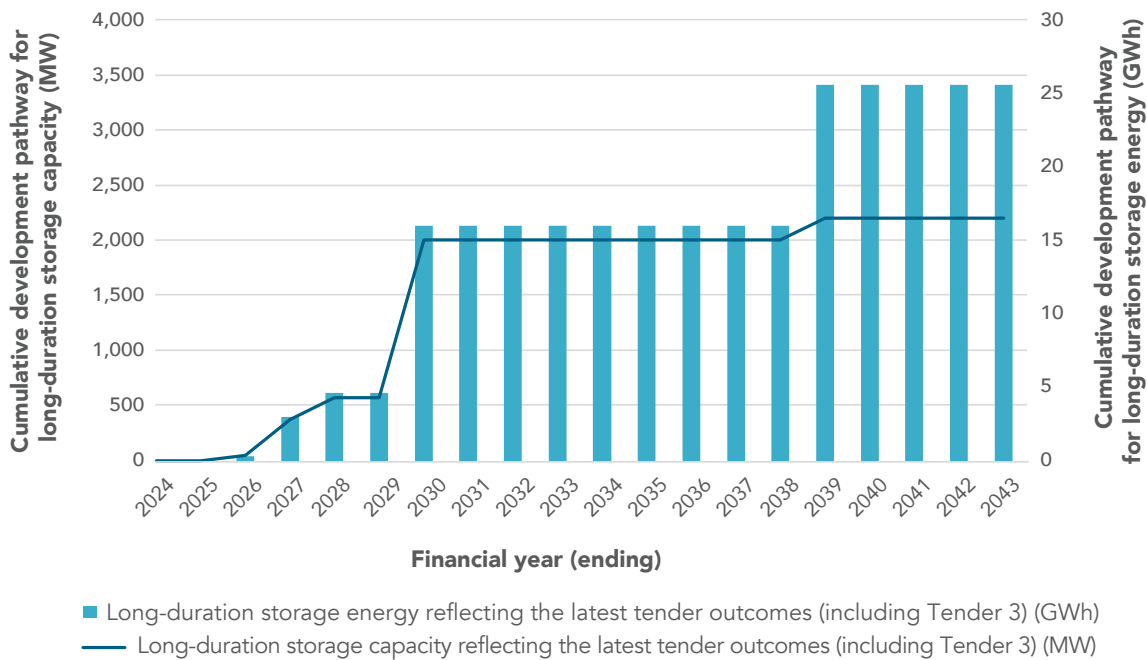


3.4 Long-duration storage infrastructure pathway

In this IIO Report, the long-duration storage element of the Development Pathway is largely consistent with prior modelling. Pumped hydro still has a significant role to play in delivering the minimum objectives, though the share of batteries has increased. This is due to changes to assumed pumped hydro lead times, reflecting the latest market information, along with build limits included in the model.

The long-duration storage element of the Development Pathway for NSW is set out in [Figure 21](#), which shows both capacity (MW) and energy (GWh) installed on a cumulative basis over the period 2024 to 2043. Results from Tender 3 have been captured. The Development Pathway is designed to meet the minimum objective of 2 GW and 16 GWh of long-duration storage capacity by 2030 and the overall objective of meeting the reliability standard.

Figure 21: NSW Cumulative long-duration storage pathway⁵⁰



While the pathway represents the lowest-cost approach, AEMO Services considers there are benefits in bringing forward the build of long-duration storage to mitigate deliverability risks, if it can be proved through LTESA tenders that these projects can be delivered either earlier or at a lower cost than currently assumed in the modelling. This was the case in Tenders 1 and 3. Similar decisions may be made in future tenders where AEMO Services considers this is appropriate in further addressing the deliverability risks associated with the construction of 2 GW and 16 GWh of long-duration storage infrastructure in the final years of the 2020s. This issue is considered further in the design of the 10-Year Plan (see [Section 4](#)).

With the entry of Snowy 2.0 in 2029-30, the Development Pathway then forecasts only a small amount of additional long-duration storage capacity being required beyond this once the minimum objective is achieved as shown in [Figure 21](#). This additional capacity is, however, of a longer duration and thus adds significantly to the energy storage available. This additional energy storage coincides with the exit of coal-fired generation from the NSW electricity system and any changes to the timing of these closures could see changes to the need for deeper energy storage.

The reliability assessment undertaken by AEMO Services in addition to co-optimised modelling, identified risks to the meeting of the reliability standard in the years 2025-26 and 2026-27 (described further in [Appendix A](#)). AEMO Services has not incorporated further long-duration storage into the Development Pathway as a risk treatment due to associated affordability and deliverability considerations. The NSW Government is continuing to consider the near-term risk to reliability and what, if any, additional actions may be appropriate in response.

⁵⁰ The long-duration storage development pathway was modelled prior to results from Tender 3 being available. The results have subsequently been included into this figure.

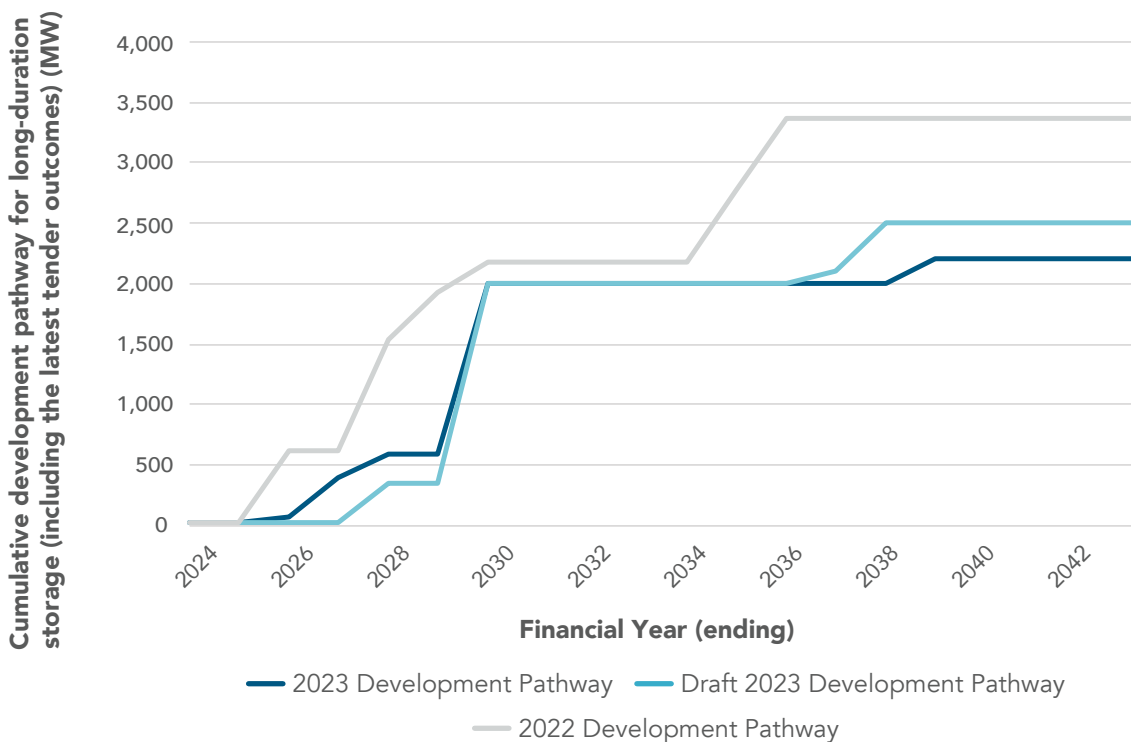
Comparison to prior IIO Reports

The long-duration storage element of the Development Pathway is broadly consistent with the Draft 2023 Development Pathway to 2030, with long-duration storage built late to meet the 2 GW and 16 GWh minimum objective by 2030 (Figure 22). The inclusion of outcomes from Tender 3 show capacity entering earlier when compared to the Draft 2023 Development Pathway. The share of pumped hydro projects to meet the 2 GW and 16 GWh minimum objective has decreased and been delayed relative to the Draft 2023 development pathway, reflecting latest market information about pumped hydro lead times as noted above.

Less long-duration storage is modelled to be constructed from 2038 than in the Draft 2023 development pathway. This is reflective of updated assumptions regarding the WACC along with increased capacity and duration of firming infrastructure.

Similar to the generation and firming development pathways, there remains some uncertainty as to needs of long-duration storage towards the end of the modelling horizon. For example, the Draft 2024 ISP considered a lower projection for distributed storage uptake in NSW to 2030, which is approximately 600 MW lower than what has been assumed to inform the Development Pathway. If this alternate assumption were to be adopted, additional firming or long-duration storage capacity may be required beyond 2030 to meet the infrastructure investment objectives.

Figure 22: Comparison of Development Pathway to 2023 Draft and 2022 Development Pathways (Long-duration storage)⁵¹



⁵¹ The long-duration storage development pathway was modelled prior to results from Tender 3 being available. The results have subsequently been included into this figure.

Explainer: The duration of storage used in meeting the reliability standard

A comparative assessment of the merits of constructing long-duration storage infrastructure and firming infrastructure to meet the reliability standard.

Under the EII Act, AEMO Services can plan for both the construction long-duration storage infrastructure and firming infrastructure to meet the reliability standard.

The minimum objective for the construction of long-duration storage infrastructure means that by the end of 2029, the Development Pathway includes at least 2 GW and 16 GWh of long-duration storage which will contribute to meeting the reliability standard. Where the 2 GW and 16 GWh of long-duration storage infrastructure is sufficient to meet the reliability standard, firming infrastructure is not required to meet this objective. Following the achievement of the minimum objective by the end of 2029, if additional firming or storage infrastructure is required to meet the reliability standard, long-duration storage could present a more cost-effective solution than other forms of firming infrastructure, depending on the duration of firming required.

AEMO Services notes that AEMO's 2023 Electricity Statement of Opportunities, published 31 August 2023, indicates that expected unserved energy is forecast to exceed the reliability standard in NSW in 2025-26.⁵² However, the Electricity Statement of Opportunities modelling incorporates existing, committed and anticipated projects and does not take account of the additional generation, long-duration storage and network infrastructure included in this report that is required to be constructed to meet the infrastructure investment objectives.

The 2023 Electricity Statement of Opportunities does test some of these elements in the sensitivities carried out, including the Actionable Transmission sensitivity, which shows expected unserved energy in NSW is forecast to meet the reliability standard until 2027-28. Transmission developments including HumeLink from 2027-28 and Hunter Transmission Project from 2028-29, as well as the expected commissioning of Snowy 2.0 in 2029-30, all help in improving unserved energy forecasts. The Federal and State schemes sensitivity shows the expected effectiveness of the developments from these schemes with the reliability risks falling within the reliability standard over the entire horizon.

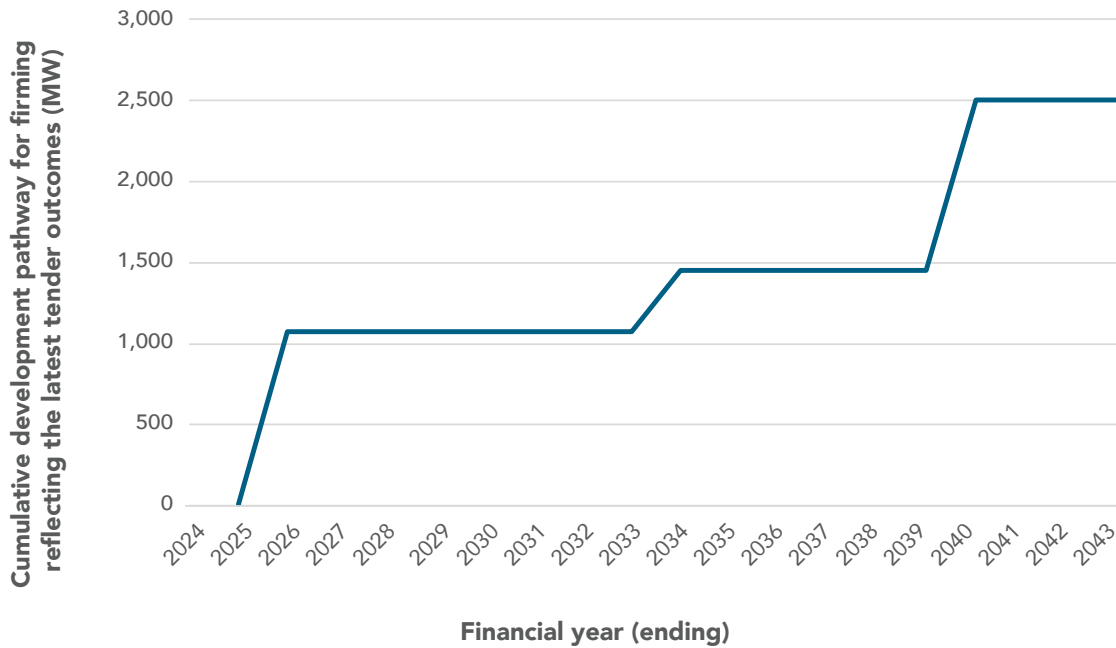
Based on this information, AEMO Services expects that if delivery of additional generation and long-duration storage infrastructure under the Roadmap and the firming tender outcomes occur by their target entry dates that will be sufficient to meet the reliability standard over the 10-year assessment horizon to 2033. AEMO Services considers, however, that there is a risk of a small gap in 2025/26 and 2026/27 where expected delivery of committed and anticipated projects are delayed and there is no additional future uptake of consumer energy resources. AEMO Services reliability assessment of these two scenarios is set out in Appendix A. Forecast reliability outcomes will continue to be monitored and any updates will be captured in future IIO Reports.

3.5 Firming infrastructure pathway

The firming element of the Development Pathway for NSW is set out in [Figure 23](#), which shows the cumulative capacity installed over the period 2024 to 2043, respectively.⁵³ It is designed to identify the construction of firming infrastructure that is necessary to meet the energy security target and the reliability standard, where it is expected that a firming infrastructure LTESA tender could achieve these objectives in any given year. The Consumer Trustee may only conduct a firming infrastructure LTESA tender where the Minister has directed it to do so.

The firming element of the Development Pathway consists of 1,075 MW in 2026 which is consistent with the outcomes of Tender 2, the results of which are discussed in [Section 2.5](#) of this report.

Figure 23: NSW Cumulative firming pathway reflecting the latest tender outcomes (including Tender 2)⁵⁴



After 2026, the firming element of the development pathway then also includes additional firming of 530 MW and 1,030 MW in 2034 and 2040 respectively to coincide with coal-fired power plants exiting the NSW energy system. The additional firming need identified in 2040 is consistent with the Draft 2023 IIO Report, while the 2034 need is identified as a new addition. Firming needs to meet the overall objectives are, however, sensitive to inputs, assumptions and methodology. Outcomes are thus highly uncertain over this timeframe and may differ between assessments.

AEMO Services will continue to closely monitor these requirements in the second decade of the Development Pathway, with regard to the mix and distribution of new capacity constructed and connected by various network infrastructure projects. If additional firming or storage infrastructure is required to meet the reliability standard, long-duration storage could present a more cost-effective solution than other forms of firming infrastructure, depending on the duration of firming required.

As noted above, the reliability assessment undertaken by AEMO Services in addition to co-optimised modelling, identified risks to meeting of the reliability standard in the years 2025-26 and 2026-27, which are described further in [Appendix A](#). AEMO Services has considered this risk in preparing the Development Pathway and has formed the view that planning for additional long-duration storage and firming infrastructure in this timeframe would not be appropriate. AEMO Services is of the view that it may be unfeasible and/or high-cost to NSW electricity customers to deliver additional long-duration storage by 2026 and has not received a direction to conduct any additional tender for firming infrastructure. It is understood the NSW Government is continuing to explore actions to address these near-term risks.

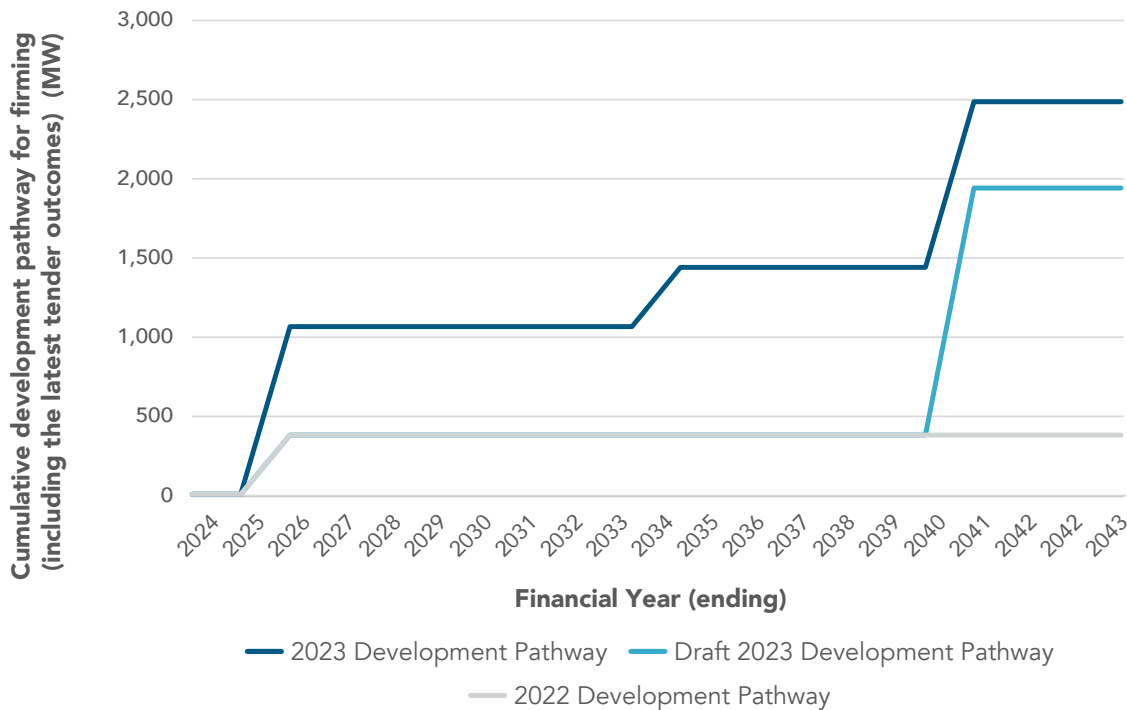
53 The design of the firming element of the Development Pathway is explained in section 3.3.2 of the 2022 IIO Report.

54 The firming development pathway was modelled prior to results from Tender 2 being available. The results have subsequently been included into this figure.

Analysis of the extent to which the energy security target is met under the Development Pathway, taking into account projects from AEMO Services' Tenders 2 and 3 shows no breach of the energy security target where these projects are assumed to be delivered on time. AEMO Services' analysis of both the extent to which the reliability standard and energy security target under the Development Pathway are met is further described in [Appendix A](#).

AEMO Services is not able to conduct competitive tenders for LTESAs to support firming infrastructure in the absence of a direction from the Minister.⁵⁵ As at the date of this report, no such direction has been given (other than the August 2022 direction to conduct the Q2 2023 tender scheduled via the 2022 IIO Report).

Figure 24: Comparison of Development Pathway to 2023 Draft and 2022 Development Pathways (Firming)⁵⁶



Explainer: The location of infrastructure and meeting reliability needs

Under the EII Act, firming infrastructure is required to meet the energy security target and the reliability standard. Location impacts the ability of a project to contribute to meeting future reliability needs considered by these metrics.

AEMO looks at each sub-region in assessing whether forecast available firm capacity provides an energy security target surplus/breach. Major constraints on intra-regional transmission infrastructure between the outer and inner sub-regions of New South Wales are also considered and in instances where they exist, discounts are applied to the firm capacity.

AEMO Services has considered the importance of infrastructure location in conducting tenders for firming and long-duration storage infrastructure. In the firming tender, projects not located in the Sydney-Newcastle-Wollongong sub-region were required to demonstrate their contribution to meeting the requirements of the energy security target considering transmission constraints. When assessing long-duration storage projects, AEMO Services also considers a projects' location in addition to capacity and duration with regard to their capability to reduce unserved energy.

⁵⁵ EII Act, section 47(2).

⁵⁶ The firming development pathway was modelled prior to results from Tender 2 being available. The results have subsequently been included into this figure.

3.6 Network infrastructure to support the pathways

The Development Pathway is a plan for the construction of generation, long-duration storage and firming infrastructure. The EII Act does not establish infrastructure investment objectives for the construction of network infrastructure. Transmission and distribution network infrastructure will, however, be critical to facilitating the development of new renewable generation and long-duration storage infrastructure. Accordingly, AEMO Services has considered how the existing network, and augmentations to the existing network, might best support the delivery of the Development Pathway.

The model is able to select network infrastructure options for NSW REZs and downstream capacity (including the additional network capacity delivered by the option) based on the earliest delivery date and cost in these assumptions. The network co-optimisation in this report is primarily focussed on optimising the timing of major NSW REZ network augmentations. At a local level, this new network construction can be complimented with the use of existing network capacity. Opportunities associated with existing network capacity are explored further in this section.

In addition to NSW network infrastructure required to support the 20-year development pathway, significant transmission build and upgrades are occurring within and between other NEM jurisdictions to ensure the broader system's operation. The Draft 2024 ISP provides further commentary on the broader energy system and presents a range of scenarios and sensitivities capturing longer term risks and uncertainties, including considerations on supply chain, social licence, market maturity and the speed of decarbonisation and electrification.

3.6.1 New network infrastructure

The modelling for this report involved producing an optimal combination and set of timings for new network infrastructure.

REZ and priority transmission infrastructure network projects under the EII Act

The REZ and priority transmission infrastructure network projects that have been co-optimised with generation and storage infrastructure as part of the modelling that underpins the Development Pathway are set out in [Table 4](#) below.^{57, 58} These options (i.e. their technical configurations and the network capacity they enable) and their estimated capital costs were provided by EnergyCo in July/August 2023, along with other projects for consideration.

Based on EnergyCo's inputs from July/August 2023, the estimated total capital costs (excluding construction finance, and contingency costs) of the network projects in [Table 4](#) amount to \$14.3 billion (in real 2022 dollars), which equates to \$9.6 billion in present value terms.⁵⁹ These costs do not reflect latest market information on transmission infrastructure costs from the Central-West Orana REZ network operator tender, exclude contingency costs and are therefore likely underestimated. Further the profile of costs may not reflect the profile of cost recovery which will only be known once the Central-West Orana tender concludes. These costs therefore may not align with transmission costs included in contribution determinations expected to be published by the Australian Energy Regulator in mid-2024.

The network infrastructure projects underpinning the Development Pathway listed in [Table 4](#) do not include augmentations in the South West REZ. The model is able to first utilise existing capacity in this REZ from the delivery of Project EnergyConnect, HumeLink and VNI West. The model did not select augmentations additional to these projects that are proceeding under the NER framework.

57 Table 4 sets out the optimal options and timings under the Central scenario. See Sections 3.8 and 5 for further discussion regarding the scenarios modelled for this report.

58 Additional network projects may be required to facilitate the connection of certain pumped hydro projects if they are developed. These are set out in EnergyCo's Network Infrastructure Strategy. The modelling for this report included simplified representations of the costs associated with such network projects as an uplift to the connection costs of candidate pumped hydro projects.

59 This figure is derived by discounting estimated costs from the modelled delivery date to 2023-24 using a 7% discount rate.

Table 4: REZ network and priority transmission infrastructure projects underpinning the Development Pathway

Project	Description	Optimal timing under Development Pathway
Waratah Super Battery	New battery with system integrity protection scheme and associated minor network augmentation, to improve transfer limit between Central NSW and Sydney-Newcastle-Wollongong.	2025-26*
Hunter Transmission Project	A 500 kV transmission upgrade to reinforce supply to Sydney, Newcastle and Wollongong load centres.	2027-28*
New England Option 1A	Construction of new 500 kV transmission line from Bayswater to a new Central South hub. Cut into existing Tamworth to Armidale Line to create a new Central hub. New 330 kV lines from Central hub to create Northern and Eastern hubs as well as creating a connection to the Central South hub. Utilisation of Phase Shifting Transformers. Additional network capacity of 2,400 MW delivered.	2029-30
New England Option 2A	Building on New England Option 1A, enables an additional 3,700 MW of network capacity through operating lines at higher voltage and installing or expanding associated infrastructure. New 500 kV line built from Central Hub to Bayswater. Cut North Hub into the existing Armidale to Sapphire line. Utilisation of Phase Shifting Transformers.	2031-32
New England Option 3A	Building on New England Option 2A with further upgrades to existing lines and the creation of a new Southern hub with a 330 kV line connecting it to the Central South hub. A further 500 MW of capacity is delivered.	2033-34
New England Option 5A	Building on New England Option 3A with further upgrades to existing lines and installing or expanding associated infrastructure delivering an additional 1,400 MW of capacity.	2036-37
Central-West Orana Option 1	New 500 kV and 330 kV transmission lines from the existing network at Wollar to Merotherrie, with extensions to Elong Elong and Uarbry to enable the delivery of 4,500 MW of additional network capacity.	2027-28
Central-West Orana Option 2	An increase to the operating voltage from 330 kV to 500 kV between Merotherrie and Elong Elong. This will support an additional 1,500 MW of network capacity.	2036-37
Central-West Orana Option 3	New 330 kV extension from Elong Elong through Uungula to Burrendong adding a further 1,630 MW of additional network capacity.	2040-41
Hunter-Central Coast Option 1	Upgrades to existing networks in the Upper Hunter and new lines to new substations east and/or west of Muswellbrook. This will support an additional approximately 1,000 MW of network capacity.	2026-27

*The timing of Waratah Super Battery and Hunter Transmission Project were input assumptions aligned with the 2023 IASR.

Figure 25 below sets out the generation enabled in each renewable energy zone identified by the modelling process. This figure demonstrates the importance of both:

- Timely development of transmission infrastructure, and
- The importance of geographic diversity of renewable energy zones in enabling wind generation with diverse resource profiles to minimise costs to customers.

Geographic diversity in REZ locations provides further benefits not captured in the model including improving system security and resilience, mitigating delivery risk and promoting inter-REZ competition for LTESAs.

Figure 25: New entrant VRE generation by REZ



Information in this report on REZ network and priority transmission infrastructure projects is intended to help inform EnergyCo in its role as Infrastructure Planner in NSW.

Network infrastructure recommendations under the EII Act

The EII Act provides a framework for the development, construction, operation and cost recovery of new network infrastructure projects,⁶⁰ outside of the usual NER process. EnergyCo – in its capacity as the Infrastructure Planner for the five REZs specified in the EII Act – is responsible for assessing and making recommendations to AEMO Services about REZ network infrastructure projects.⁶¹ AEMO Services must consider EnergyCo’s recommendations and decide whether to authorise a network operator to carry out such a project.⁶²

The Central-West Orana REZ will soon be considered for authorisation. For the purposes of IIO Report modelling, the CWO REZ has been assumed to be available from 2027-28 (and as shown above in Table 4). A formal decision on the authorisation is expected in 2024, and future modelling will be guided by that decision.

In respect of priority transmission infrastructure projects, EnergyCo makes recommendations to the Minister, and the Minister may decide to authorise or direct a network operator.⁶³

EnergyCo in its future decision making uses this report as one input which is considered alongside other factors in setting out its plans for the development and delivery of network projects. Like generation, as transmission projections move further into the future, uncertainty increases. The needs of the electricity system in the final years of the modelling horizon will continue to be reviewed and addressed in future IIO Reports.

60 See EII Act, Part 5.

61 EII Act, section 30(1).

62 EII Act, section 31(1).

63 EII Act, sections 32(1) and 36(2).

Other relevant network infrastructure projects

In addition to network projects that are expected to be delivered under the EII Act framework, the Development Pathway also requires the completion of the network projects set out in [Table 5](#) below. These projects are either currently under construction or were listed as Actionable or Future projects in AEMO's 2022 ISP and are being delivered under the NER framework for transmission investment.

Table 5: Current, actionable or future ISP projects underpinning the Development Pathway

Project	Description	Assumed timing
Project EnergyConnect	A new 330 kilovolt (kV) double-circuit interconnector between South Australia and New South Wales.	2026-27
HumeLink	A 500 kV transmission upgrade to connect the Greater Sydney load centres to Project EnergyConnect and the Snowy Mountains Hydroelectric Scheme.	2028-29
VNI West	A new 500 kV double-circuit transmission line to connect Western Renewables Link (north of Ballarat) with Project EnergyConnect, which will increase network capacity between NSW and Victoria, provide greater access to Snowy 2.0's deep storage and support new VRE in Victorian REZs.	2031-32
QNI Connect	A new 330 kV double-circuit line (one circuit strung) from locality of Armidale South to Dumaresq to Bulli Creek to Braemar, which will enable >1 GW of transfer capacity between southern Queensland and the New England REZ.	2032-33

3.6.2 Existing Network Infrastructure

Hosting capacity on the distribution network

Whilst the IIO focuses on development of the high-voltage network, there are also development opportunities at the mid- and low-voltage level networks across NSW. This is the case for generation and storage both above and below the 30 MW and 5 MW size thresholds required to participate in generation and firming infrastructure LTESA tenders, respectively.

The market model which underpins this IIO Report uses a simplified network topology and only optimises for infrastructure expansion along high voltage networks. Whilst this is a prudent approach to long-term system planning, it does not capture opportunities that exist in the mid- and low-voltage networks.

Utilisation of existing distribution networks will contribute to the 2030 minimum objectives and will not be subject to risks associated with the delay of new transmission infrastructure.

EnergyCo is engaging in joint planning with existing network service providers to identify potential minor upgrades to existing networks to release additional capacity.

Shadow REZ

The Shadow REZ is a concept established in the 2020 ISP which allows the model to 'build' VRE in parts of the network which are not the 'AEMO REZs' and are instead in close proximity to brown-field sites. In NSW, the Shadow REZ is defined as the area surrounding the 500 kV line between Mt Piper and Bayswater (close to CWO REZ and with relatively good access to load centres). In the Draft 2023 IIO Report the HCC REZ was included in modelling in place of the 2022 ISP NSW Shadow REZ.

The final 2023 IASR has updated assumptions for the NSW Shadow REZ and AEMO Services has aligned with these assumptions and included the Shadow REZ in the modelling completed for this report. In this IIO Report the model has not selected generation infrastructure in the shadow REZ under the central scenario, however it has under the Infrastructure Delay scenario to ensure the generation minimum objective is achieved.

Forestry NSW tender

In 2021, NSW Parliament amended the Forestry Act 2012 to enable renewable energy infrastructure to be established in on the State-owned softwood plantation estate. There are around 225,000 hectares of State forest pine plantations in NSW with four locations having been identified near existing energy infrastructure where the operation of renewable energy infrastructure could be compatible with activities carried out by the Forestry Corporation.⁶⁴ An Expressions of Interest (EOI) process was completed during 2022 with over 94 submissions being made. In 2023 shortlisted proponents were invited to submit formal proposals. Any suitable proposals will receive a permit, which will allow the provider to commence more detailed studies to assess project viability.

3.7 Testing the Development Pathway

AEMO Services explicitly tests the Development Pathway for outcomes related to affordability, reliability and resilience to lulls in variable renewable energy sources. The results of this analysis are discussed below, including considerations AEMO Services may take into account in future decisions.

This section and the following shows how the Development Pathway will contribute to the objects of the EII Act – to improve the affordability, reliability, security and sustainability of electricity supply. Additional discussion, including scenario analysis and emissions profiles, is provided in [Section 3.8](#).

3.7.1 Costs of the pathway for NSW electricity customers

AEMO Services seeks to deliver value for customers through setting a Development Pathway that minimises customer costs and informs AEMO Services in setting 10-year plans to support investor certainty. In preparing the Development Pathway, AEMO Services has prepared a 10-year forecast of the costs of providing wholesale energy services to NSW customers.

Approach to forecasting costs

Given the multitude of variables inherent in the modelling, it is impossible to accurately forecast precise market conditions and resulting wholesale electricity costs or scheme costs over a 20-year period. With this in mind, and to provide more meaningful information, cost forecasts have been prepared over a 10-year horizon in line with the timeframe of the 10-Year Plan. Cost forecasts are prepared to aid in providing an understanding of the impact of different factors on customer costs.

Estimates of costs for the supply of wholesale energy services to NSW electricity customers involves considering:

- wholesale electricity costs, and
- ‘scheme costs’, being the following costs associated with the scheme established by the EII Act:
 - costs associated with payments made under LTESAs to generation, long-duration storage and firming infrastructure projects,
 - costs of network infrastructure that is delivered under the EII Act, and
 - costs for administration associated with Scheme entities including the consumer trustee, financial trustee, infrastructure planner and regulators (AER and IPART).

⁶⁴ More information is available from the Forestry Corporation of NSW at: forestrycorporation.com.au/sustainability/renewable-energy

These different cost components, which are included in AEMO Services' forecast, are defined in [Table 6](#).⁶⁵

Table 6: Cost components included in forecast of costs for provision of wholesale energy services to NSW customers

Cost type	Description	Cost recovery mechanism
Wholesale electricity costs	The wholesale electricity purchase costs to NSW customers (assuming that spot prices reflect contract prices). This is calculated by multiplying the load-weighted average of NSW spot prices by NSW region operational demand.	Via retailers
Scheme (LTESA) costs⁶⁶	<p>Generation LTESA liabilities – A proxy for the total net cost paid by the Scheme Financial Vehicle⁶⁷ under LTESAs for generation projects. Consistent with the Draft 2023 IIO Report this has been calculated as the difference between total levelised cost of energy (LCOE) and revenue for each unit. This is effectively a representation of the 'missing money' required by each unit to breakeven on its costs. This is only considered for projects with greater costs than revenues across their economic life. For Generation units, revenue includes the wholesale electricity market revenue and the Large-Scale Generation Certificate⁶⁸ (LGC) revenue.</p> <p>This approach is a simplified approach that does not reflect the manner in which AEMO Services expects proponents to bid for and exercise the LTESA options. In reality, the LTESA provides flexibility for projects to maximise revenues and AEMO Services' competitive tender process ensures the LTESA is bid to a more efficient strike price than total levelised costs.⁶⁹</p> <p>Long-duration storage LTESA liabilities – A proxy for the total net cost paid by the Scheme Financial Vehicle under LTESAs for long-duration storage projects. For the purposes of this report, this has been calculated using the same method as outlined above for generation LTESAs. For Long-duration storage units, revenue includes the wholesale electricity market revenue with a 15% revenue uplift to reflect other revenue streams.⁷¹</p> <p>Firming LTESA liabilities – A proxy for the total net cost paid by the Scheme Financial Vehicle under LTESAs for firming projects. For the purposes of this report, this has been calculated using the same method as outlined above for generation LTESAs. For Firming units, revenue includes the wholesale electricity market revenue with a 30% revenue uplift to reflect other revenue streams.⁷²</p>	Via distribution network service providers under the EII Act contribution determination process. ⁷⁰

65 In addition to these cost categories, contributions under section 58 of the EII Act may also cover costs of the entities appointed under the EII Act to exercise functions related to the Roadmap. The Australian Energy Regulator published its first contribution determination in February 2023, which includes amounts for administrative costs from 2022-23 to 2025-26. <https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/cost-pass-throughs/nsw-electricity-infrastructure-fund-2023%E2%88%9224-contribution-determination/decision>

66 For an illustration of Scheme LTESA costs see the 2023 Draft IIO Report pages 35-37.

67 The Scheme Financial Vehicle is established under the EII Act to fund key activities of the Roadmap and collects contributions from NSW distribution network service providers.

68 For Generation-eligible LTESA projects, revenue earned from LGCs was considered. The LGC assumptions were derived from the Mercari LGC forecast to 2026, followed by a linear decrease to \$15 in 2030, followed by \$0 from 2031 onwards. The \$15 LGC value in 2030 reflects the continuation of high demand currently observed in the market caused by voluntary surrendering. The \$0 value from 2031 onwards reflects the conclusion of the Large-scale Renewable Energy Target (LRET) scheme.

69 Learn more about the LTESA product on the AEMO Services website <https://aemoservices.com.au/products/ltesa>

70 See EII Act, Part 7.

71 For Long-Duration Storage and Firming LTESA-eligible projects, multiple additional revenue streams were considered. The FCAS markets and cap contract markets are two primary revenue streams analysed in the development of this assumption. Other existing, future and potential markets were also considered, such as capacity credits, portfolio optimisation, Fast Frequency Response (FFR) markets and inertia markets. Given the inherent uncertainty surrounding these markets, a simplified and bundled assumption was made, noting that each revenue stream is highly dependent on project qualities such as size, location and technical characteristics. A revenue uplift of 15% and 30% on wholesale revenues has been assumed for all Long-Duration Storage and Firming-eligible projects respectively in the calculation of Scheme (LTESA) costs. These assumptions are believed to be conservative in nature and aims to increase the accuracy of Scheme (LTESA) costs. They were derived from analysis provided through Aurora Energy Research Q4 2022 Flexible and Storage Market report.

72 See footnote 68.

Scheme (Transmission) costs	EII Act network infrastructure – The annualised capital costs (reported for 20 years only) of new ‘REZ network infrastructure projects’ or ‘priority transmission infrastructure projects’ (as defined under the EII Act) that are funded by the Scheme Financial Vehicle. The capital costs are annualised over their economic lifetime ⁷³ using a 3.04% ⁷⁴ rate of return, noting that the Development Pathway only reports on a 20-year period. This simplified approach utilises class 5b estimates on capital costs of transmission projects provided by EnergyCo, and makes theoretical simplified assumptions on how these are recovered by customers over time. It excludes construction finance and considerations of depreciation.	Via distribution network service providers under the EII Act contribution determination process ⁷⁵
Scheme (Administration) costs	Administration costs – A proxy for the total administration expenses of the Roadmap. ⁷⁶ For the purposes of this report forecast administration expenses as contained in the AER’s NSW Electricity Infrastructure Fund 2023–24 contribution determination ⁷⁷ are used as an estimate for future administration expenses.	Via distribution network service providers under the EII Act contribution determination process ⁷⁸

As shown in [Figure 26](#), the Roadmap passes on scheme costs via distribution charges. The Scheme costs arising from the Roadmap are intended to give rise to reductions in the wholesale price. That is, without the Roadmap, there would be no scheme costs but wholesale costs would rise (at a greater rate than scheme costs).

It is important to note that these costs do not represent all cost components that appear on an electricity customer’s bill and instead seek to quantify those cost elements included in the IIO Report as outlined in further detail below. Costs estimated in this report specifically exclude NSW’s distribution network and Transgrid’s transmission network costs which are both regulated under the NER. Retail charges and other environmental charges are also excluded and therefore do not form part of the cost estimates provided within this section of the report.

73 Assumed to be 50 years in line with AEMO’s assumptions in the ISP.

74 Aligned with The regulated WACC from the Final Decision Transgrid transmission determination 1 July 2023 to 30 June 2028. See Table 12 for all WACC assumptions and rationale.

75 See EII Act, Part 7.

76 This is a new addition following the release of the initial 2023-24 AER Contribution Determination which includes information on administration costs. This includes costs incurred by the consumer trustee, financial trustee and regulators in exercising their functions under the EII Act s. 55(b). The infrastructure planner may also recover administration costs through alternative pathways, such as on the basis of access scheme declarations or approval under section 66(4) of the EII Act.

77 [Australian Energy Regulator Contribution Determination for 2023-24 Gazette Notice.pdf \(aer.gov.au\)](#) page 7.

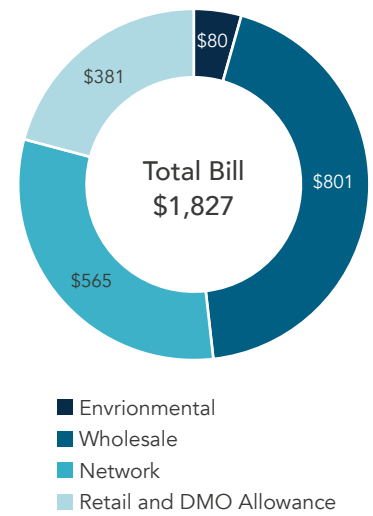
78 See EII Act, Part 7.

Figure 26: Components of Customer Bill Modelled in IIO Reports

The IIO consumer costs exclude a number of elements that get captured on a customer’s retail electricity bill.

Consumer bill cost item	Typical portion	Modelled in the IIO	Directly impacted by NSW Roadmap
Wholesale	≈ 45%	Yes	Yes, decreases
Network:		Scheme (Transmission, LTESA and Admin) costs included in distribution charge	Yes, distribution component increases with Scheme costs
<ul style="list-style-type: none"> Transmission Distribution Metering 	≈ 30%		
Environmental policies:			
<ul style="list-style-type: none"> LRET SRET Jurisdictional schemes Efficiency schemes 	≈ 5%	No	No
Retail and DMO Allowance	≈ 20%	No	No

Indicative Breakdown of Customer Bill Ausgrid Default Market Offer no control load



Breakdown can vary over time and by region

Information based on Ausgrid figures from the AER Default market offer prices 2023–24 Final determination.

Forecast costs for the supply of wholesale energy services

The results of the modelling for this report indicate that the present value of total costs (in real 2022 dollars)⁷⁹ for the supply of wholesale energy services⁸⁰ to NSW electricity customers is \$49.6 billion over the 10-year horizon to 2033. Costs beyond the 10-year horizon AEMO Services uses for tender planning are subject to high levels of uncertainty.

An annual breakdown of forecast wholesale and scheme costs, in real terms, is set out in [Figure 27](#).

This shows scheme costs related to LTESA payments becoming material as they help to drive down wholesale electricity costs. These costs represent a proxy estimate for a simplified contractual mechanism that does not necessarily represent the innovative design and use of the LTESA that is emerging from the tender approach. Due to a simplified approach, annual costs are subject to a high degree of uncertainty but the total forecast costs over 10 years is expected to represent a reasonable estimate.

These increased forecast LTESA costs also reflect updated assumptions about the forecast WACC for generation and storage projects which have more than doubled since the draft report. The revised WACC assumptions seek to reflect up to date market conditions and have been informed through a range of evidence including a survey of debt and equity providers. While these increased WACC assumptions reflect latest market conditions, they are highly uncertain in the context of long-term cost forecasting and may reduce again over time due to technology innovations and eased supply chain constraints.

The costs presented in this report consider the modelled wholesale price outcomes which arise where the development pathway is delivered, and the implications these could have on scheme costs under the Roadmap. Modelled wholesale prices reflect assumed bidding behaviour⁸¹ and marginal pricing⁸² of both new and existing generators which in total will be higher than the capital costs of new delivered infrastructure alone. Accordingly, there are differences in the costs forecast in this report and those forecast in other publications which report on system costs, such as AEMO’s Draft 2024 ISP.

79 The present value of the cost forecast is in real 2022 dollars, calculated by discounting costs to the first modelling year (2023-24) at a real discount rate of 7% (consistent with the discount rate in AEMO’s 2023 IASR).

80 Wholesale energy services include wholesale electricity costs, system strength, Roadmap transmission and LTESA costs. It does not include distribution or retail costs.

81 Including assumptions on short-run marginal costs.

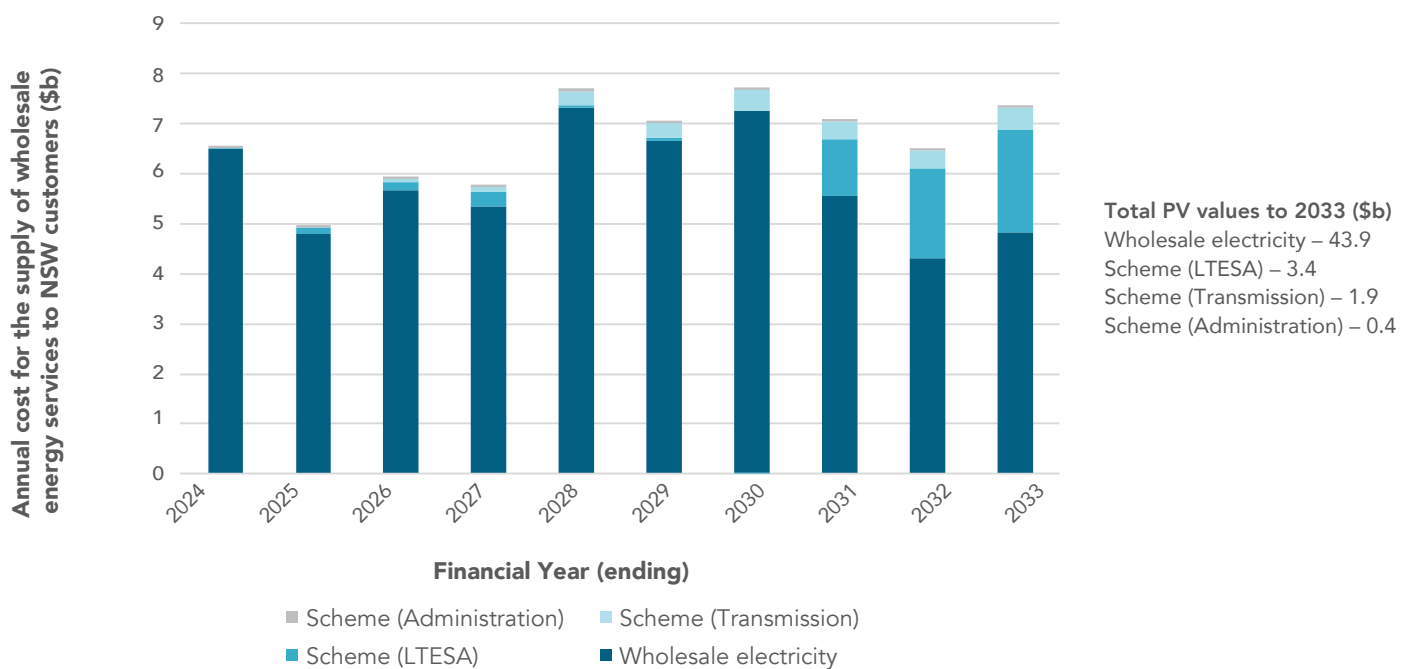
82 Where the highest-bid dispatched generating unit sets the price for all other dispatched units every dispatch interval.

As a general rule, higher wholesale costs are associated with generator retirements and/or higher demand. Lower wholesale costs are generally associated with new investment in generation and/or transmission capacity. Differences in the timing, amount, and mix of generation along with the timing of transmission entering have driven differences in the wholesale prices between the Draft 2023 IIO Report and those presented above. For example, higher wholesale electricity costs seen at the end of this decade are being driven by changes in REZ timings, lower entry of renewable generation through the NEM wide supply chain constraint implemented for this report, and a change in technology mix where more solar is built in initial years as a result of the limited availability of wind in the near-term development pipeline.

As noted above, transmission costs included in the forecast costs do not reflect latest market information from the Central-West Orana REZ network operator tender which will reveal further cost information particularly about the cost of network infrastructure projects including contingency, financing costs and the profile of cost recovery over time. These forecast of transmission costs in this report are therefore unlikely to align with transmission costs included in contribution determinations expected to be published by the Australian Energy Regulator in mid-2024.

Scheme administration costs, whilst they make only a small contribution to the overall estimated costs, are being incorporated into the report for the first time in response to stakeholder feedback on the draft 2023 IIO report.

Figure 27: Forecast of annual costs for the supply of wholesale energy services to NSW electricity customers (2024-2033 total \$b)



Other Roadmap estimates of costs and benefits to customers

The approach taken by AEMO Services for estimating scheme costs over a 10-year horizon in this report varies from the contribution determination which is completed by the AER.⁸³ The AER’s contribution determination process is an annual determination conducted over a three-year time horizon and is based on a detailed build-up of revenues and expenditures as well as considering liquidity requirements of the Scheme Financial Vehicle. The purpose of this determination process is to allow the Scheme Financial Vehicle to be able to recover costs paid through payments from the NSW distribution network service providers.

Further, the forecast costs set out in this section of the report need to be compared to the costs that would have otherwise been borne by customers in the absence of the NSW Electricity Infrastructure Roadmap. The NSW Government is undertaking modelling to provide an update on customer benefits of the infrastructure that is planned to be enabled by the Roadmap. This modelling is undertaken as a separate exercise to the modelling for this report but uses a comparable set of input assumptions. The results of this modelling are expected to provide information on the total costs for providing wholesale energy services to NSW electricity customers in a “no Roadmap modelling” scenario (i.e. with a different development pathway for generation and network infrastructure).

83 For further information on the approach see the AER’s NSW contribution determination guideline (2022) [NSW contribution determination guideline \(2022\)](https://www.aer.gov.au/publications-and-reports/contribution-determination-guideline-2022).
[Australian Energy Regulator \(aer.gov.au\)](https://www.aer.gov.au)

3.7.2 Reliability assessment

The model used for the IIO Reports includes an objective in the capacity expansion modelling to meet a proxy for the reliability standard, including minimum reserve levels and the inclusion of the Value of Lost Load (VoLL) to ensure sufficient capacity enters to meet demand. For this 2023 IIO Report, additional detailed analysis was conducted as part of the modelling process to confirm both the reliability standard and energy security target are met under the Development Pathway. Results of this analysis show no gap against these measures where the development pathway is delivered, however AEMO Services is of the view that there remains a risk to reliability outcomes in the medium-term when taking a more conservative view. The outcomes of this analysis are described in more detail in [Appendix A](#).

3.7.3 Resilience to VRE lulls

As the share of VRE in the NSW electricity system increases, the impact of weather patterns becomes increasingly important. As part of our planning function, AEMO Services is focused on ensuring our development pathway is resilient to VRE lulls.

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 VRE sources, as it relates to the Development Pathway, including by reference to climate modelling.⁸⁴

As set out in [Appendix B](#), the Consumer Trustee's analysis indicates that the Development Pathway maintains resilience to various severities of VRE lulls. This resilience is driven by the diversity of VRE capacity, increased transmission and increased LDS and firming capacity.

The VRE lulls do nonetheless materially increase NSW wholesale prices and increase reliance on hydro generation, gas generation and imported energy from other regions. AEMO Services also notes that this analysis relies on many assumptions with inherent uncertainties that could impact the Development Pathway's resilience.

⁸⁴ EII Regulation, clause 24(2)(e).

3.8 Alternative infrastructure delay scenario

There is significant uncertainty inherent in the complexities of the energy transition for the electricity sector and challenges associated with meeting broader net zero emissions objectives across the economy. In preparing the Development Pathway, AEMO Services has tested uncertainties around infrastructure delay through modelling an additional alternative scenario to the central case. This section outlines the alternative scenarios considered and key insights from the analysis, which shows that delays to key infrastructure and capacity builds are material for NSW electricity customers. AEMO Services will use insights from scenarios to inform its tender processes.

3.8.1 Scenario descriptions

2023 IIO Report scenarios

AEMO Services has modelled two scenarios to inform the 2023 IIO Report: the central scenario and an alternate scenario to test the impact of infrastructure delay. The intent of this Infrastructure Delay scenario is to enable AEMO Services to identify the implications of the changed assumptions under this sensitivity in a way that can support it to pivot its planning if required. The scenario also provides valuable information regarding the resilience of the Development Pathway.

This is a different approach to that taken to the Draft 2023 IIO Report that previously considered four scenarios, including a significantly different future considered through a 'No Coal by 2030 with Strong Electrification' scenario. AEMO Services considers that the revised approach for this report is better aligned to the purposes of this report, which is principally to inform the conduct of AEMO Services tenders for LTESAs. The two scenarios considered in this 2023 IIO Report can be broadly described as follows:

- **Central scenario:** Consistent with the Draft 2023 IIO Report, this scenario largely aligns with the 'Step Change' scenario in AEMO's 2022 ISP, the scenario that energy industry stakeholders considered most likely to eventuate.⁸⁵ This scenario demonstrates action on climate change at transmission and distribution levels, including substantial consumer energy resources. The scale of electrification across all sectors is high, with relatively fast commitments made by industry and customers to reduce emissions levels where alternative energy sources exist. The central scenario underpins the Development Pathway in this report.
- **Infrastructure Delay:** This pathway builds on the transmission delay sensitivity included in the Draft 2023 IIO Report. It considers delays occurring to transmission, gas and pumped hydro projects. Delays to gas and pumped hydro occur in recognition of the fact that these technologies have smaller project pipelines compared to wind, solar and battery storage and are therefore more at risk if individual projects experience delays. This scenario uses the same assumptions as the central scenario described above, except that:
 - key ISP and Roadmap network projects are delayed by 1 year, from their assumed completion or earliest entry date (in the case of REZ infrastructure) in the central scenario, and
 - gas generation and pumped hydro lead times, including Snowy 2.0, are delayed by 1 year.

This alternate scenario seeks to identify the costs and risks of underbuilding infrastructure and provides insights into how the risk of delays to transmission, gas and pumped hydro can be mitigated.

85 2022 ISP, section 2.3.

AEMO's 2024 ISP Step Change scenario

As noted above, the central scenario represents a departure from AEMO's Draft 2024 ISP with respect to some important inputs. This includes differences in assumptions including in relation to demand forecasts and government policies, as detailed further in [Section 5.2](#). Importantly, the Draft 2024 ISP adopts a scenario that includes additional jurisdictional policies as its most likely scenario based on the scenario weightings it has used. These additional policies since the 2022 ISP include updates to the Victorian and Queensland renewable energy targets along with the Australian Government's Powering Australia plan.

Policy mechanisms are subject to change as implementation pathways are resolved, which creates some uncertainty in terms of modelled outcomes that AEMO Services must consider in preparing the Development Pathway in the long-term financial interest of NSW electricity customers. To rely on policy from other states creates a dependency, as some electricity infrastructure policies may increase the amount of infrastructure required in NSW while others may decrease modelled construction. Similarly, the Australian Government's Powering Australia plan calls for additional capacity across the NEM, including in NSW. AEMO Services understands bilateral agreements are being worked through between the federal and state governments which will shape future activities to meet capacity targets.⁸⁶

AEMO Services did not adopt these additional announced policies in the central scenario as, at the time of preparing this report, it considered that this would not be consistent with its particular planning role as NSW Consumer Trustee. This is because under the EII Act NSW electricity customers pay the costs which arise under LTESAs. It is possible that adopting these policies in AEMO Services planning would change the amount and timing of capacity in the Development Pathway. If AEMO Services were then to reflect this in its 10-year plan it may result in costs to NSW customers through LTESAs. Therefore, given the implementation mechanisms for these policies are still being settled as noted above and in the context of its specific statutory role to plan in the long-term financial interest of NSW electricity customers, AEMO Services has decided to not incorporate these policies in its central scenario at this time.

3.8.2 Scenario outcomes

AEMO Services has modelled the two scenarios to produce separate pathways representing a least-customer cost build trajectory to meet both the minimum infrastructure investment objectives and the overall objectives as outlined in [Section 2](#) of this report. The different build trajectories for each infrastructure type across the two pathways are discussed below, including analysis of each of the trajectories in terms of costs, carbon emission profiles and network infrastructure.

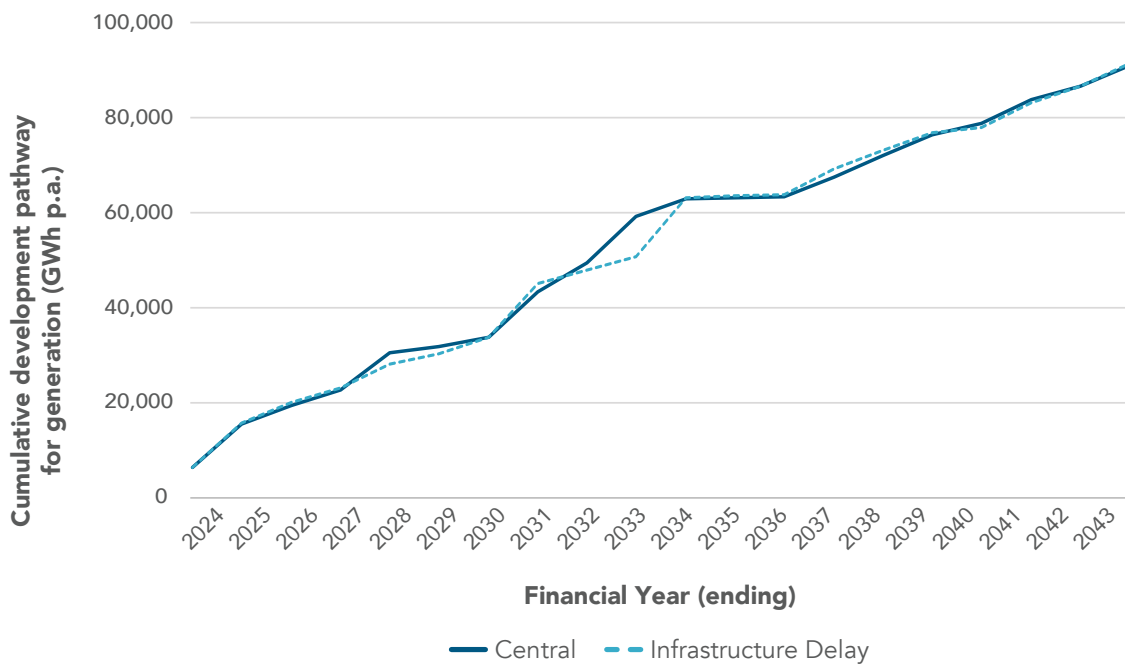
The Infrastructure Delay scenario is not considered the 'most likely' and therefore does not represent the formal development pathway, but rather, is used to represent how AEMO Services may choose to pivot tender plans were certain conditions to eventuate. The scenario represents a plausible set of circumstances to plan for, given that material delays to infrastructure delivery continue to be observed.

⁸⁶ Energy Ministers agreed that the Commonwealth and respective state and territory governments will work in partnership to negotiate bilateral Renewable Energy Transformation Agreements (RETAs) under the National Energy Transformation Partnership (NETP). Energy and Climate Change Ministerial Council meeting communiqués available at: energy.gov.au/government-priorities/energy-and-climate-change-ministerial-council

Generation infrastructure

The build trajectories for generation infrastructure under the two scenarios are set out in [Figure 28](#).

Figure 28: Comparison of alternative development pathways (generation)

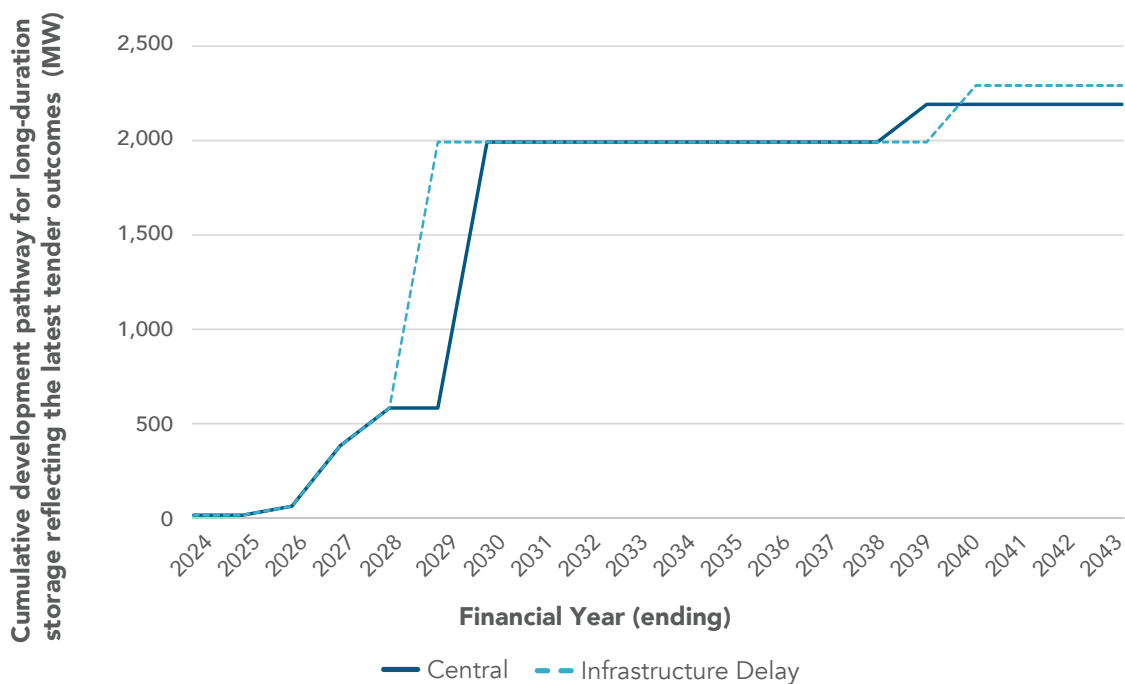


The trajectory of the two scenarios over the period to 2030 is very similar owing to the limited degrees of freedom to meet the minimum objective by 2030 given the existing pipeline. Under the Infrastructure Delay scenario there is some limited variation over this period, and after 2030 with generation infrastructure development lagging compared to the central scenario due to the delayed completion of enabling REZ and non-REZ transmission infrastructure.

Long-duration storage infrastructure

The build trajectories for long-duration storage infrastructure under both scenarios are set out in [Figure 29](#).

Figure 29: Comparison of alternative development pathways (long-duration storage)⁸⁷



⁸⁷ The long-duration storage development pathway was modelled prior to results from Tender 3 being available. The results have subsequently been included into this figure.

The build trajectories across both scenarios for long-duration storage are anchored by the minimum objective for 2030, with some limited variation up until this time and further limited variation in the late 2030's and early 2040's.

Under the Infrastructure Delay scenario, the need for long-duration storage capacity prior to 2030 is brought forward from 2029 to 2028. This is driven by the overall objective to meet the reliability standard in a situation where the Hunter Transmission Project is delayed. Later in the horizon, the quantum of generation becomes a key factor. The Infrastructure Delay pathway builds slightly more generation in the later 2030s, but less by 2040 where the model selected additional storage as least-cost to customers.

The Hunter Transmission Project

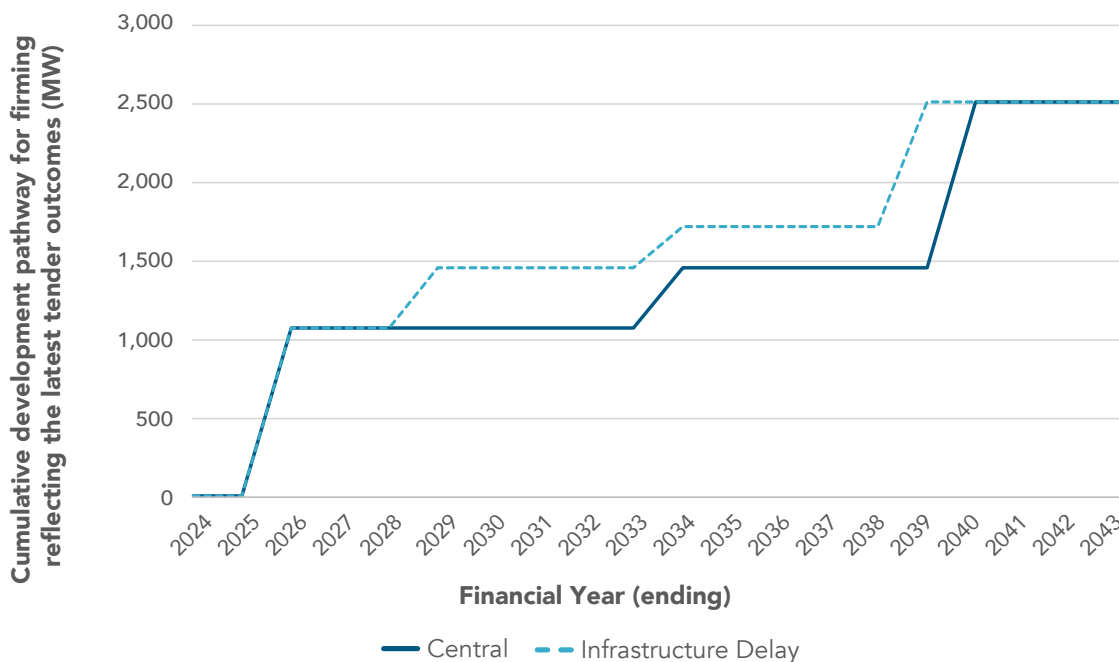
The Hunter Transmission Project (HTP) is one of the most critical energy projects in NSW. Its purpose is to strengthen the State's core electricity network so that more renewable energy can flow to the Hunter, Sydney and Illawarra. 80% of NSW's electricity is consumed in those parts of the state, much of which is currently supplied by power stations that are due to retire. It was classified as an urgent NSW Actionable Project under AEMO's 2022 ISP and will receive part of the \$4.7 billion allocated to the NSW Government to modernise the electricity grid under Australian Government's Rewiring the Nation program.

By closing the loop of existing transmission lines, the HTP will unlock 5 GW of additional transfer capacity.⁸⁸ This capacity is essential to meeting demand in the medium term, and the NSW Government has classified it as Priority Transmission Infrastructure Project (PTIP) on the basis of its contribution to energy security. In the longer-term, the project will enable the supply of high-value renewable electricity from projects in the Central-West Orana and New England REZs to pass via Bayswater, putting downward pressure on prices.

Firming infrastructure

The build trajectories for firming infrastructure under both of the modelled scenarios are set out in [Figure 30](#) below.

Figure 30: Comparison of alternative development pathways (firming)⁸⁹



88 The Hunter Transmission Project is a priority for EnergyCo. More information is available at: energyco.nsw.gov.au/projects/hunter-transmission-project

89 The firming development pathway was modelled prior to results from Tender 2 being available. The results have subsequently been included into this figure.

Under the Central scenario, no additional firming infrastructure (beyond the 1,075 MW identified for the completed firming tender) is required until after the 10-year tender planning period. Under the Infrastructure Delay scenario, additional firm capacity is constructed by the model compared to the central scenario to meet the reliability standard. Outcomes are highly uncertain over this timeframe, as they will be determined by the mix and distribution of new capacity constructed and connected by various network infrastructure projects.

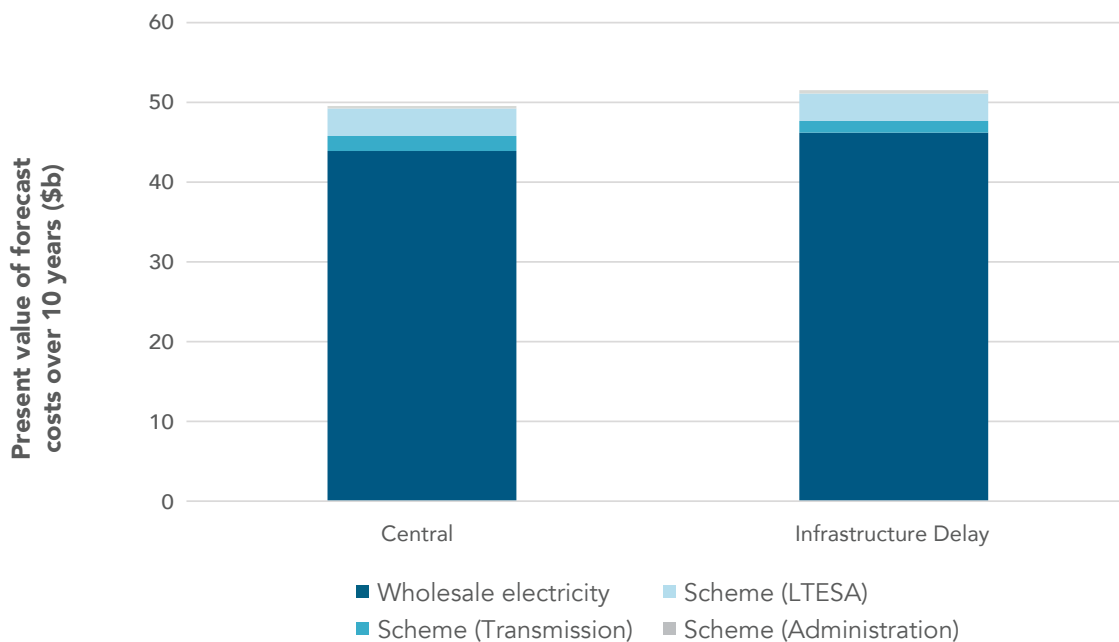
Under the Infrastructure Delay scenario, additional firming infrastructure would be required in the Sydney-Newcastle-Wollongong sub-region before 2030 to meet the reliability standard. The additional firming required would be substantial, representing approximately 400 MW of unconstrained capacity based on analysis for this scenario in the IIO Report. The need for this firming is driven by a delay to the Hunter Transmission Project, which is critical to maintaining reliability and minimising costs to NSW customers. This represent a risk to NSW electricity customers, as firming constructed to mitigate this in the short-term is not a cost-effective solution to the longer-term need best addressed by network infrastructure augmentation. Network augmentation, particularly the Hunter Transmission Project, allows electricity from high-value renewables in the regions to flow to load centres and drive down costs for customers.

Cost outcomes

The infrastructure construction under each scenario represents the least-cost trajectory under different input assumptions, which are independent variables that are not within AEMO Services' control. AEMO Services selects a central case that represents a credible development pathway, in the long-term financial interests of NSW electricity customers. AEMO Services then uses the alternate scenario to analyse the impacts of uncertainties on outcomes.

[Figure 31](#) outlines the forecast costs⁹⁰ for the supply of wholesale energy services to NSW electricity customers over a 10-year period under both modelled scenarios, which clearly shows wholesale electricity costs are the greatest driver of cost outcomes.

Figure 31: Present value of forecast costs by scenario



⁹⁰ The present value of the cost forecast is in real 2022 dollars, calculated by discounting costs to the first modelling year (2023-24) at a real discount rate of 7% (consistent with the discount rate in AEMO's 2023 IASR).

Under the Infrastructure Delay pathway, both wholesale electricity costs and scheme (LTESA) costs are higher than under the Central case. Wholesale costs are higher due to the delay in connecting wind and solar generation and the development of lower quality wind projects, driven by delays to critical transmission and the need to meet the 2030 minimum objectives. Wholesale costs are also increased due to the delay in HumeLink and Snowy 2.0 compared with the Central case. An increase in modelled scheme costs related to LTESAs is driven by higher volumes of firming and long-duration storage infrastructure required earlier in the forecast, thereby having higher costs, as well as higher cost long-duration storage infrastructure due to the delay to pumped hydro projects. These are somewhat offset by a small reduction in scheme costs related to transmission over this period, due to their assumed delay in this scenario.

The combined customer cost results across both scenarios demonstrate the importance of timely co-ordinated infrastructure delivery to enable renewable generation to connect to the grid and supply load centres with lower cost electricity.

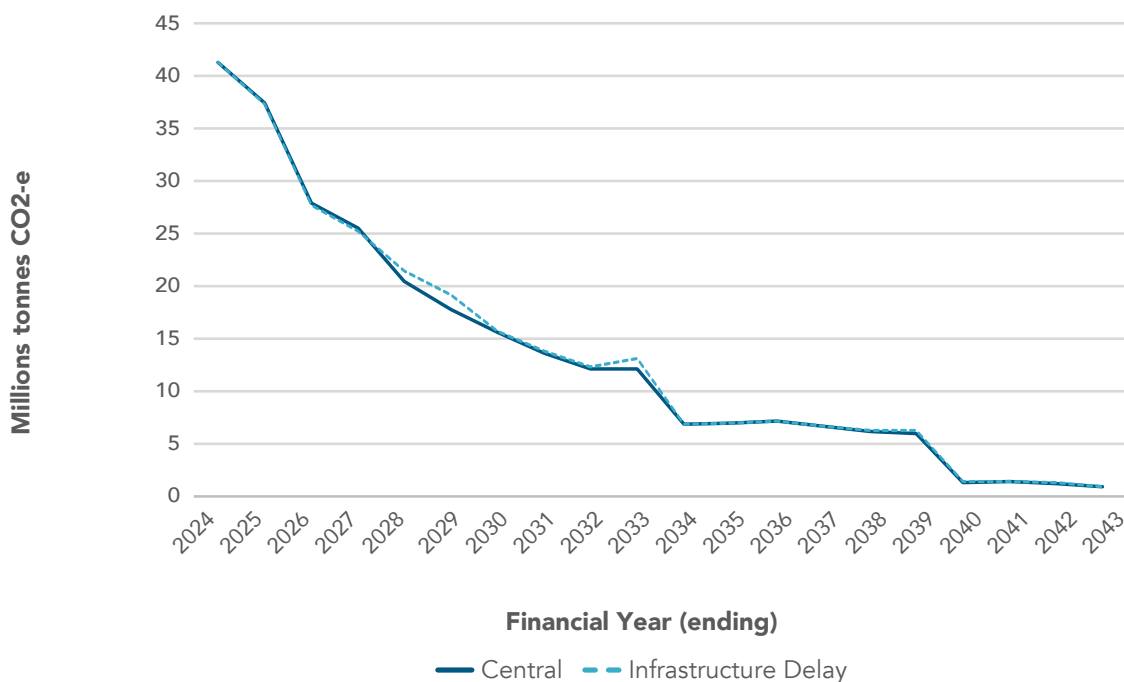
Emissions profiles

Figure 32 sets out the trajectories of carbon dioxide equivalent (CO₂-e) emissions from the electricity sector in NSW under both of the scenarios modelled for the 2023 IIO Report, showing a dramatic reduction in each case. The rate of emissions reduction is driven by the construction of new utility-scale renewable generation infrastructure, coal-fired generator retirement and uptake of rooftop solar.

In the infrastructure delay scenario decarbonisation occurs more slowly in the initial period due to more emissions intensive generation in the electricity system being required for longer. From 2033 to the modelled endpoint, both scenarios show similar CO₂-e emissions levels.

Due to the modelling for this IIO Report commencing prior to updated assumptions being available, these trajectories assume power station retirements modelled consistent with the Commonwealth’s prior 26-28% emissions reductions target for 2030 using a NEM-wide carbon budget constraint. This is aligned with 2022 ISP Step Change outcomes. The 2024 Draft ISP has since been released reflecting updated coal retirement outcomes based on the Commonwealth’s recently legislated 43% emissions reduction target for 2030.⁹¹

Figure 32: Comparison of modelled NSW emissions profiles



91 Climate Change Act 2022 (Commonwealth).

NSW Parliament passed the *Climate Change (Net Zero Future) Bill 2023* on 30 November 2023.⁹² When assented, the *Climate Change (Net Zero Future) Act* will set targets for the reduction in net greenhouse gas emissions in NSW in legislation:

- at least 50% by 2030,
- at least 70% by 2035, and
- net zero by 2050.⁹³

AEMO Services analysis for this 2023 IIO Report, shown above, sees the electricity sector in NSW outperforming the greenhouse gas emissions reduction targets for 2030 and 2035 under the Development Pathway when applied to this sector alone. AEMO Services notes, however, that this does not account for the greater role that the electricity sector will need to play as part of an economy wide approach required to deliver emissions reduction aligned with net zero objectives.

AEMO in the 2023 IASR scales down state economy-wide emission reduction targets to a state electricity target using pro-rata factors. To perform this task AEMO use information based on state emissions data from the Clean Energy Regulator and the economy-wide emission figures from the Department of Climate Change, Energy, the Environment and Water. In the instance where less emissions reduction is achieved by one sector, this then needs to be offset by higher reductions in other sectors to achieve the overall targets, which may come at additional costs.

Network augmentations

The two development pathways include a different schedule of modelled timing for major REZ network augmentations, as set out in [Table 7](#) below. The trajectory for REZ network infrastructure affects the rate and resource quality of renewable generation constructed in NSW, as well as the transmission costs recovered from customers under the EII Act.

Table 7: Modelled optimal timing of NSW REZ network infrastructure projects (financial year ending)

REZ option	Additional REZ network capacity (MW)	Pathway	
		Current Policies	Infrastructure Delay
New England Option 1A	2,400	2030	2031
New England Option 2A	3,700	2032	2033
New England Option 3A	500	2034	2037
New England Option 5A	1,400	2037	2037
Central-West Orana Option 1	4,500	2028	2029
Central-West Orana Option 2	1,500	2037	2038
Central-West Orana Option 3	1,630	2041	2041
Hunter-Central Coast Option 1	950	2027	2028
Hunter-Central Coast Option 3	500	Not built	2028

⁹² *Climate Change (Net Zero Future) Bill 2023* documentation available at: parliament.nsw.gov.au/bills/Pages/Profiles/climate-change-net-zero-future-bill-2023.aspx

⁹³ Proportional reductions are from the net greenhouse gas emissions in 2005, and targets refer to 30 June of the relevant year (financial year ending).

AEMO Services adopts inputs from EnergyCo on REZ network infrastructure project options and earliest delivery dates in its co-optimised modelling (in addition to the non-REZ network augmentation input assumptions outlined in [Table 7](#)). The Infrastructure Delay scenario included modifications to assumptions that pushed out the earliest possible delivery date for REZ projects by one year, which results in REZ network capacity being delivered later than under the central scenario. The Infrastructure Delay scenario also results in the model selecting an additional network augmentation in the Hunter Central Coast REZ to meet the minimum objectives, compensating for New England being unable to enter until 2030.

AEMO Services notes that maximising the opportunities in the Hunter-Central Coast REZ and South West REZ can mitigate some of the risks of delays to New England REZ and Central-West Orana REZ. The model showed relatively small levels of investment in South West REZ, even in the Infrastructure Delay scenario, owing to assumptions about its relatively low wind resource potential. Generators in this REZ are, however, reporting higher capacity factors. If this is true, then South West REZ may also offer mitigation to network delays, due to no additional transmission infrastructure investment required under the EII Act.

Further, the model brings forward network augmentation in the New-England REZ at its earliest possible delivery date under this scenario, highlighting the importance of this REZ to delivering new capacity from diverse resources across the state.

The Hunter Transmission Project is critical to delivering reliability and security outcomes in the long-term financial interest of NSW electricity customers, as discussed above with respect to storage infrastructure. If it is not delivered by 2028 as planned, modelling for the IIO Report shows more firm capacity will be needed sooner to address the reliability need before 2030. The Hunter Transmission Project remains the long-term solution, however, to unlocking capacity in the state's core network infrastructure so this intervention would be undesirable for affordability outcomes.

Benefits of multiple renewable energy zones

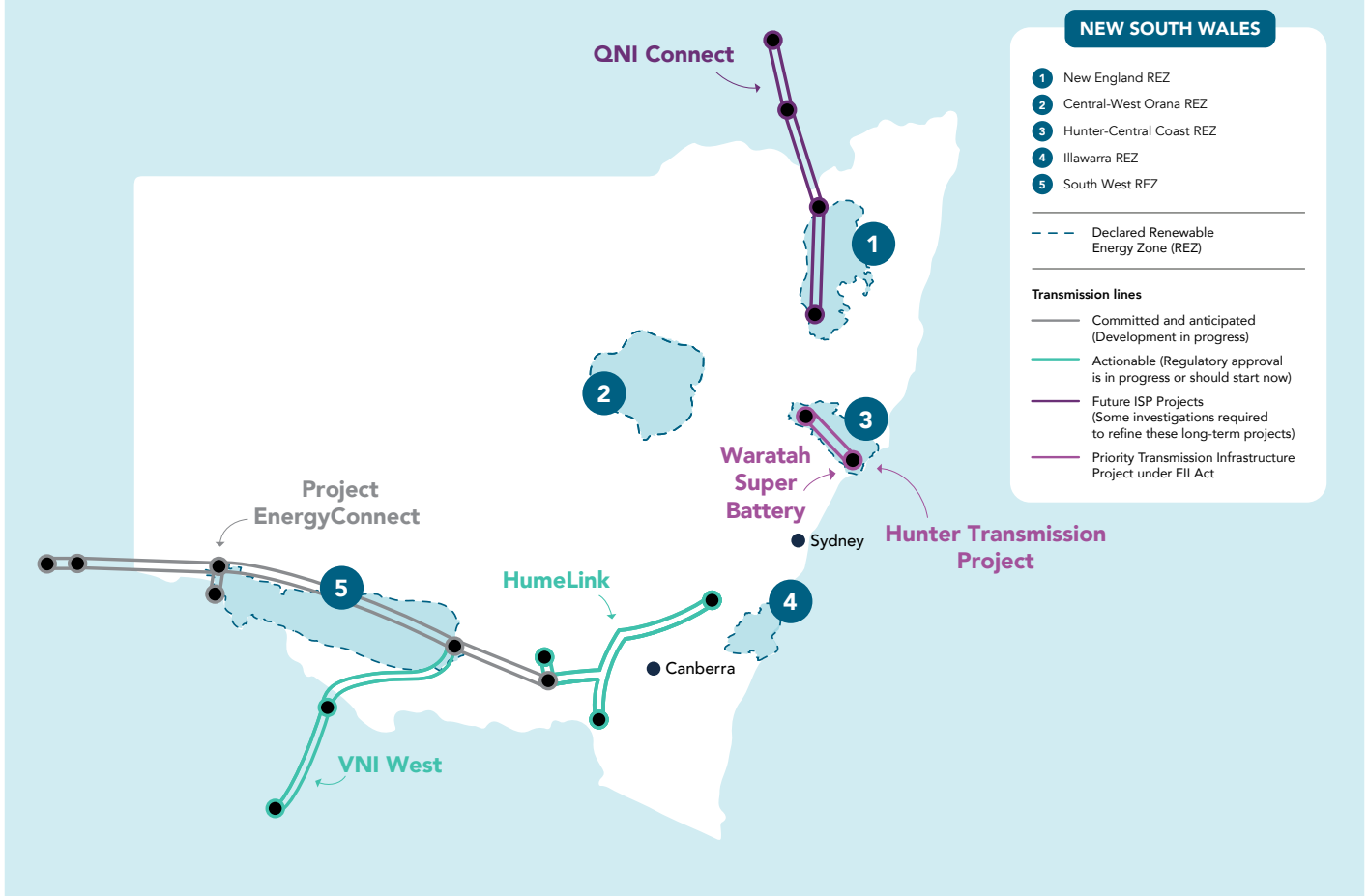
AEMO Services considers that geographic diversity is important to minimising cost to customers and mitigating risk associated with the timeframes for delivery of network projects.

More available locations for projects are expected to result in increased competition, and hence better commercial terms, through tenders conducted by AEMO Services. Having multiple REZs available for participation in LTESA tenders as soon as possible will increase competition for LTESAs, increase competition in the wholesale market and drive down costs for NSW customers. Generation and storage projects in different locations also have different operational characteristics. The model used for the IIO Report prefers a diversity of wind project locations for their generation output, with New England options entering at their soonest possible dates.

Diversity of project location in NSW can mitigate risk associated with project delivery. Every electricity infrastructure project has inherent risks to delivery, and a greater spread of projects across the state will reduce delivery risks associated with reliance on the timely delivery of any particular network project. Maximising the opportunities in the Hunter-Central Coast REZ and South West REZ can mitigate some the risks of delays to New England REZ and Central-West Orana REZ.

If Central-West Orana and New England REZ reference scopes are delayed, further investment in Hunter-Central Coast is prioritised by the model used for the IIO Report. Hunter-Central Coast represents brownfield development by existing network operators, with fewer social licence issues expected in the delivery of additional infrastructure. South West REZ may also offer opportunities to mitigate risk associated with network delays as capacity in the REZ is unlocked incrementally by Project EnergyConnect, HumeLink and VNI West.

Figure 33: NSW declared renewable energy zones and NER transmission projects and EII Act priority transmission infrastructure projects



4. 10-Year Plan

AEMO Services considers that the Development Pathway is resilient, on the basis that the corresponding 10-Year Plan aims to provide the necessary optionality for industry and the Consumer Trustee to manage risks over the medium-term to 2025. Regular tenders for generation and storage will allow AEMO Services to consider the most up-to-date information from market developments to inform the consideration of infrastructure construction in the long-term financial interest of NSW electricity customers. This proposed tender plan is explained further below.

4.1 Overview

The 10-Year Plan sets out an indicative schedule for competitive tenders giving effect to the Development Pathway in respect of generation and long-duration storage infrastructure. The purpose of the 10-Year Plan is to provide a level of certainty to investors, to the extent possible allowing them to plan for participation in tenders, improving the likelihood of receiving high-value submissions.

Indicative tender sizes and testing the modelled pathway through tenders

As with all Consumer Trustee tenders, the target volumes should be interpreted as indicative only. AEMO Services may adjust the tender sizes prior to the next publication of an IIO Report if it considers this to be in the long-term financial interests of NSW electricity customers. How AEMO Services might adjust the indicative tender sizes over time in response to various events is discussed in [Section 3](#).

A range of modelling uncertainties underpin the generation and long-duration elements of the Development Pathway. These uncertainties also extend to the ongoing evolution of reliability modelling approaches and the assessment of reliability tail risks in a system dominated by renewable generation. In conducting its competitive tenders AEMO Services will have regard to the real-market information it receives and tests these uncertainties to recommend LTESAs that are in the long-term financial interests of NSW electricity customers.

AEMO Services may recommend more or less LTESAs depending on its assessment following evaluation of bids received in each competitive tender process against a set of merit criteria, including the quality and size of projects, lead times and the extent to which a project offers financial value to NSW electricity customers and pathway to commercial operation.⁹⁴

In the context of emerging reliability risks in NSW described in [Section 3](#), AEMO Services expects that it will generally err on the side of over-investment, rather than under-investment across its tenders.

Tenders for REZ access rights

The 10-Year Plan primarily schedules competitive tenders for LTESAs. EnergyCo develops the access right for REZs and projects are expected to compete for these rights in AEMO Services competitive tenders. Tender participants will be able to bid for both an LTESA and an Access Right in a tender. Where a tender participant is seeking an access right only,⁹⁵ AEMO Services may recommend the award of access rights above the indicative tender size (up to the maximum aggregate capacity for any given REZ).

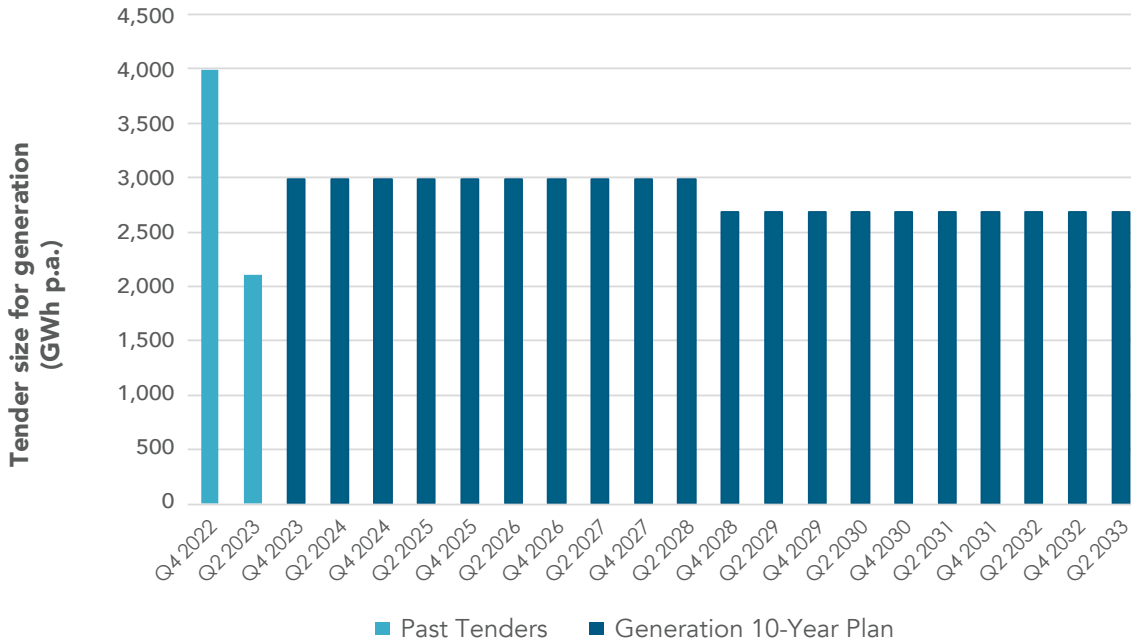
⁹⁴ The current Tender Rules and Tender Guidelines, which set out the eligibility and merit criteria for competitive tenders, are available on AEMO Services' website at <https://aemoservices.com.au/tenders/tender-pack>

⁹⁵ Projects that have received an access right may only seek an LTESA in a later tender in exceptional circumstances.

4.2 Tender plan for generation infrastructure

The timing and indicative sizing for competitive tenders for generation infrastructure over the next 10-year period is shown in [Figure 34](#).

Figure 34: 10-Year Plan (Generation)



Values for past tenders are based on actual awarded amounts (not the indicative volume).

Similar to the Draft 2023 IIO Report the 10-year plan for generation infrastructure seeks to deliver consistently sized tenders. Tenders capable of producing 3,000 GWh of electricity per year are planned up to Q2 2028. A small reduction in tender size is planned from the end of 2028 to reflect the generation element of the Development Pathway. The indicative size of the tenders has been set by:

- Considering the total amount of generation infrastructure to be constructed under the Development Pathway by both 2029-2030 to meet the minimum objective, and to 2035-36 to reflect the next 10 years, with a two-year lead time. This captures the additional time anticipated to be needed between tendering for LTESAs and the construction of infrastructure.⁹⁶
- Considering the amount of existing and committed projects eligible for generation LTESAs (as at November 2023), and what portion of these may require an LTESA.
- Apportioning this volume over biannual tenders from Q4 2023 in accordance with the two time periods considered.

This approach is intended to be simple and provide greater certainty for participants in AEMO Services' competitive tenders. It also reflects the reality that not all projects will have the same lead time between receiving an LTESA and commissioning.

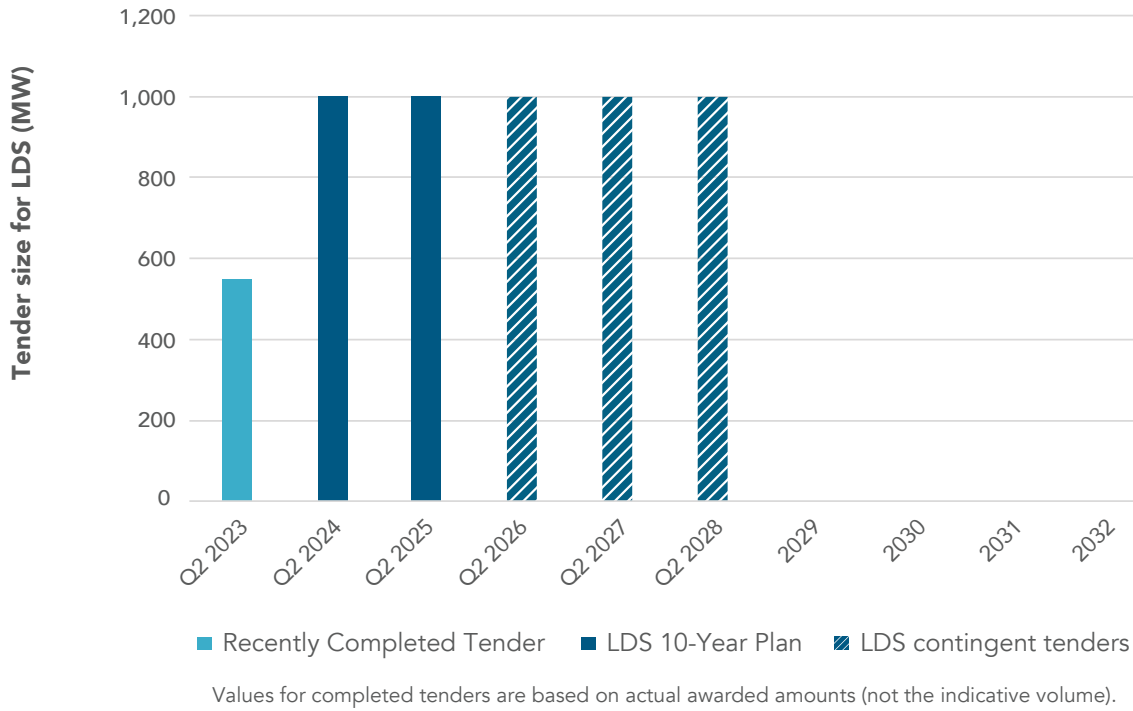
How AEMO Services might adjust the indicative tender sizes over time in response to various events is discussed in [Section 4.5](#).

⁹⁶ Lead time assumptions are average estimates to reflect the requirement to tender for LTESAs in advance of infrastructure being constructed. These will vary greatly by project. AEMO Services expects that future sizes of LTESA tenders will be informed by the outcomes of previous tenders.

4.3 Tender plan for long-duration storage infrastructure

The timing and indicative sizing for competitive tenders for long-duration storage infrastructure over the next 10-year period is shown in [Figure 35](#).

Figure 35: 10-Year Plan (Long-Duration Storage)



AEMO Services intends to maintain the same 10-year plan for long-duration storage as presented in the Draft 2023 IIO Report. [Figure 35](#) shows the outcomes of the long-duration storage component of Tender 3 run by AEMO Services. Following this, consistently sized tenders are proposed for long-duration storage infrastructure. This will allow the testing of assumptions around lead times and costs for various technologies in the NSW context. It will also provide a way to monitor the ongoing risk associated with a late build in meeting the minimum objective of 2 GW and 16 GWh by the end of 2029.

In the tenders through to 2025, AEMO Services will consider recommending projects up to the 2 GW and 16 GWh objective, if it is in the long-term financial interests of NSW customers. Should projects not be of sufficient quality and/or financial value in these tenders, then AEMO Services will proceed to conduct the contingent tenders set out in [Figure 35](#) until the 2 GW and 16 GWh objective is met.

4.4 Tender plan for firming infrastructure

AEMO Services commenced a firming tender in the second quarter of 2023 in response to a Ministerial direction received in August 2022 and the outcomes of this tender were subsequently announced in November 2023. This tender is captured in the firming development pathway presented in [Section 3](#) and the outcomes of this tender were subsequently announced in November 2023. With the tender now complete and in the absence of a direction from the Minister to conduct a further tender, a 10-year plan for firming is not required at this stage.

4.5 How the 10-Year Tender Plan can be adjusted between reports

To adapt to changes occurring in the market in a timely manner, AEMO Services may adjust the indicative tender sizes in the 10-Year Plan under certain circumstances. For example, and without limitation, AEMO Services may determine to vary the indicative tender sizes on the basis of a:

- **Material market event** – if a material event has or is anticipated to occur in the energy market.
- **Decision to recommend more in tender** – AEMO Services may decide to recommend LTESAs that exceed the indicative size as part of a tender, because of reasons including but not limited to:
 - tender submissions demonstrate high value for customers, or
 - project lead times are earlier than assumed by AEMO Services in setting the Development Pathway and 10-Year Plan, or
 - individual projects of high merit are of a large size and exceed the indicative tender size.
- **Decision to recommend less in tender** – AEMO Services decides to recommend fewer LTESAs than the indicative size as part of a tender, because of reasons including but not limited to:
 - tender submissions demonstrate low value for customers, or
 - project lead times are later than assumed by AEMO Services in setting the Development Pathway and 10-Year Plan.

The alternative scenario modelled for this report, discussed in [Section 3.8](#), provides an indication of how AEMO Services may vary the Development Pathway in response to delays of the kind assumed in this scenario. In such circumstances, AEMO Services may adjust the indicative size of the subsequent tenders for the remainder of the 10-Year Plan.

This approach is intended to simplify the 10-Year Plan for the market and enhance competition. It provides an incentive for projects to participate early (given the possibility of AEMO Services recommending LTESAs above the indicative size if high-quality bids are received), while also ensuring the subsequent tenders remain of a size that allows large projects to participate.

As noted above, where a tender participant is seeking an access right only, AEMO Services may recommend the award of access rights above the indicative tender size (up to the maximum aggregate capacity for any given REZ).

5. Preparing the Development Pathway

This section explains the modelling methodology AEMO Services used in preparing the Development Pathway contained in this 2023 IIO Report, including the objectives and the range of inputs and assumptions.

5.1 Setting up the model

The market modelling involves considering a range of forecast inputs and assumptions over a 20-year period to produce an optimal (customer least-cost) trajectory for the development of new infrastructure (including generation, storage, firming and network infrastructure).

5.1.1 Objective Functions

The objective functions of the model underpinning the Development Pathway are to:

- minimise costs for NSW electricity customers across the 20-year horizon,
- achieve the minimum infrastructure investment objectives of approximately 33,600 GWh per year of available generation volume and 2 GW and 16 GWh of long-duration storage by the end of 2029, and
- meet the reliability standard and energy security target.

The model allows for the entry of generation or long-duration storage infrastructure that is additional to the minimum requirements, both before and after the end of 2029, if it is determined to minimise costs for NSW electricity customers or is required to maintain reliability.

The objective functions of the model differ from that of AEMO's standard modelling approach for the ISP. AEMO's ISP modelling optimises to produce least-cost outcomes across the energy system, with a particular focus on the capital costs of new infrastructure in the capacity expansion modelling stage.

The modelling for the IIO Reports involves a level of iteration between the capacity expansion model and the time-sequential model. The purpose of this iteration is to validate the expansion plan produced in the capacity expansion step by assessing how the planned infrastructure is likely to operate and bid into the electricity market. In doing so, the modelling exercise is able to forecast the likely impacts of the new infrastructure on wholesale electricity costs, as well as the costs likely to be paid out under LTESAs. The costs of EII Act network infrastructure and scheme administration are also added at the third stage where the cost forecast is calculated.

The model seeks to minimise both wholesale electricity costs and scheme costs associated with LTESAs and certain network infrastructure projects.

5.1.2 Modelling inputs and forecast outputs

The market modelling involves considering a range of forecast inputs to produce the development pathways.

Given the multitude of variables, it is impossible to accurately forecast precise market conditions over a 20-year period. Rather, the forecasts are a proxy for how the market operates, and AEMO Services acknowledges simplifications are needed which lack the detail and nuances that can materialise in actual operations of the market. The foresight and rational decision making assumed in the modelling processes are examples.

IIO Report modelling is not intended to be used as a precise forecast, but rather used to inform AEMO Services' tender decisions as one input alongside other considerations. This ultimately informs investment decisions about timing and need for new infrastructure to best achieve outcomes for NSW electricity customers.

The preparation of this report relies on the use of AEMO's in-house models and utilises the most up to date data that was available as inputs to the model.

5.2 Modelling assumptions

The build trajectories for both scenarios are driven by a range of assumptions. Assumptions used in the modelling cover a broad range of variables and include:

- existing and planned supply,
- forecast demand,
- policy settings,
- fuel costs,
- the transmission network configuration, and
- the expected costs and attributes of new candidate infrastructure.

Those assumptions are drawn from various sources including AEMO's 2022 ESOO, 2022 ISP and 2023 IASR (draft and final). Since the draft 2023 IIO Report, updates have been made to capture information from AEMO's 2023 IASR where timing allowed it to be incorporated. Updated assumptions around the delivery timing of REZ and some non-REZ transmission augmentations, are provided by EnergyCo and incorporated into the modelling.

IIO Reports are conducted separately to AEMO's ISP and occur on a different timeline for modelling and analysis. Some of the diversions in assumptions between the IIO Report and ISP relate to timing and information able to be incorporated into the IIO Report modelling when it commenced. For instance, coal retirement information which is an output contained in the Draft 2024 ISP was not available at the time modelling commenced.

Some of the diversions reflect the difference in purpose of the two reports, with the IIO Report being designed to identify development pathways in respect of generation and long-duration storage infrastructure that meet the minimum objectives specified in the EII Act (see Section 2).⁹⁷

The key assumptions used in the modelling for the 2023 IIO Report, including a discussion on key diversions between this report and the Draft 2024 ISP are set out further in this Section.

Assumptions common to both scenarios

Since the draft report, the final 2023 IASR has been released and timing has allowed some of these to be captured in modelling. Updates to assumptions between the draft and final 2023 IIO Report include changes to WACCs, project lead times, fuel costs, and jurisdictional policies.

On the supply-side, key assumptions and their associated data sources are listed below in [Table 8](#).

Table 8: Key modelling assumptions for supply-side considerations

Supply-side assumption	Source	2023 IIO Report
Assumed capacity	AEMO Generation Information (July 2023) plus 2023 IASR additional projects	Existing, committed and anticipated projects are assumed as per AEMO Generation Information. The 2023 IASR included additional projects ⁹⁸ associated with jurisdictional policies that have been included where relevant. Additional assumed capacity includes 930 MW of firming infrastructure in 2025-26.
Coal retirement timing	2022 ISP	Aligned with 2022 ISP Step Change outcomes whilst enforcing the National Electricity Rules 3.5-year advance notice period and Yallourn commercial contracts.
Coal and gas fuel cost	2023 IASR	Aligned with Step Change scenario price forecasts.

⁹⁷ The ISP considers AEMO Services' development pathway as an input to its modelling and does not identify a least-customer cost path independently.

⁹⁸ 2023 IASR workbook, rows 364-379 Existing Gen Data Summary tab.

Demand assumptions (including consumer energy resources) used in the 2023 IIO Report remained consistent with those used for the Draft, from the 2022 ESOO and ISP as summarised below in [Table 9](#). This was the latest information able to be incorporated at time of modelling. Updated demand assumptions have been released in the 2023 ESOO and AEMO's Draft 2024 ISP which assume materially higher demand and lower levels of embedded storage, compared to the assumptions used for this report.

AEMO Services notes that the 2022 ESOO operational consumption assumptions adopted in this report are similar to those adopted in the Progressive Change scenario in the 2024 ISP for 2030, which was considered to have 42% likelihood by the 2024 ISP Delphi Panel, closely following the Step Change scenario at 43%. The operational consumption forecast before and after 2030 is however materially different between the assumptions used to inform this Report and the Draft 2024 ISP Progressive Change scenario.

There is significant uncertainty inherent in forecasts for these assumptions. Demand forecasts are strongly associated with assumptions regarding electrification to meet net zero pathways, and the orchestration of consumer energy resources will depend on willingness to participate amongst other matters under consideration by jurisdictions and the federal government.

Table 9: Key modelling assumptions for demand-side considerations

Demand-side assumption	Source	Financial year ending		
		2025	2030	2035
NSW total operational consumption (GWh)	2022 Electricity Statement of Opportunities	64,042	65,665	69,476
NSW distributed PV generation (GWh)	2022 ISP	8,401	11,970	15,380
NSW embedded energy storages (MW)	2022 ISP	998	2,949	6,673

Build cost assumptions used in this report have been updated from the Draft 2023 IIO Report to reflect latest available information when modelling commenced ([Table 10](#)). The updated costs utilise Draft 2023 IASR cost information and show price increases across the board compared to those figures used in the draft. The Draft 2024 ISP utilises a further update in costs based on those contained in the 2023 IASR.

Table 10: Key modelling assumptions for capital costs of renewable technologies

Capital cost assumption* (\$/kW)	Source	Financial year ending		
		2025	2030	2035
2-hour battery	Draft CSIRO GenCost 2023	1,270	968	758
8-hour battery	Draft CSIRO GenCost 2023	3,664	2,744	1,976
Wind (onshore)	Draft CSIRO GenCost 2023	2,392	1,817	1,697
Solar PV	Draft CSIRO GenCost 2023	1,418	1,098	927
Pumped hydro 8 hours	Draft CSIRO GenCost 2023	2,944	2,643	2,621

*Build costs in the model are applied on a technology-specific regional basis and should be considered alongside AEMO's Regional Cost Factors presented in the draft 2023 IASR.

AEMO Services imposes annual build limits for new entrant renewable energy projects in the NEM (i.e. excluding existing, committed or anticipated)⁹⁹ to reflect supply chain constraints to 2030. Additionally, NSW build limits are applied in the first few years of the modelling horizon in order to reflect the existing pipeline of projects. The intention of these build limits is to produce development pathways that are achievable having regard to economic and logistical circumstances. A constraint is also applied to limit the amount of generation overbuild in the NSW REZs. The key assumptions used in this report and their reason for divergence from the Draft 2024 ISP are summarised below in [Table 11](#).

Table 11: Key generation build limit modelling assumptions

Constraint assumption	Draft 2024 ISP	2023 IIO Report	Rationale for diversion
Annual build limit to reflect a supply chain constraint	N/A	An annual build limit for new* entrant NEM generation and storage of 4 GW up until 2029-30 and then no limit from 2030-31 onwards. The limit is modelled as a soft constraint that can be exceeded with a high penalty.	Explicit consideration of supply chain constraints. ¹⁰⁰
Technology-specific and locational build limits	N/A	Technology-specific build limits for each NSW subregion informed by approved projects in the NSW planning and approval process. This equates to ~3.1 GW total new VRE limit by 2024-25 and ~3.5 GW total new VRE limit by 2025-26, as well as ~2.5 GW pumped hydro limit by 2030-31.	Updated view on near-term ability for new project development using real world data.
Target transmission curtailment level	N/A	A constraint is applied to limit the amount of generation overbuild in the NSW REZs to reflect access scheme declaration settings such as the CWO REZ Target Transmission Curtailment Level.	Reflective of REZ Access Rights.

*New excludes those projects listed as existing, committed or anticipated in the July 2023 Generation Information.

⁹⁹ Committed projects meet all five of AEMO's commitment criteria (land, contracts, planning, finance and construction) but have not yet met the requirements of their first commissioning hold point. Anticipated projects have made progress towards at least three of AEMO's commitment criteria and have provided AEMO confirmation or update of project status in the last six months.

¹⁰⁰ See section 3.3 for further discussion on supply chain constraints.

A range of other important modelling assumptions and how they differ to the Draft 2024 ISP as a result of timing and report purposes are explored in [Table 12](#) below.

A key difference in assumptions is that the 2023 IASR includes additional renewable energy targets, most notably the national 82% renewable energy by 2030 target under the Australian Government’s Powering Australia plan. As noted in [Section 3.8](#) above, AEMO Services considers that there is not yet sufficient certainty regarding implementation mechanisms for announced policies in other states or the Australian Government’s Powering Australia Plan, for these to be used as the central basis for NSW tender plans at this time.

The 2023 IIO Report contains updated WACC assumptions compared to the Draft 2023 IIO Report.

Table 12: Key modelling assumption diversions from the Draft 2024 ISP related to timing and policy

Assumption	Draft 2024 ISP	2023 IIO Report	Rationale for diversion
Coal Retirements	An output of Draft 2024 ISP report	Aligned with 2022 ISP Step Change outcomes whilst enforcing the National Electricity Rules 3.5-year advance notice period and Yallourn commercial contracts.	Latest information able to be incorporated at time of modelling.
Jurisdictional Policies	2023 IASR	2022 ISP policies are maintained.	Additional policies are unsuitable to use as a central assumption in IIO modelling to inform NSW tender plans until implementation pathways are settled.
REZ network augmentations	Options as per 2023 IASR	Optimise for timing of all NEM REZ network augmentations. Options, timings and costs for NSW REZs updated from the Draft report based on information provided by EnergyCo.	Updated information from EnergyCo.
Generation, storage and transmission WACCs (real, pre-tax)	7% consistently for all technologies	WACC assumptions for generation and storage projects are based on their technology and whether they have an LTESA. Updated from Draft report based on new available information. For transmission projects the regulated WACC from the Final Decision Transgrid transmission determination 1 July 2023 to 30 June 2028 is assumed.	Variations in cost of capital are important to reflect for the accuracy of customer costs, considering AEMO Services obligation to consider the long-term financial interests of NSW electricity customers.

5.2.1 Modified assumptions used to model infrastructure delay scenario

The sensitivity used in this report seeks to alter a set of specific variables in order to further help understand how to pivot planning should it be required. The Infrastructure Delay scenario considers implications associated with different timings for the entry of infrastructure.

Timing assumptions

Energy infrastructure projects are subject to significant delays across the NEM and further delays to the delivery of generation, storage and transmission projects could materially impact the Development Pathway. [Table 13](#) below captures the delay rules adopted for use in the Infrastructure Delay scenario, and resulting adjustments to key dates, used to assess outcomes should these risks eventuate.

Table 13: Infrastructure Delay Sensitivity modelling assumptions

Infrastructure	Delay rule	Key dates
Generation (generic new entrants)	+1 year lead time to gas.	Gas lead time increased to 5 years (earliest entry July 2028).
Storage	+1 year lead time to pumped hydro. +1 year delay to Snowy 2.0.	PHES lead time increased to 7 years (earliest entry July 2030). Snowy 2.0 delayed to Dec 2030.
Transmission	+1 year delay to earliest entry of NSW Renewable Energy Zone Network Infrastructure Projects (RNIP) reference scopes and expansions (also REZs in other regions).	HCC delayed to Dec 2027. CWO delayed to Sep 2028. NE delayed to Oct 2030. SW delayed to Jun 2032.
	+1 year delay to one of two PTIPs.	HTP delayed to Dec 2028. WSB not delayed (committed by AEMO).
	+1 year delay to Actionable and Future ISP projects.*	HumeLink delayed to Jul 2029. Marinus Link 1 delayed to Jul 2030. VNI West delayed to Jul 2032.

*Project EnergyConnect is considered committed by AEMO and is not included in the delays proposed.

Appendix A – Reliability Assessment

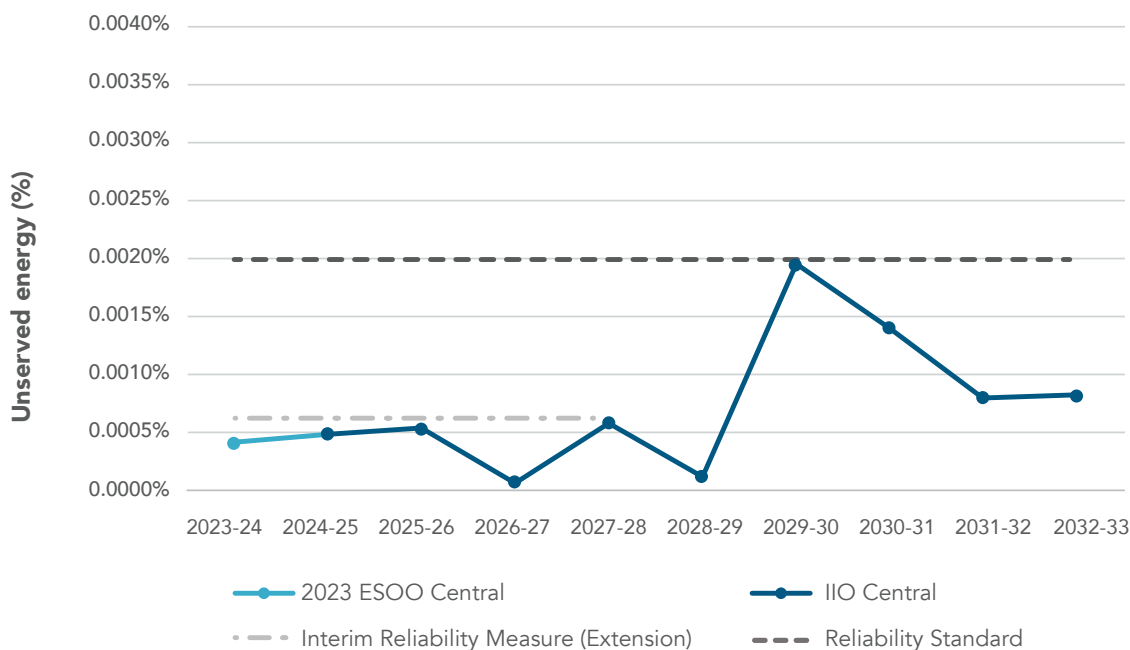
The Development Pathway in the IIO Report provides an indication of the infrastructure to be constructed to meet the infrastructure investment objectives. The overall objectives include the construction of long-duration storage infrastructure to meet the reliability standard and firming infrastructure to meet the energy security target as well as the reliability standard.

To inform the preparation of the IIO Report and the Development Pathway contained within it, AEMO Services conducts assessments for both these reliability related measures. Aligned with the standard practice that AEMO applies to the methodologies for its ESOO and ESTM Reports, these assessments were conducted for a 10-year period. Both show the Development Pathway meets these objectives. There are risks to meeting both of these objectives, however, associated with delays to project delivery, as discussed below.

A1. The reliability standard

AEMO Services' reliability assessment shows that the Development Pathway meets the reliability standard over the 10-year period under base case assumptions, as shown in [Figure 36](#).

Figure 36: Reliability assessment of the Development Pathway against the reliability standard



The first modelled year is taken from analysis conducted for the 2023 ESOO Central scenario, which AEMO Services considers a reasonable proxy for the first modelled year of the Development Pathway before additional infrastructure¹⁰¹ is delivered. There is a reduction in unserved energy in 2026-27, reflective of an additional 1 GW of new entrant wind projects delivered in this year in the Development Pathway, alongside infrastructure developments across the NEM. Unserved energy increases again in 2027-28 in line with assumed coal unit retirements in New South Wales, and reduces in 2028-29 in line with assumed entry of Snowy 2.0 and additional wind generation. In 2029-30, in line with coal unit retirements in New South Wales, Victoria and Queensland, there is an increase to unserved energy. Beyond 2030, additional generation infrastructure in New South Wales reduces unserved energy.

Notwithstanding, there are material risks to achieving the reliability standard in 2025-26 and 2026-27, especially where AEMO's latest demand forecasts and other assumptions underpinning its ESOO are adopted. Further analysis was undertaken on these risks as set out below.

¹⁰¹ Additional to projects that are already existing, committed or anticipated by AEMO.

A1.1. Risks to meeting the reliability standard

The 2023 ESOO was published in August 2023 and outlined the risks to meeting the reliability standard in NSW. Unlike the above modelling, the 2023 ESOO assumed:

- A higher demand forecast, with 10% higher operational demand in NSW by 2030 compared to the assumption used to derive the Development Pathway;
- The delayed delivery of committed and anticipated projects;
- No uptake of non-committed or anticipated distributed, coordinated storage;
- No projects that are not already existing, committed or anticipated by AEMO.

AEMO Services has conducted reliability modelling to understand risks in meeting the reliability standard in 2025-26 and 2026-27. This modelling closely follows the 2023 ESOO Central scenario, although with the addition of projects that have received an LTESA. In particular, this analysis assumed:

- Projects that are existing, committed or anticipated by AEMO;
- Project delivery delays for committed and anticipated projects, in line with the 2023 ESOO approach to help reflect observed development and delivery risks of new projects;
- All projects that have received an LTESA in any of AEMO Services' first three tenders are delivered in line with their contracted expected commercial operational date;
- No further infrastructure developments in addition to the above proceed.

[Table 14](#) presents the outcomes of this analysis, which shows that there is a 177 MW and 271 MW firm unconstrained gap against the IRM, in 2025-26 and 2026-27, respectively, when using this methodology.

Table 14: Reliability gap forecast for 2025-26 and 2026-27 with LTESA projects

Reliability gap (MW)	2023 ESOO Central		2023 ESOO Central + LTESA projects	
	2025-26	2026-27	2025-26	2026-27
Firm, unconstrained gap against IRM	786	796	177	271

The NSW Government is continuing to consider the near-term risk to reliability and what, if any, additional actions may be appropriate in response. Options to help further accelerate the transition underway in NSW have been identified by the NSW Government in their response to the Electricity Supply and Reliability Check Up.¹⁰² The Australian Government also recently announced an expanded Capacity Investment Scheme (CIS) to underwrite new renewable generation and storage using federal funding mechanisms alongside the Roadmap in NSW.¹⁰³

¹⁰² See NSW Government (September 2023) Electricity Supply and Reliability Check Up NSW Government response. [Electricity Supply and Reliability Check Up \(nsw.gov.au\)](#)

¹⁰³ Announcement from Minister Bowen on 23 November 2023.

Available at: minister.dcceew.gov.au/bowen/media-releases/delivering-more-reliable-energy-all-australians

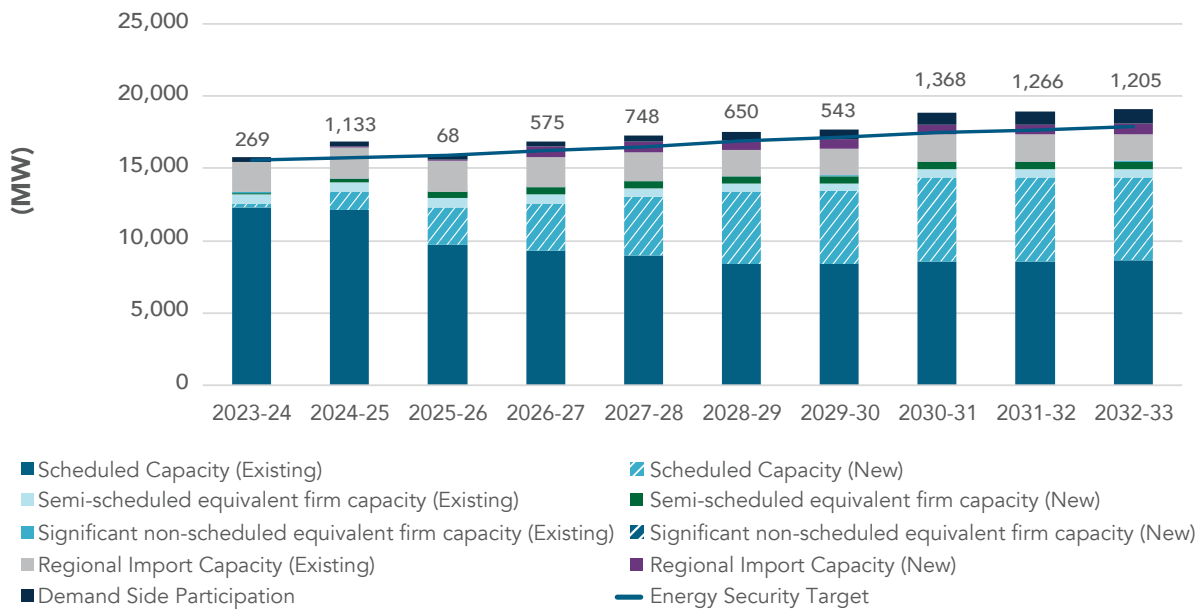
A2. The energy security target

AEMO Services considers that the Development Pathway is able to meet the EST over the 10-year assessment period. This assessment is reflective of a sensitivity where:

- Anticipated projects are included in addition to the central scenario, with an assumed delay in delivery in line with the 2023 ESOO approach;
- Projects that have received an LTESA are delivered on the target date specified in the contract.

AEMO Services considers these assumptions to be most appropriate to demonstrate the ability of the Development Pathway to meet the EST, where all projects committed or anticipated by AEMO are delivered with a delay and only the successful LTESA projects from our first three tenders are delivered on time. Under these assumptions, there is no breach of the EST across the 10-year modelled horizon, as shown in [Figure 37](#).

Figure 37: EST Central + Anticipated Projects (subject to development delays) and LTESA projects (delivered on target date)



AEMO Services notes that the 2023 ESTM Report considers a more optimistic sensitivity whereby committed, anticipated and LTESA-recipient projects are all delivered at their target date, and in this sensitivity the EST surplus is higher than the surplus shown in [Figure 37](#).

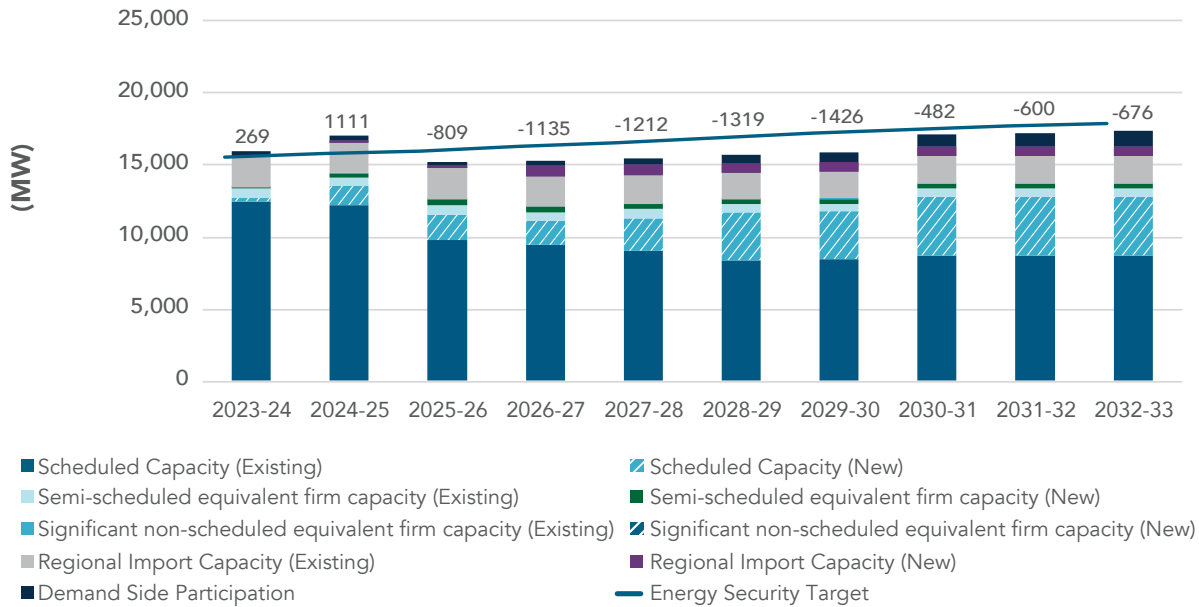
A2.1. Risks to meeting the energy security target

As outlined in the 2023 Energy Security Target Monitor Report,¹⁰⁴ under a Central scenario which includes only existing and committed projects, there is a breach in the EST from 2025-26. In particular, this scenario assumes:

- No anticipated projects or projects that have received an LTESA are delivered;
- Committed projects have a delayed delivery.

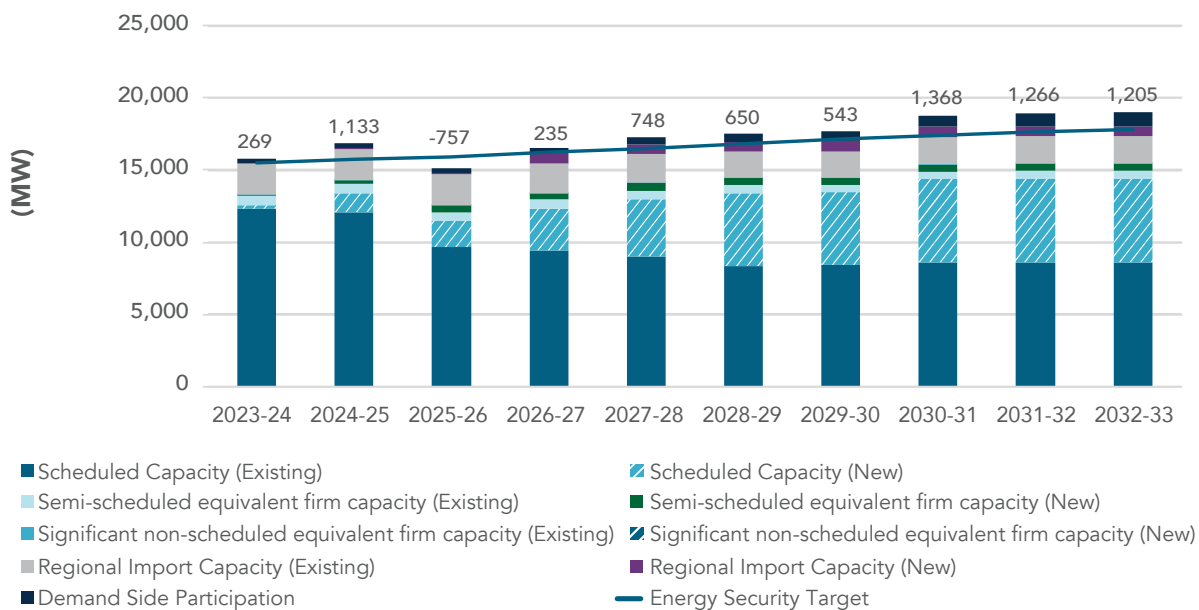
The EST outlook under this scenario is presented in [Figure 38](#).

Figure 38: EST central scenario



AEMO Services has also considered a sensitivity where projects that are anticipated by AEMO and projects that have received an LTESA are added to the central scenario, as shown previously, though here assumed to be delivered with a delay. Where projects that have received an LTESA are not delivered on their contracted target date, and delivery is delayed in line with AEMO’s standard 2023 ESOO assumptions of delivery date for committed and anticipated projects, there is a breach in the EST in 2025-26, as shown in [Figure 39](#).

Figure 39: EST Central + Anticipated Projects (subject to development delays) and LTESA projects (subject to development delays)



¹⁰⁴ Reports are available on the NSW Government website: energy.nsw.gov.au/nsw-plans-and-progress/major-state-projects/electricity-infrastructure-roadmap/entities-delivering/target-monitor

Appendix B – Resilience to variable renewable energy lulls

B1. Summary

AEMO Services, as Consumer Trustee undertakes an assessment of the resilience of the NSW electricity system in relation to lulls in variable renewable energy (VRE) sources as part of its IIO Report. For the 2023 IIO Report, AEMO Services' assessment indicates that the Development Pathway maintains resilience to various severities of VRE lulls. This resilience is driven by the diversity of VRE capacity, increased transmission and increased LDS and firming capacity introduced via the NSW Electricity Infrastructure Roadmap. VRE lulls do increase reliance on hydro generation, gas generation and imported energy from other regions and materially, but temporarily, increase NSW wholesale prices during lull periods.

This analysis is underpinned by theoretical assumptions that are uncertain and this uncertainty needs to be taken into account in the assessment of the Development Pathway's resilience.

B2. Legislative requirement and interpretation

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 VRE sources, as it relates to the Development Pathway, including by reference to climate modelling.¹⁰⁵

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

- **Lull:** A VRE lull is an extended period of low availability from wind and solar generators. In this analysis, predefined durations 1-day, 3-days and 7-days have been selected. The most severe VRE lulls (the 1-in-43-year cases) are defined as the periods with the lowest amount of NSW VRE availability over each duration. The 1-in-10-year cases are VRE lulls with slightly more NSW VRE availability based on the distribution of the historical data.
- **Climate modelling:** A historical analysis of 43 years of weather data was conducted to identify VRE lull events, more than the 12 weather reference years used to model the Development Pathway. The MERRA-2 atmospheric reanalysis dataset was used, which contains hourly weather observations at a 50 square kilometre granularity. The impact of climate change to the severity of VRE lulls has not been analysed, which is discussed in [Section B5.3](#).
- **Resilience:** Resilience to VRE lulls was analysed across multiple metrics including the sufficiency of generation to meet NSW demand, the impact on wholesale electricity price and the increased reliance on sources of generation additional to VRE, including hydro generation, gas generation and interregional energy imports. Resilience to lulls is analysed as a comparison of a lull event with an equivalent control period which has typical VRE conditions.

With the interpretation outlined above, the assessment covered 18 different VRE lull events, selected to include all combinations of:

- three lull durations: 1-day, 3-day and 7-day periods,
- three forecast years: 2030, 2035 and 2043,
- two lull severities: the 1-in-10-year and 1-in-43-year lull event.

Example: Identifying a 3-day, 2035, 1-in-10-year VRE lull

This refers to a historical VRE lull event which occurred in the last 43 years. The event is identified by assuming the 2035 capacity mix of the Development Pathway, calculating aggregate NSW VRE availability over 3-day periods, and sorting from highest to lowest. The 1-in-10-year event is the 90th percentile event across the distribution, expected to occur about 4 times across 43 years.

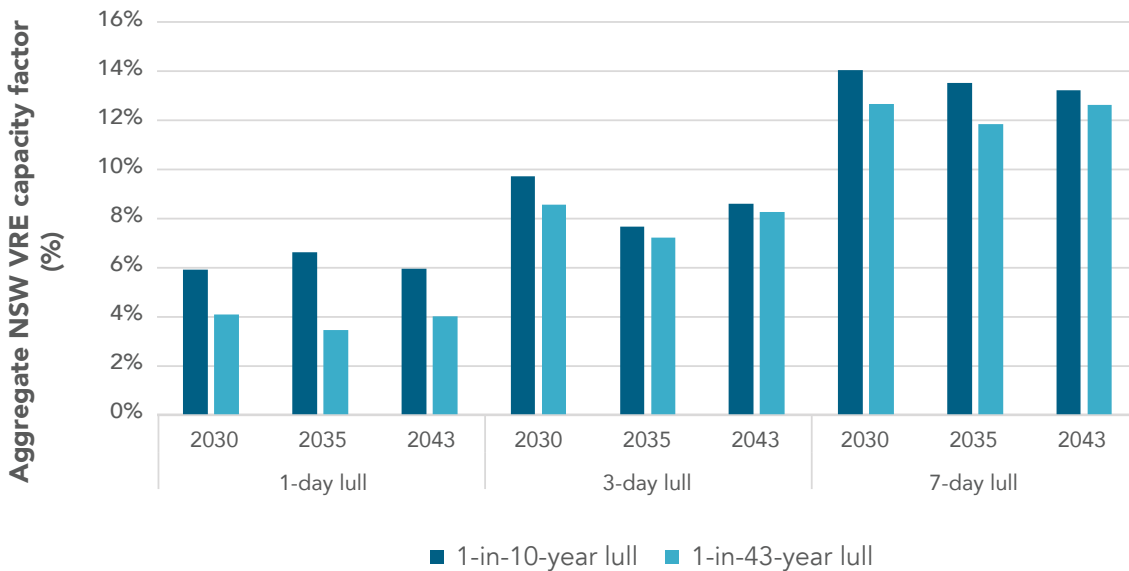
¹⁰⁵ EII Regulation, clause 24(2)(e).

The assessment considered the operation of the electricity system during these lull events compared to equivalent control periods with typical VRE conditions, where the lull events were introduced through adjusted VRE trace data that incorporated the lower availability of wind and solar generation in these events.

B3. Results

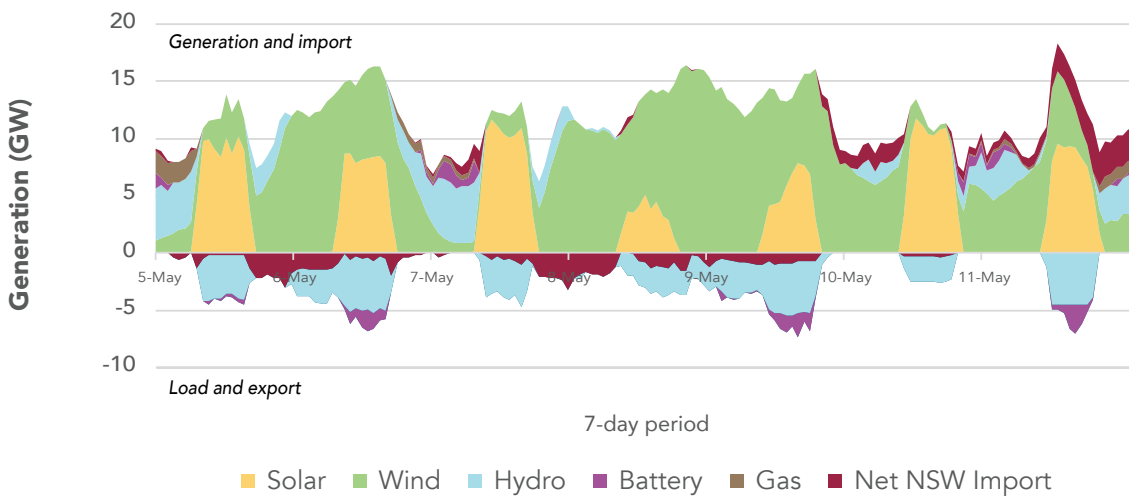
Figure 40 shows the assumed aggregate NSW VRE availability capacity factor over the lull period for each of the 18 modelled lulls. The capacity factor is higher across the longer periods given the variability of VRE decreases over longer durations. The capacity factor is lower across the more severe 1-in-43-year lulls than the 1-in-10-year lull. For reference, the NSW capacity factor over an entire year is about 35% for wind and 28% for solar.

Figure 40: Assumed aggregate NSW VRE availability capacity factor over the VRE lull period



The 7-day VRE lulls simulated in the 2043 forecast are presented and analysed in detail. Figure 41 shows modelled NSW generation of the Development Pathway by technology type in the control case, a 7-day period with typical VRE conditions from the 2019 reference year. In the 2043 forecast year, the Development Pathway contains 16 GW of wind capacity and 20 GW of large-scale solar capacity. In this 7-day control case, the aggregate NSW VRE availability capacity factor is 31.6%.

Figure 41: NSW generation (GW) during the control case (a 7-day period simulated in 2043 with typical VRE conditions)



In the control case, VRE generation meets the majority of NSW demand, with hydro, battery and gas projects dispatched as needed. NSW is a net exporter of energy to other regions, relying on import energy as needed.

[Figure 42](#) and [Figure 43](#) show modelled NSW generation during the 1-in-10-year and 1-in-43-year VRE lull simulations respectively, also for the 2043 forecast year. These VRE lulls occurred in 2021 and 1991 and have aggregated NSW VRE availability capacity factors of 13.2% and 12.6% respectively. NSW operational demand is constant across these two VRE lulls and is higher than occurred during the control case.

Figure 42: NSW generation (GW) during the 1-in-10-year case (a 7-day lull simulated in 2043 with 1-in-10-year VRE lull conditions)

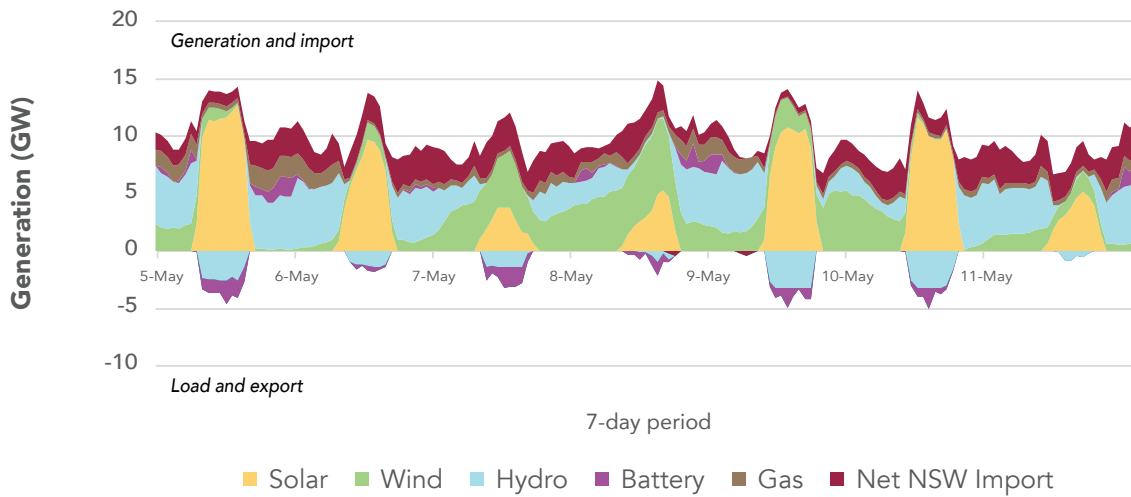
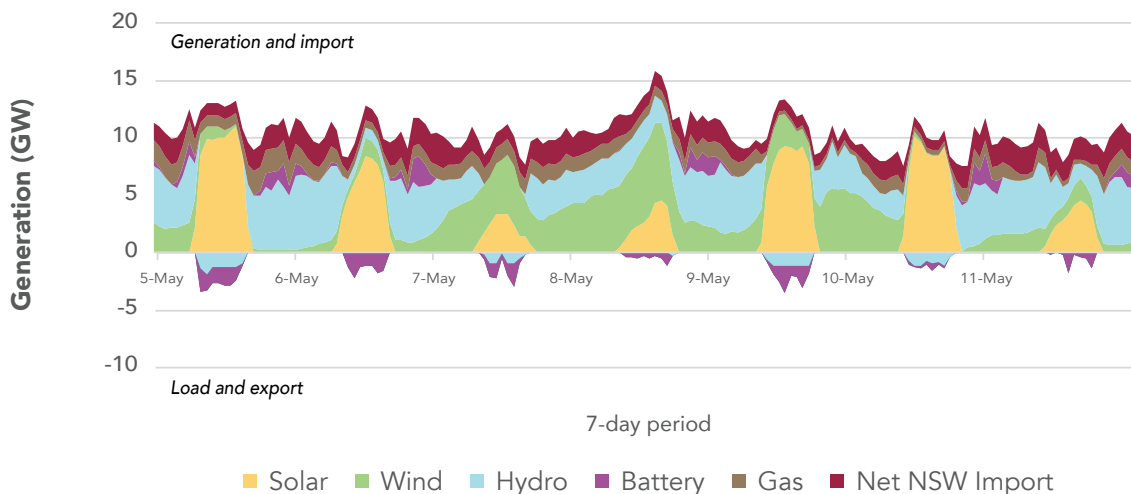


Figure 43: NSW generation (GW) during the 1-in-43-year case (a 7-day lull simulated in 2043 with 1-in-43-year VRE lull conditions)



In both VRE lull cases, there is sufficient generation to meet NSW demand. The reduction in VRE availability is mostly replaced by hydro generation, gas generation and imported energy. Energy assumed to be imported from other regions may be unrealistic and therefore resilience of the NSW system may be over-estimated. [Figure 44](#) shows an increase in NSW hydro generation (above the x-axis) and a decrease in hydro pumping (below the x-axis) for both VRE lull cases compared with the control case. The model is able to maximise reservoir levels prior to the VRE lull, reducing the need to pump during the VRE lull, the implication of which is discussed in [Section B5.3](#).

Figure 44: NSW hydro generation and load (MW) comparison between cases

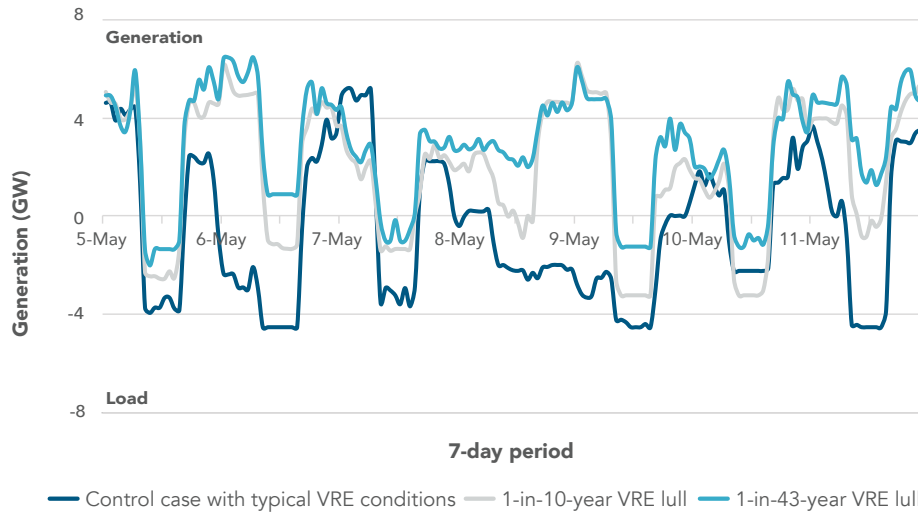


Figure 45 shows an increase in NSW gas generation for both VRE lull cases compared to the control case across the 7-day event.

Figure 45: NSW gas generation (MW) comparison between cases

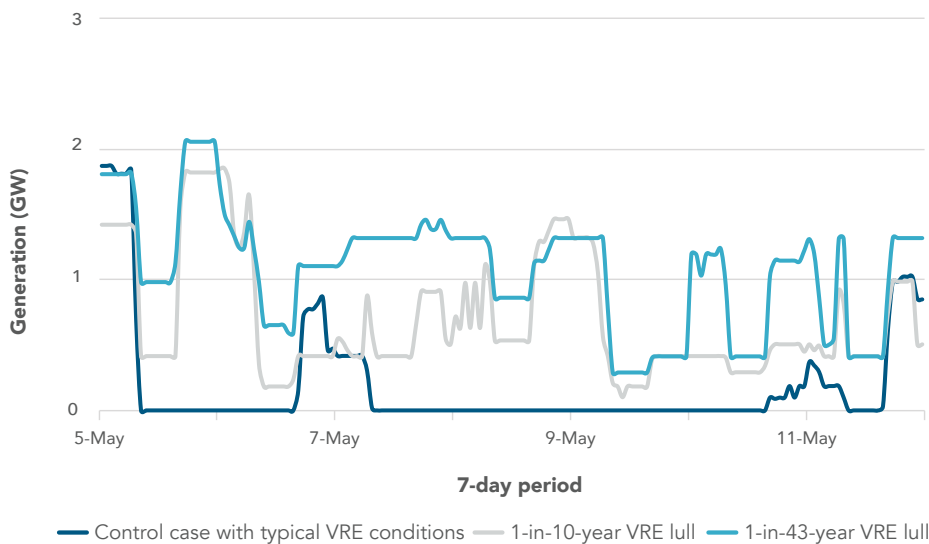
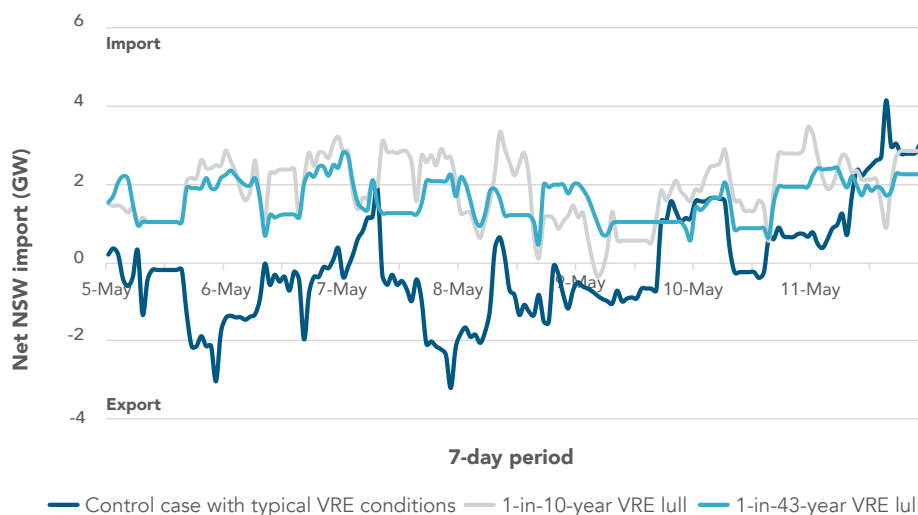


Figure 46 shows an increase in net imported energy (above the x-axis) and a decrease in net exported energy (below the x-axis) for both VRE lull cases compared to the control case. The 1-in-43-year VRE lull case relies less on imported energy than the 1-in-10-year VRE lull case, given this historically observed lull had coinciding low VRE availability in Victoria.

Figure 46: NSW net import (MW) comparison between cases



Additionally, batteries cycle more frequently during the VRE lull events, at 1.6 cycles per day on average, compared to the control case at 1.0 cycles per day on average, to further time-shift supply to better meet demand.

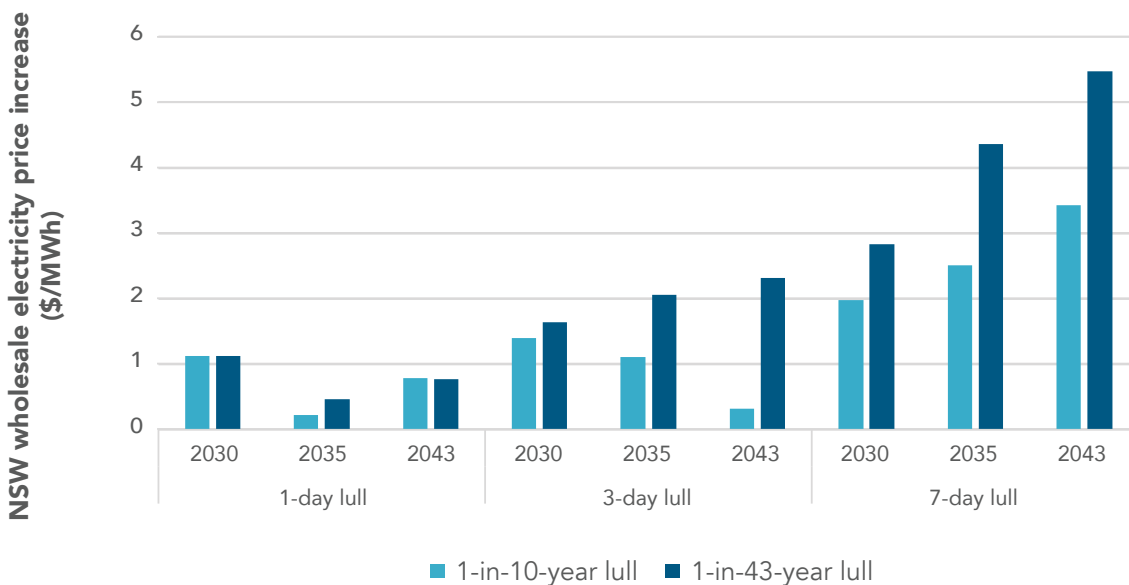
Table 15 compares the average NSW wholesale price outcomes, both over the 7-day period and over the entire simulated year. The impact of the 7-day VRE lulls to NSW price is material, driven by lower availability of low-cost VRE and greater reliance on higher cost gas, hydro and imports.

Table 15: NSW load-weighted wholesale electricity price comparison between cases in 2043

	Control case with typical VRE conditions	1-in-10-year VRE lull	1-in-43-year VRE lull
7-day average price (during the lull event)	\$47/MWh	\$158/MWh	\$195/MWh
Annual average price	\$36/MWh	\$39/MWh	\$42/MWh

The full set of VRE lull simulations showed similar results to the 7-day 2043 VRE lulls described above. In all VRE lull cases, there was sufficient generation to meet NSW demand. Figure 47 shows the increase to annual NSW wholesale electricity price of the VRE lull cases relative to the control case with typical VRE conditions.

Figure 47: Increase to annual NSW wholesale electricity price with the lull event compared to typical conditions



The impact on wholesale price is generally greater in later forecast years, as the capacity of VRE in NSW increases, thereby rendering VRE lulls more impactful. The noise in this correlation can be explained by the unique characteristics associated with each historical VRE lull.

B4. Discussion

In all VRE lull cases in this analysis, there was sufficient generation to meet NSW demand. The analysis indicates that the NSW Development Pathway is resilient to VRE lulls which have occurred over the last 43 years.

This resilience is supported by three main drivers:

- 1. Geographic diversity of VRE capacity:** In this analysis, the most severe VRE lulls modelled still provided some VRE generation, with the 7-day, 1-in-43-year VRE lull in 2043 having an aggregate VRE capacity factor of 12%. This is enabled by the geographical diversity of VRE developed across NSW REZs in the Development Pathway. The availability profile of VRE, particularly wind, varies across NSW. Expanding VRE across NSW mitigates against the risk of localised VRE lulls.
- 2. Increased transmission:** In this analysis, NSW relied on imported energy during the VRE lulls to meet NSW demand. This was enabled by the assumed expansion of interconnection with South Australia (EnergyConnect), Victoria (VNI West) and Queensland (QNI Connect). This analysis also relied on transmission within NSW to enable imported generation and generation from NSW REZs to reach the load centres, including Hunter Transmission Project, Waratah Super Battery and Humelink.
- 3. Increased long-duration storage and firming capacity:** In this analysis, NSW relied on dispatchable capacity from existing and new long-duration storage and firming infrastructure, including hydro generation, storages and gas generation.

This analysis relies on many assumptions in modelling the characteristics of historical VRE lulls, and the dispatch of supply and demand in response to the VRE lulls. These assumptions are uncertain and may overestimate the resilience of the Development Pathway indicated by the analysis. Limitations are further explored in [Section B5.3](#).

B5. Approach

B5.1. Evolution of the VRE lull analysis

The VRE lull method has evolved since the inaugural analysis in the 2022 IIO Report, as shown in [Figure 48](#).

Figure 48: Evolution of the VRE lull assessment



The consultation on the 2022 IIO Report led to three key methodological improvements, as shown in [Table 16](#).

Table 16: Methodological improvements since the 2022 IIO VRE lulls analysis

	2022 IIO Method	2023 IIO Method	Reason for update
VRE lull definition	The maximum duration for which rolling average wind speeds and solar irradiance in a NSW REZ fell below a defined threshold.	The minimum NSW VRE availability over defined durations (1, 3 and 7 days).	Aggregating the definition to NSW availability is more holistic. Fixing the VRE lull duration rather than fixing an output threshold is simpler to define and analyse.
Resilience assessment	VRE lulls were extended and assessed via post processing analysis.	VRE lulls were endogenised into time-sequential modelling.	Capturing half-hourly dispatch dynamics gives a more accurate representation of market outcomes to inform a resilience assessment.
Approach	Assessed <i>whether</i> the Development Pathway was resilient to VRE lulls.	Assessed <i>how</i> resilient the Development Pathway is to VRE lulls.	Given the uncertainties surrounding VRE lull resilience, it is appropriate to analyse a broader set of outcomes than unserved energy.

B5.2. 2023 IIO Report VRE lulls method

The method has been developed to assess to what extent the NSW Development Pathway is resilient to VRE lulls which occurred between 1980 and 2022. The following key terms are defined as follows:

- **Weather reference year:** A timeseries of wind or solar availability (MW) developed by AEMO, reflective of historical years ranging from 2011 to 2022.
- **Historical trace:** A timeseries of wind or solar availability (MW) reflective of historical years, ranging from 1980 to 2022.
- **Host trace:** The historical trace for which the VRE lull events are inserted into.
- **Synthetic trace:** A historical trace with a VRE lull event inserted into it.
- **Typical VRE lull:** A 1-in-2-year VRE lull as observed in the weather reference years or historical traces.
- **Extreme VRE lull:** A 1-in-10-year or 1-in-43-year VRE lull as observed in the historical traces.
- **Capacity factor:** The average availability from a generator, or a group of generators, divided by their nameplate capacity. A typical capacity factor for solar and wind in NSW is 28% and 35% respectively. Whilst capacity factors are typically used to describe availability over an entire year, this analysis uses the term to describe availability over the 1-day, 3-day, and 7-day VRE lull events.

The method contains the following four stages:

1. Identify historical VRE lull events
2. Create synthetic traces
3. Re-run time-sequential model of the Development Pathway with synthetic traces.
4. Assess the resilience of the Development Pathway with respect to impacts on wholesale price and reliance on non-VRE generation sources and imported energy.

Stage 1: Identify historical VRE lull events.

The MERRA-2 reanalysis weather dataset developed by NASA was used to create VRE lulls. The dataset covers the 43-year period between 1980 and 2022 at a 50 square kilometre granularity. A statistical power curve model was used to convert the weather data into historical traces for each existing and new entrant generators in the NEM.

The assessment created 18 VRE lulls, as described in [Section B2](#).

The 1-in-43-year VRE lull was the period with the lowest NSW VRE availability over the dataset. The 1-in-10-year VRE lull was based on the distribution of VRE lulls, so that about four events of this severity occurred over the 43-year dataset.

Stage 2: Create synthetic traces.

Synthetic weather traces were created by inserting VRE lull events into a host trace. The 2019 historical year was selected as the host year due to its typical weather conditions. The VRE lull events were created by identifying VRE lull events from AEMO weather reference years and scaling these to reflect more extreme historically observed VRE lull events. The scaling factor represents the relativity between typical and extreme VRE lulls in the historical traces. The scaling was applied by technology and by region to preserve the historical conditions. The historical traces were not used directly in this analysis, which is further discussed in [Section B5.3](#).

When inserting the VRE lull event into the host trace, the simultaneous wind, solar and demand profiles across the entire NEM were all inserted, as to preserve the weather-driven relationship between these variables. The NSW capacity mix is maintained for each forecast year and reflective of the Development Pathway. The day-of-the-week relationship was also maintained, given the differences in demand between weekdays and weekends. Whilst VRE was scaled downwards to reflect more severe VRE lull events, demand was assumed consistent with that of a typical VRE lull.

Stage 3: Re-run time-sequential model of the Development Pathway with synthetic traces.

The time-sequential model of the Development Pathway was re-run with the synthetic traces from stage 2. A control case was simulated for each forecast year using the unadjusted 2019 historical reference year. The assumptions made for the time-sequential model in the VRE lull assessment match the assumptions used in the time-sequential modelling of the Development Pathway. This included maintenance and forced outages, which were held constant across VRE lull cases for each assessed forecast year. Storage units operated with perfect foresight, which is further discussed in [Section B5.3](#).

Stage 4: Assess the resilience of the Development Pathway.

Resilience was analysed across multiple metrics including impact on wholesale electricity price and the adequacy of generation to meet NSW demand. The increased reliance on sources of generation additional to VRE, including hydro generation, gas generation and interregional energy imports was also analysed. Resilience to lulls was analysed as a comparison of a lull event with an equivalent control case which has typical VRE conditions.

B5.3. Limitations

This analysis relies on many assumptions in representing the characteristics of historical VRE lulls, and in simulating dispatch outcomes during a VRE lull event. These assumptions are uncertain and may overestimate the resilience of the Development Pathway indicated by the analysis.

The following limitations underpin the VRE lull resilience assessment:

- **The profile of historical VRE lull events is not captured.** In this analysis, the definition of VRE lulls is more closely tied to the aggregated NSW VRE availability of historically observed lulls, rather than their detailed profiles. The analysis relied on the detailed profiles of typical VRE lull events already captured in the weather reference years used to model the Development Pathway. The NSW VRE availability was then scaled downward to reflect more severe VRE lull events which occurred over the 43-year historical dataset. The implication of this approach is that the dynamics of historically observed lulls and the impact this would have on dispatch is not accurately captured. This approach was taken given the historical traces contained less severe VRE lulls than the weather reference years and would therefore not be useful if inserted into the host trace directly. For NSW VRE generators, the scaling was equal to the between extreme and typical VRE lull events within historical traces. For other regions, scaling was used to achieve the VRE availability in the historical trace. Scaling was performed on a technology and regional-specific basis.
- **The most extreme historical periods may not have been identified.** Firstly, the identification of historical periods was based on minimum NSW VRE availability rather than maximum NSW residual demand,¹⁰⁶ given this is prescribed in the EII Regulations.¹⁰⁷ Considering demand when identifying the VRE lulls may have resulted in more challenging periods for NSW resilience, particularly in winter when demand is high. Secondly, for timing reasons, the identification of the historical VRE lulls was based on the Draft Development Pathway from the Draft 2023 IIO Report. The identification of VRE lulls does depend upon the timing, volume and location of new VRE infrastructure.¹⁰⁸ After the VRE lulls were identified, the VRE lull assessment was still carried out using the capacity mix of the final 2023 IIO Report Development Pathway.
- **The modelled amount of gas generation and imported energy from other regions may be unrealistic.** Gas generators run continuously for multiple days to meet NSW demand during the modelling VRE lull events. For this to be realistic, there may need to be investment in the supply, distribution, and operation of NSW gas generation. NSW also relies on imported energy from other regions, which assumes significant investment in transmission, generation, storage, and firming infrastructure in those regions as per the set of modelling assumptions used in setting the Development Pathway.
- **Demand was kept constant across the VRE lull events.** The 2022 IIO Report showed a binary correlation between the occurrence of a VRE lull event and higher operational demand. The updated method maintains demand across the VRE lulls given the demand is already reflective of a typical VRE lull and the binary relationship is not appropriate for increasing the severity of the VRE lulls.

The assessment contains the following general modelling limitations:

- **Dispatchable generation is operated with perfect foresight.** With perfect foresight, hydro and storage units operate in a way which maximises their storage or reservoir levels before the VRE lull event. This may be an unrealistic representation of the ability of energy-limited dispatchable capacity to respond to VRE lull events, thereby potentially over-estimating the modelled resilience of the system.
- **Variables simulated in a reliability assessment were not captured.** This analysis does not extend to other variables which impact reliability such as hydro droughts, generator outages or transmission outages.

General uncertainty about the future:

- **The potential impact of climate change on VRE lull severity has not been captured.** There is limited research on the impacts of climate change on the detailed wind and solar availability profiles. It is possible that this analysis, which relies on historical observations, does not adequately capture potential extreme lull events of the future. In conjunction with AEMO, AEMO Services is seeking to improve its approach to consideration of climate change on the resilience of the energy system for future reports. AEMO Services is aware of the NSW Government's NARCLiM¹⁰⁹ project and there is potential to utilise this work for future reports.

¹⁰⁶ Equal to operational demand minus VRE availability.

¹⁰⁷ EII Regulation, clause 24(2)(e)

¹⁰⁸ That is, a Development Pathway with large amounts of VRE capacity concentrated in one specific geographical region will be less resilient to severe lulls in that region.

¹⁰⁹ NSW and Australian Regional Climate Modelling (NARCLiM) is a NSW Government led initiative that generates detailed climate projections and data for NSW.

Appendix C – Regulatory requirements

Regulations made under the EII Act mandate certain items that must be contained in a report prepared by the NSW Consumer Trustee regarding the infrastructure investment objectives, as well as matters which the NSW Consumer Trustee must take into account in preparing such reports.¹¹⁰

A summary of the relevant requirements, and where they are addressed in this report, are set out in the table below.

Regulation	Report reference
An infrastructure investment objectives report must contain the following:	
how the infrastructure required under the development pathway specified in the report will assist in achieving the infrastructure investment objectives,	Sections 2 and 3
information about the expected timing, staging and sequencing of the construction of: (i) the infrastructure required under the development pathway, and (ii) REZ network infrastructure projects that may be required,	Sections 3.3, 3.4, 3.5 and 3.6
a comparative assessment of the merits of constructing long-duration storage infrastructure that exceeds the minimum objective specified in section 44(3)(b) of the EII Act and firming infrastructure to meet the reliability standard,	Sections 3.4 and 3.5
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,	Section 3.7.1
details of the current, planned and expected construction and operation of infrastructure for the supply of electricity in New South Wales and the national electricity market,	Sections 2, 3, 4 and 5
an analysis, including the methodology, of the risks to NSW electricity customers of early or delayed investment in relevant infrastructure,	Sections 3.8 and 5
an estimate of the amount of electricity in gigawatt hours that is equivalent to the gigawatts of capacity required under the minimum objectives specified in section 44(3) of the EII Act, using information in the 2020 Integrated System Plan published by AEMO under the National Electricity Rules,	Section 2.2
a description of the changes since the previous report to (i) the development pathway, and (ii) the plan for competitive tenders under the Act, section 45(1)(b),	Sections 3 and 4
the outcomes of tenders carried out since the previous report, including (i) the number of persons who made a bid in each tender, including the number of eligible and ineligible bids according to the rules made under the Act, section 47(5), and (ii) the number of LTES agreements recommended by the Consumer Trustee after each tender, and (iii) the number of LTES agreements entered into.	Section 2.5
The NSW Consumer Trustee must take the following into account in preparing an infrastructure investment objectives report:	
any target breaches identified in the most recent energy security target monitor report,	Section 2.4.3
the forecast of unserved energy from the most recent statement of opportunities published by AEMO under the National Electricity Rules,	Sections 2.4.2, 3.4, 3.5 and Appendix A
the most recent Integrated System Plan published by AEMO under the National Electricity Rules,	Sections 1.3, 3.8 and 5
the market conditions, including supply chains and labour and capital constraints,	Section 3.3
the payments required to be made by the scheme financial vehicle under existing and planned LTES agreements,	Section 3.7.1
how the development pathway in the report will contribute to the object under section 3(1)(a) of the EII Act,	Section 3
the resilience of the NSW electricity system in relation to lulls in variable renewable energy sources, including by reference to climate modelling.	Section 3.7.3 and Appendix B
When preparing the development pathway, the NSW Consumer Trustee must:	
take into account several scenarios for the construction of generation, long-duration storage and firming infrastructure in New South Wales,	Section 3.8 and Appendix A
analyse the resilience of the outcomes for each scenario, including in relation to (i) the reliability of supply and (ii) the financial exposure risks to NSW electricity customers.	Section 3.8 and Appendix A

¹¹⁰ Electricity Infrastructure Investment Regulation 2021, regulations 24 and 25.

List of tables and figures

Tables

Table 1: Information excluded from IIO Report modelling	24
Table 2: Tender projects	32
Table 3: Tender Participation	33
Table 4: REZ network and priority transmission infrastructure projects underpinning the Development Pathway	46
Table 5: Current, actionable or future ISP projects underpinning the Development Pathway	48
Table 6: Cost components included in forecast of costs for provision of wholesale energy services to NSW customers	50
Table 7: Modelled optimal timing of NSW REZ network infrastructure projects (financial year ending)	61
Table 8: Key modelling assumptions for supply-side considerations	69
Table 9: Key modelling assumptions for demand-side considerations	70
Table 10: Key modelling assumptions for capital costs of renewable technologies	70
Table 11: Key generation build limit modelling assumptions	71
Table 12: Key modelling assumption diversions from the Draft 2024 ISP related to timing and policy	72
Table 13: Infrastructure Delay Sensitivity modelling assumptions	73
Table 14: Reliability gap forecast for 2025-26 and 2026-27 with LTESA projects	75
Table 15: NSW load-weighted wholesale electricity price comparison between cases in 2043	82
Table 16: Methodological improvements since the 2022 IIO VRE lulls analysis	84

Figures

Figure 1: Timeline	5
Figure 2: Summary of stakeholder feedback themes	5
Figure 3: Progress made to date toward achieving the minimum objective for generation	11
Figure 4: NSW Development Pathway (Generation)	12
Figure 5: 10-Year Plan (Generation)	13
Figure 6: NSW Development Pathway Long-duration storage reflecting the latest tender outcomes	13
Figure 7: 10-Year Plan (Long-duration storage)	14
Figure 8: NSW Development Pathway Firming reflecting the latest tender outcomes (including Tender 2)	15
Figure 9: Forecast of annual costs for the supply of wholesale energy services to NSW electricity customers (2024-2033 total \$b)	17
Figure 10: Defining features of the Infrastructure Investment Objectives Report	18
Figure 11: Summary of IIO Reports released to date	19
Figure 12: The IIO Report as part of a broader planning framework	21
Figure 13: Infrastructure investment objectives and eligible infrastructure	25
Figure 14: Progress made to date toward achieving the minimum objective for generation	29
Figure 15: Overview of IIO Report modelling steps	34
Figure 16: Overview of scenarios considered	35
Figure 17: NSW Development Pathway - Annual (Generation)	36

Figure 18: NSW Development Pathway - Cumulative (Generation).....	36
Figure 19: Forecast installed capacity in NSW over time	38
Figure 20: Comparison of Development Pathway to 2023 Draft and 2022 Development Pathways (Generation)	39
Figure 21: NSW Cumulative long-duration storage pathway.....	40
Figure 22: Comparison of Development Pathway to 2023 Draft and 2022 Development Pathways (Long-duration storage)	41
Figure 23: NSW Cumulative firming pathway reflecting the latest tender outcomes (including Tender 2)	43
Figure 25: New entrant VRE generation by REZ	47
Figure 26: Components of Customer Bill Modelled in IIO Reports	52
Figure 27: Forecast of annual costs for the supply of wholesale energy services to NSW electricity customers (2024-2033 total \$b)	53
Figure 28: Comparison of alternative development pathways (generation)	57
Figure 29: Comparison of alternative development pathways (long-duration storage).....	57
Figure 30: Comparison of alternative development pathways (firming)	58
Figure 31: Present value of forecast costs by scenario.....	59
Figure 32: Comparison of modelled NSW emissions profiles.....	60
Figure 33: NSW declared renewable energy zones and NER transmission projects and EII Act priority transmission infrastructure projects.....	63
Figure 34: 10-Year Plan (Generation)	65
Figure 35: 10-Year Plan (Long-Duration Storage)	66
Figure 36: Reliability assessment of the Development Pathway against the reliability standard.....	74
Figure 37: EST Central + Anticipated Projects (subject to development delays) and LTESA projects (delivered on target date)	76
Figure 38: EST central scenario	77
Figure 39: EST Central + Anticipated Projects (subject to development delays) and LTESA projects (subject to development delays).....	77
Figure 40: Assumed aggregate NSW VRE availability capacity factor over the VRE lull period	79
Figure 41: NSW generation (GW) during the control case (a 7-day period simulated in 2043 with typical VRE conditions).....	79
Figure 42: NSW generation (GW) during the 1-in-10-year case (a 7-day lull simulated in 2043 with 1-in-10-year VRE lull conditions)	80
Figure 43: NSW generation (GW) during the 1-in-43-year case (a 7-day lull simulated in 2043 with 1-in-43-year VRE lull conditions)	80
Figure 44: NSW hydro generation and load (MW) comparison between cases.....	81
Figure 45: NSW gas generation (MW) comparison between cases	81
Figure 46: NSW net import (MW) comparison between cases	81
Figure 47: Increase to annual NSW wholesale electricity price with the lull event compared to typical conditions.....	82
Figure 48: Evolution of the VRE lull assessment.....	83