

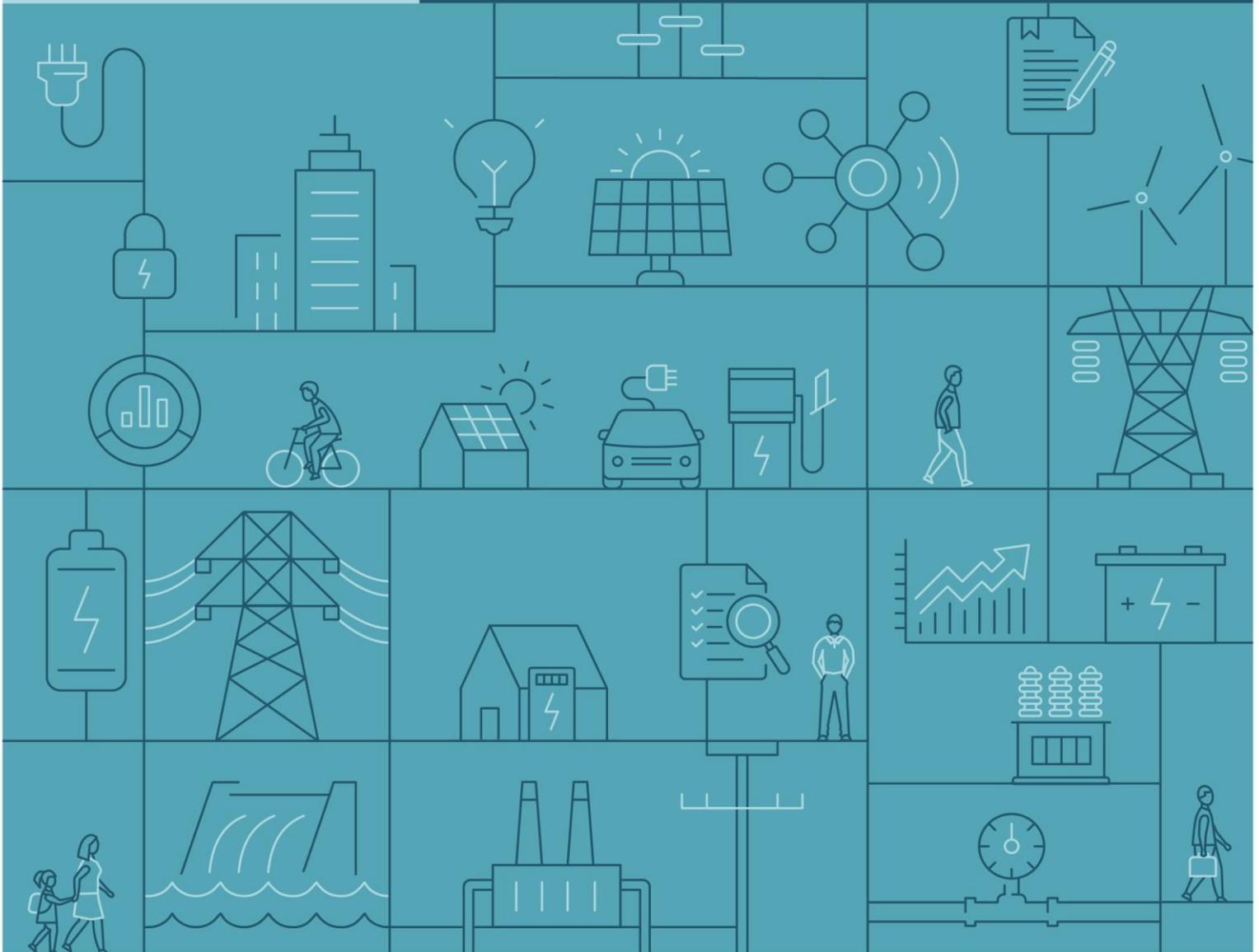


Consumer
Trustee



2021 Infrastructure Investment Objectives Report

December 2021



Important notice

PURPOSE

AEMO Services Limited acting as the NSW Consumer Trustee publishes the Infrastructure Investment Objectives Report under section 45(1) of the *Electricity Infrastructure Investment Act 2020* (NSW).

This publication has been prepared by AEMO Services using information available at 20 July 2021. Information made available after this date may have been included in this publication where practical.

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VERSION CONTROL

Version	Release date	Changes
#1	7/12/2021	First release

Executive summary

In November 2020, the NSW Parliament passed the *Electricity Infrastructure Investment Act 2020* (EII Act), the legislation enabling the delivery of the NSW Government's Electricity Infrastructure Investment Roadmap (Roadmap). The EII Act establishes the NSW Consumer Trustee, an independent statutory role with various planning, advisory and procurement functions that it must exercise to deliver in the long-term financial interests of NSW electricity customers.

In July 2021, the NSW Minister for Environment and Energy appointed AEMO Services Limited as the NSW Consumer Trustee, with an effective date of 31 October 2021.

A key function of the NSW Consumer Trustee is planning for the achievement of the infrastructure investment objectives established by the EII Act. These include:

- minimum objectives for the construction of specified amounts of renewable generation infrastructure and long-duration storage infrastructure by the end of 2029, and
- overall objectives to construct additional infrastructure necessary to minimise costs to NSW electricity customers and meet the NSW energy security target¹ and reliability standard.

This report, the 2021 Infrastructure Investment Objectives Report, sets out:

- the NSW Consumer Trustee's 20-year Development Pathway for the construction of electricity infrastructure in NSW to achieve the infrastructure investment objectives, and
- its 10-Year Plan for conducting competitive tenders for Long-term Energy Service (LTES) agreements to give effect to the Development Pathway.

Following presentation of these plans, the report then sets out the approach that was used to select the 20-year Development Pathway.

This report, which is required to be updated every two years, will inform the NSW Consumer Trustee's exercise of its advisory and procurement functions. It will also serve as a critical market signal and input to decision-making in other areas of the Roadmap.

Development Pathway

The NSW Consumer Trustee has set out a Development Pathway that is designed to deliver the infrastructure investment objectives in a practically feasible way. Accordingly, the Development Pathway sets out a managed build. The build is approximately aligned with the anticipated timing of the development of renewable energy zone (REZ) network infrastructure in NSW, but also seeks to avoid peaks and troughs in construction activities by smoothing construction over the first 10 years.

This approach acknowledges that the construction required in NSW will:

- likely occur in the context of a global renewable energy infrastructure boom and seeks to mitigate the significant risks associated with global supply chain constraints and disruptions, and
- affect local communities and seeks to both minimise local impacts and create local supply chain opportunities.

¹ Planning for the construction of firming infrastructure to meet the energy security target is only required to be undertaken by the NSW Consumer Trustee in the event that the Minister has directed the NSW Consumer Trustee to undertake firming infrastructure tender, which has not occurred to date.

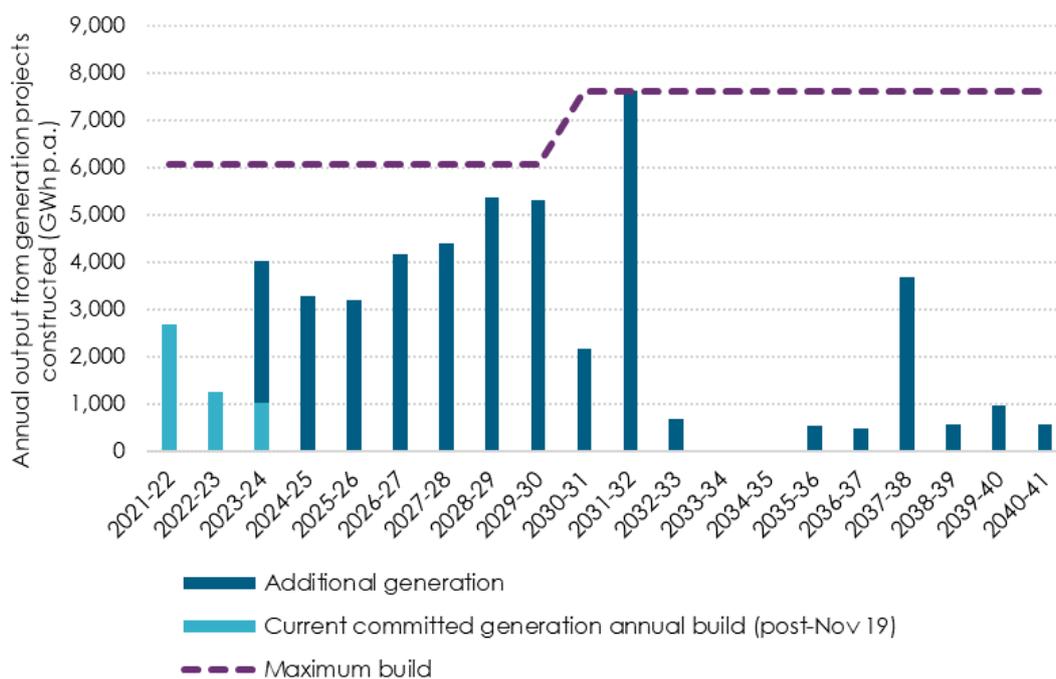
Alternative approaches more closely reflect outputs from electricity market modelling, optimising the benefits of renewable energy development in reducing wholesale prices with the timing of coal withdrawals as the plants reach end-of-life (and the subsequent price rises). Optimised build trajectories tend to result in peaks and troughs reflecting the modelled timing of coal withdrawals. Electricity market modelling is important in understanding how the build trajectory influences costs to NSW customers and how the NSW Consumer Trustee may respond to any early coal plant withdrawals. However, the modelling – which is reliant on input assumptions – is ultimately limited in its ability to accurately forecast the timing of such withdrawals².

The Development Pathway seeks to support the entry of new generation and long-duration storage infrastructure as soon as practicable, having regard to supply chain constraints and opportunities, and independent of the timing of coal plant withdrawals. This approach ensures that sufficient energy is available in NSW in advance of any unexpectedly early coal plant withdrawal that may occur, and also allows for construction to be brought forward if such a withdrawal were to occur.

Generation infrastructure Development Pathway

The generation infrastructure Development Pathway sets out the plan for the construction of renewable energy generation (by financial year) over a 20-year period (see Figure 1).

Figure 1 Development Pathway (Generation)



The Development Pathway seeks to meet the minimum objective of the completed construction of generation projects capable of producing a combined 33,600 GWh of electricity per year by the end of

² Existing NSW coal plants are already under significant economic pressure. In 2021 alone, the planned withdrawal dates for three Australian coal plants have brought forward. Withdrawal of such generation capacity from the market is subject to the commercial decisions of the relevant asset owners, who must consider a complex range of commercial factors including maintenance costs, supplier and customer contracts, end of life remediation costs and competition from other coal plants, all of which are unable to be reflected in a market model. Accordingly, the timing of such withdrawals is subject to a high degree of uncertainty.

2029³. It also seeks to meet the overall objective of minimising costs to NSW electricity customers while delivering the above generation development.

The Development Pathway for generation should be interpreted as being neither technology- nor location-specific. That is, the NSW Consumer Trustee's recommendations for LTES agreements will be based on which projects represent the highest value for NSW electricity customers at the time of the competitive tender processes, regardless of technology or location⁴.

The Development Pathway for generation aligns the construction with the anticipated delivery of network infrastructure for renewable energy zones (i.e. for the Central-West Orana and New England zones) while ensuring that, prior to 2030, annual build never:

- exceeds an annual cap of new generation projects capable of producing 6,000 GWh of electricity per year, or
- goes below a minimum annual threshold of new generation projects capable of producing 1,400 GWh of electricity per year.

The annual cap is intended to minimise the risks of supply chain constraints. The annual minimum threshold allows the NSW Consumer Trustee to establish a tender schedule that allows for frequent tenders, which is intended to enhance competition for LTES agreements and deliver value to NSW electricity customers.

The alignment of the construction of generation infrastructure with network infrastructure for renewable energy zones is intended to provide potential benefits to local communities and reduced costs to electricity customers through better network utilisation. The NSW Consumer Trustee expects further detail regarding planned network infrastructure to be developed by the Energy Corporation of NSW – the entity responsible for developing the five renewable energy zones specified in the EII Act – in its forthcoming Network Infrastructure Strategy Network Infrastructure Strategy⁵. The Network Infrastructure Strategy is intended to become an input to future infrastructure investment objective reports.

The Development Pathway also shows generation infrastructure is required beyond 2029 in response to ongoing coal withdrawal scheduled to occur in this decade. However, the scale of construction of generation needed in the 2030s is subject to a higher degree of uncertainty. Demand for electricity in this decade will be strongly impacted by trends in electrification of transport and other sectors which currently depend on fossil fuels. The emergence of a hydrogen production industry would also have significant impacts on the demand for electricity and the corresponding requirement for generation. Where these trends accelerate, for example, in line with the Australian Energy Market Operator's recent 'Hydrogen Superpower' scenario⁶, greater demand is likely to require additional generation in this decade, beyond that included in the Development Pathway above.

³ The EII Act expresses the minimum objective for the construction of generation infrastructure in volumetric terms, being infrastructure that generates *at least the same amount of electricity* in a year as 12 GW of generation capacity. The NSW Consumer Trustee, with AEMO, has determined this volumetric requirement to be approximately 33,600 GWh of electricity per year. See Section 2.2.1.

⁴ However, to recommend a LTES agreement that relates to a generation project that is not or will not be part of a renewable energy zone, the NSW Consumer Trustee must be satisfied that it shows outstanding merit: EII Act, s 48(3).

⁵ The Energy Corporation of NSW will work with the Australian Energy Market Operator, the NSW Jurisdictional Planner, NSW distribution network service providers and other parties as relevant, to develop the Network Infrastructure Strategy.

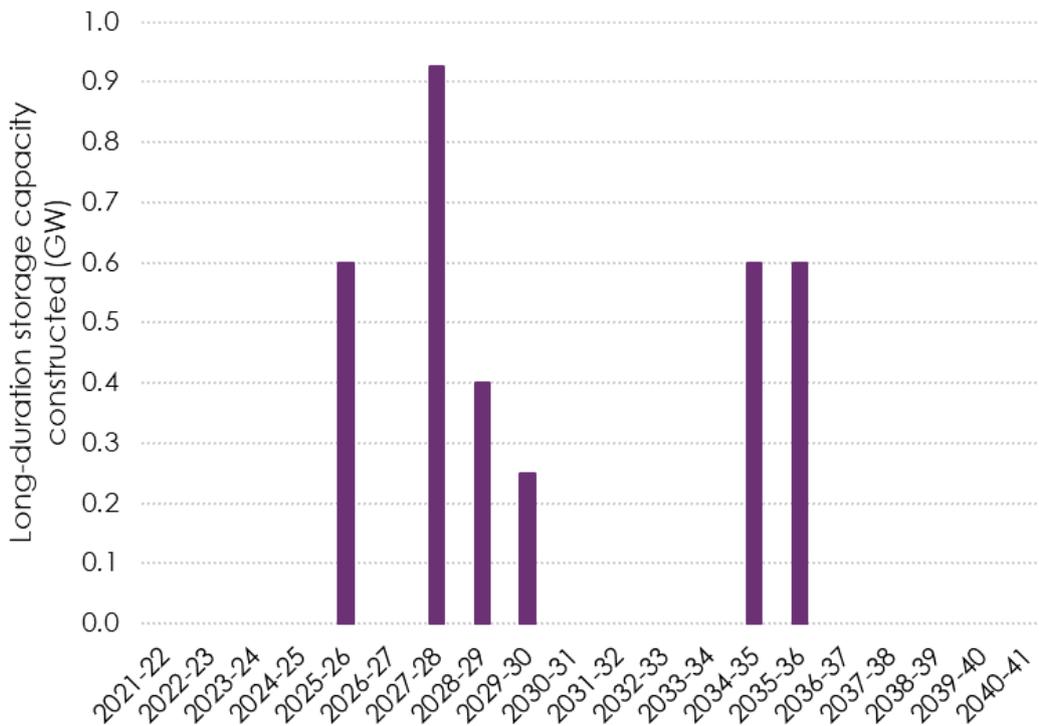
⁶ See Australian Energy Market Operator, *2021 Inputs, Assumptions and Scenarios Report* (July 2021), sections 2.1.5 and 2.4.

Long-duration storage Development Pathway

The long-duration storage Development Pathway sets out the plan for the construction of long-duration storage with a registered capacity that can be dispatched for at least 8 hours (by financial year) over a 20-year period (see Figure 2). The Development Pathway seeks to meet the minimum objective of 2 GW of long-duration storage (excluding the Snowy 2.0 project) to have completed construction by the end of 2029 and the overall objectives of minimising costs to NSW electricity customers and meeting the reliability standard.

Construction of earliest long-duration storage infrastructure does not need to be completed until 2025-26. The majority of capacity required to meet the 2 GW minimum infrastructure investment objective is constructed between 2027-28 and 2028-29. Like the Development Pathway for generation infrastructure, the long-duration storage pathway is also technology- and location-neutral.

Figure 2 Development Pathway (LDS)



The Development Pathway for long-duration storage is subject to a high degree of uncertainty in terms of technology readiness and cost. The cost of long-duration batteries is expected to significantly decline in coming years, although the extent and the rate of the decline are uncertain. Other long-duration storage technologies may also emerge, but their path to commercialisation remains uncertain.

Additionally, it is not clear whether sufficient large-scale pumped hydro energy storage, which typically involves significant lead-times, will be able to be constructed quickly enough to meet the objectives. The NSW Government's Pumped Hydro Grants scheme will help provide deeper understanding of the likely timing, feasibility and cost competitiveness of potential projects.

Network Infrastructure

The Australian Energy Market Operator has identified that network augmentations will be critical to maintaining reliable electricity supply as NSW moves to being powered by dispersed, intermittent renewable energy sources⁷. New network infrastructure will also be required to accommodate the significant additional amount of generation that is to be constructed in the renewable energy zones contemplated by the EII Act.

The market modelling undertaken to assess the Development Pathways for generation and long-duration storage infrastructure assumes that critical network infrastructure, including renewable energy zone network infrastructure and other enabling projects, can proceed in a timely manner in line with AEMO and other industry assumptions.

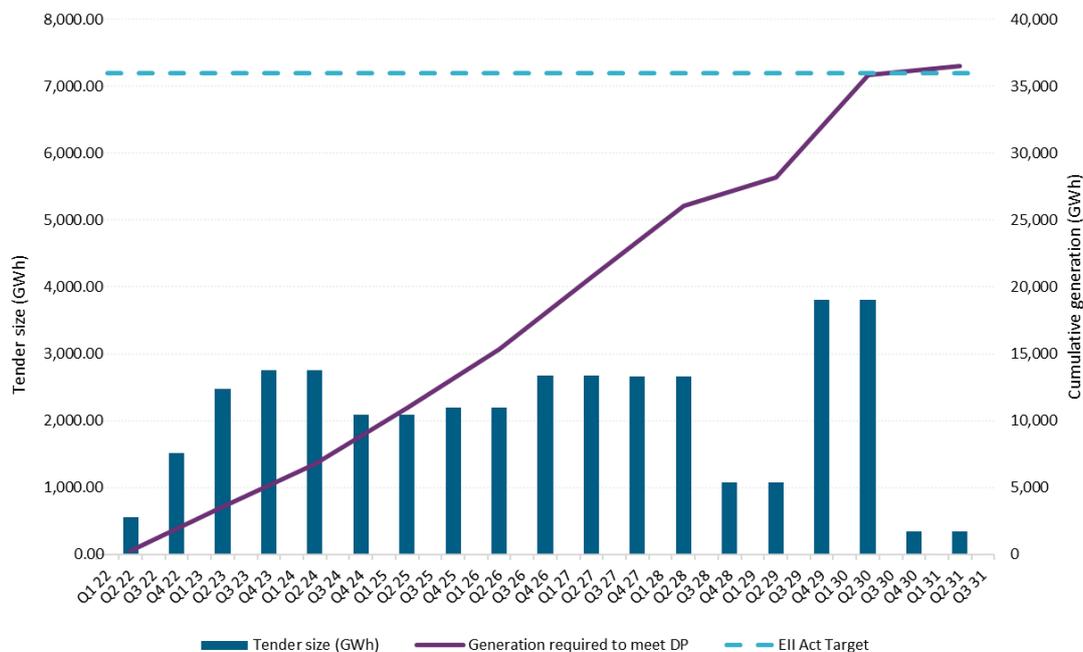
Noting the anticipated importance of network augmentations to the achievement of the Development Pathway (and, in turn, the infrastructure investment objectives), the NSW Consumer Trustee intends to model the optimal timing and size of network infrastructure projects as part of future updates to this report. This work is expected to be informed by analysis contained in future iterations of the Australian Energy Market Operator’s Integrated System Plan (ISP) and, critically, the Network Infrastructure Strategy that is intended to be prepared in 2022 by the Energy Corporation of NSW.

10-Year Plan

10-Year Plan for generation

The 10-Year Plan for generation tenders, as set out in Figure 3, sets out the proposed timing and indicative size of each competitive tender for LTES agreement to be conducted by the NSW Consumer Trustee over a 10-year period. The 10-Year Plan gives effect to the generation Development Pathway.

Figure 3 10-Year Tender Plan (Generation)



⁷ Australian Energy Market Operator (July 2020), 2020 Integrated System Plan, Part D.

Tenders for LTES agreements in respect of generation infrastructure projects are scheduled to occur every six months over the 10-year period, with an indicative targeted volume of between 500 and 2,700 GWh of electricity per year to be delivered by projects from each tender until 2030. These indicative volumes are intended to align with the annual build trajectory under the generation Development Pathway, brought forward to account for an assumed two-year project lead-time.

For any given tender, the NSW Consumer Trustee may recommend LTES agreements for generation greater or less than that indicated in the 10-Year Plan. The decision will be based on the evaluation of submissions received in each competitive tender process against a set of merit criteria, which will include the extent to which a project offers financial value to NSW customers and has a pathway to commercial operation. Further, the plan is subject to change, particularly in respect of those tenders in the later years of the 10-Year Plan. The NSW Consumer Trustee is required to prepare a 10-year plan every two years, at which point the proposed timing and indicative sizing of tenders may be amended.

The volume of generation indicated for the initial two tenders is deliberately lower than might be expected under the Development Pathway. The indicative size of the first tender is particularly small, as it will be conducted as a pilot.

This approach of conducting smaller-scale tenders initially is intended to promote competition and high-value submissions from project proponents over the 10-year period, by enabling the NSW Consumer Trustee to develop further expertise in the conduct of competitive tenders, test various aspects of the tender process and platform, and, most importantly, build understanding of the value of the LTES agreement product across the market. This will mean that in the future, the larger, more critical tenders will have the best chance of giving rise to improved outcomes for NSW electricity customers.

The significant number of renewable energy projects that have already been committed since 14 November 2019 means that development can proceed in line with the development pathway while the NSW Consumer Trustee scales up the size of LTES agreement tenders over time.

10-Year Plan for long-duration storage

The 10-Year Plan for long-duration storage tenders sets out the proposed timing and indicative scale of capacity for each tender to be conducted by the NSW Consumer Trustee over a 10-year period which gives effect to the long-duration storage Development Pathway (see Figure 4). However, as noted above in respect of the 10-Year Plan for generation, the NSW Consumer Trustee may choose to recommend long-term energy service agreements for long-duration storage greater or less than that indicated in the 10-Year Plan where this is in the long-term financial interest of NSW electricity customers.

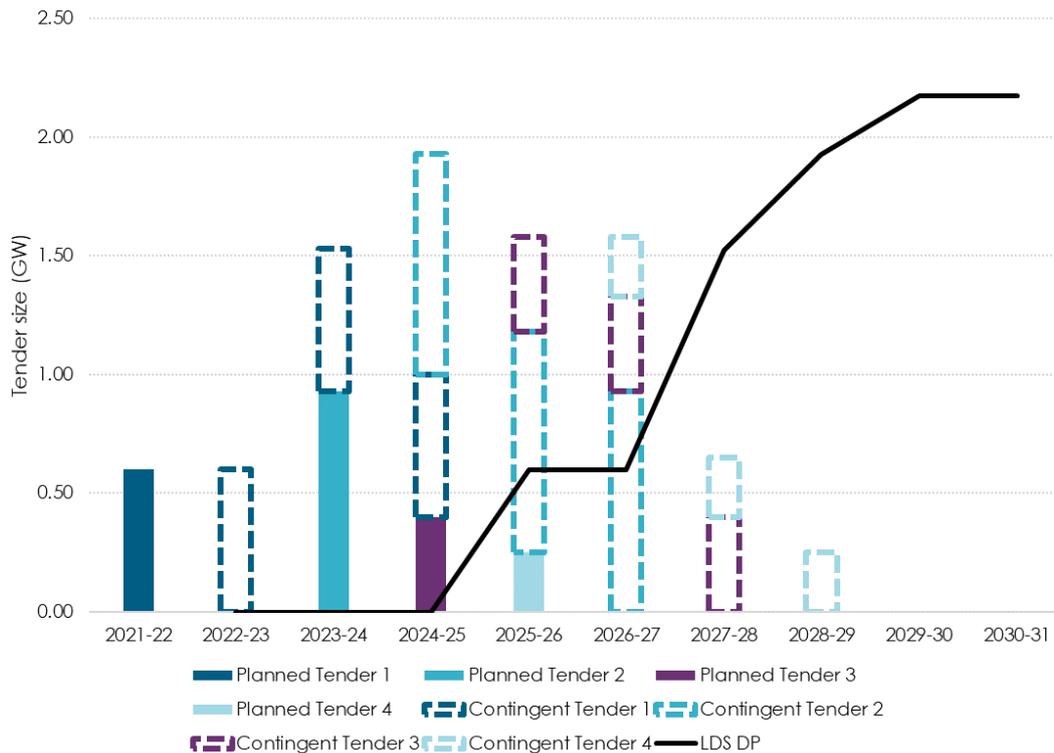
The 10-Year Plan for long-duration storage reflects that there is significant uncertainty with respect to the price and lead times for long-duration storage technologies and affords the NSW Consumer Trustee a level of flexibility through contingent tenders. As indicated in Figure 4, certain 'contingent' tenders (or contingent capacity) will only be offered where the NSW Consumer Trustee does not elect to fully subscribe the capacity that was planned to be recommended in the preceding tender(s). This would likely be the case where lead times for long-duration storage technology are longer than anticipated and/or where technologies with shorter lead times are not competitive.

The NSW Consumer Trustee plans to hold the first tender for long-term energy service agreements in respect of long-duration storage infrastructure projects in 2021-22, at the same time as the first generation tender. This would provide at least a four-year lead time to achieve the Development Pathway, allowing

long lead-time pumped hydro projects to participate (assuming these projects have already progressed to feasibility stage at this time).

The NSW Consumer Trustee may then conduct tenders on an annual basis depending on the need for contingent tender(s) and capacity. This approach will enable the NSW Consumer Trustee to minimise costs to NSW electricity customers by bringing forward or delaying the build trajectory for long-duration storage depending on technology prices in the market.

Figure 4 10-Year Plan (Long Duration Storage)



Preparing this report

Selecting the Development Pathway

In selecting the Development Pathway, the NSW Consumer Trustee developed four alternative development pathways and commissioned the Australian Energy Market Operator to undertake modelling of each pathway to assess each performance against the infrastructure investment objectives⁸.

Each pathway adopts the same set of input assumptions and achieves the minimum infrastructure investment objectives by the end of 2029, but varies in terms of the timing of the infrastructure construction. The four pathways are set out in Figure 5.

The NSW Consumer Trustee assessed each alternative pathway against six selection criteria:

1. **Minimises financial costs to NSW electricity customers:** Assesses the extent to which the development pathway aligns with the infrastructure investment objective to minimise costs to NSW electricity customers. This was measured using the net present value of the total costs for the supply of

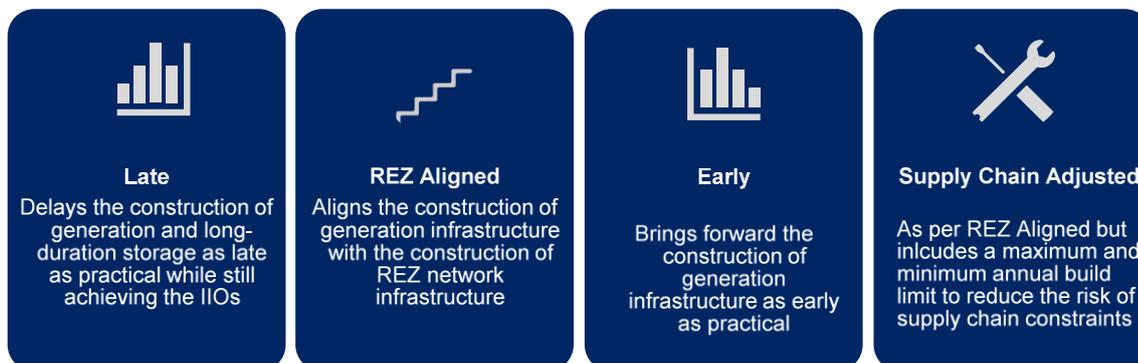
⁸ More detailed analysis of the modelling undertaken in respect of the alternative development pathways is set out in the accompanying Development Pathways Report, prepared by the Australian Energy Market Operator.

wholesale energy services to NSW electricity customers forecast over the development pathway's 20-year horizon.

2. **Improves sustainability:** Assesses the extent to which the development pathway aligns with the regulated requirement for the Infrastructure Investment Objectives Report to consider the objects of the EII Act which include to improve the sustainability of electricity supply.
3. **Maintains reliability:** Assesses the extent to which the development pathway aligns with corresponding infrastructure investment objective to meet the reliability standard, using a NSW-wide firm capacity target (equivalent to the state-wide energy security target) as a proxy for the reliability of supply.
4. **Promotes resilience:** Assesses the extent to which the cost for the supply of wholesale energy services to NSW customers under the development pathway is resilient to uncertainty in the external factors that drive electricity supply and demand in NSW.
5. **Enhances competition:** Assesses the extent to which the development pathway allows for a tender schedule likely to attract high value bids, thus minimising the costs of the scheme for the supply of wholesale energy services to NSW electricity customers.
6. **Considers supply chain impacts:** Assesses the extent to which the development pathway can minimise the risk of supply chain constraints and disruptions and the associated increase in development costs and project delays, ultimately minimising costs for NSW electricity customers.

The NSW Consumer Trustee selected the 'Supply Chain Adjusted' pathway as the Development Pathway from the alternative development pathways based on its performance against these criteria, as presented in Table 1.

Figure 5 Alternative development pathways



As part of its process in assessing the alternative development pathways, the NSW Consumer Trustee also conducted various sensitivity tests. In particular, the modelling explored sensitivities around delays to certain key network augmentations and the impact of an early unexpected coal withdrawal. The results of the early coal withdrawal sensitivity indicated significant risks to the Late development pathway in terms of high consumer costs.

The results of the other sensitivity analyses were not material to the selection of the Development Pathway, as they indicated that such delays posed risks in achieving the minimum infrastructure objectives under all alternative development pathways.

Importantly, under all development pathways there are compounding risks of early coal plant withdrawals with delays in critical capacity projects. There are material risks in achieving the necessary firm capacity where an early coal withdrawal occurs and any of the capacity projects, including the committed Snowy 2.0 and Kurri Kurri gas plant and the anticipated Tallawarra B gas plant, and the HumLink and Sydney Ring transmission projects, are delayed.

Table 1 Alternative development pathway performance against selection criteria

Criteria	Late	REZ aligned	Early	Supply Chain Adjusted
Minimises financial costs for the supply of wholesale energy services to NSW customers (NPV \$b)⁹	\$35.78	\$36.91	\$36.57	\$36.06
Improves sustainability (reduction in cumulative carbon emissions relative to Late)	-	-22.76 MtCO _{2e} (-7%)	-44.23 MtCO _{2e} (-14%)	-25.67 MtCO _{2e} (-8%)
Maintains reliability (smallest annual margin between state-wide energy security target and firm capacity across 20 years)¹⁰	2.93%	2.93%	2.52%	2.93%
Promotes resilience	Delayed schedule provides least flexibility and is the most inherently vulnerable to uncertainties	Coordinated build schedule aligns with other REZ developments and allows for advance or delay against plan in response to uncertainty	Advanced schedule is vulnerable to misalignment with other developments including transmission augmentation	Adjusted schedule offers the most resilience as it provides the greatest optionality to respond to uncertainties
Enhances competition	Late peak provides minimal learning opportunities for both CT and participants	Peaks in build reduce opportunity for participants to refine bids over time	Peaks in build reduce opportunity for participants to refine bids over time	Frequent low volume tenders leads to better value bids for NSW consumers over time
Minimises supply chain constraints	Supply chain risks exist compounded if network augmentation also delayed	Supply chain risks exist based on generation build peaks	Supply chain risks exist based on generation and network build peaks	Lowest risk of supply chain risk across the available pathways

⁹ Net present value (NPV) of total costs over the 20-year modelling horizon to supply wholesale energy services to NSW consumers. This cost is not a new cost and can be compared to spending on wholesale electricity that would be required without the Roadmap. See Section 3.3 for more detailed discussion regarding costs for the supply of wholesale energy services under the development pathway.

¹⁰ This metric is calculated as the smallest annual value of the percentage of firm capacity in NSW in excess of a NSW-wide energy security target across the 20 year horizon. See Section 6.3 for further detail.

Limitations

This report is a critical step in achieving the aims of the Roadmap and is a prerequisite for the conduct of the first LTES agreement tender and the authorisation of renewable energy zone network infrastructure. Accordingly, the report has been prepared quickly. This is intended to bring forward investment to avoid risks of cost increases toward the latter part of this decade and allow sufficient time to run smaller initial tenders for LTES agreements.

The shortened timeframe, and the nature of the electricity market modelling, has led to three key limitations associated with the development of the 2021 IIO Report:

- **Limited stakeholder consultation** – Consultation on the preparation of the report has been limited to certain key stakeholders and working groups established under the Roadmap.
- **Lack of detailed data on network augmentations** – The report reflects static inputs regarding network infrastructure, which were based on the latest AEMO and Energy Corporation of NSW information available at the time of modelling. The report does not model an optimised pathway for the development of network infrastructure.
- **Changes to some assumptions since the modelling for the report was undertaken** – The report necessarily reflects a set of input assumptions as at a certain date. Notwithstanding the timely preparation of the report, some of the sources of these assumptions have subsequently been updated. For example, AEMO's 2021 IASR – which will inform its draft 2022 ISP – was published after the modelling for this report was undertaken. The modelling incorporates assumptions from AEMO's draft 2021 IASR and some (but not all) assumptions which were ultimately included in the final 2021 IASR. The NSW Consumer Trustee does not consider that the differences in assumptions impact the validity of the modelling, because they mostly relate to the later periods of the Development Pathway where this is significant future uncertainty in any case. Further, the NSW Consumer Trustee will have regard to the latest information when exercising its procurement functions in relation to LTES agreements and network infrastructure project authorisations.

Next steps

The NSW Consumer Trustee is actively seeking feedback on this 2021 IIO Report, the technical approach underpinning it and how to better incorporate stakeholder feedback to inform the NSW Consumer Trustee's preparation of the second IIO Report.

The NSW Consumer Trustee may publish an interim report in 2022 to reflect new information which will shortly become available via the Australian Energy Market Operator's 2022 Integrated System Plan and the Network Infrastructure Strategy prepared by the Energy Corporation of NSW. This is earlier than the two-year timeframe required by the EII Act but will allow the updated development pathway contained in an update to the report to incorporate the latest assumptions from AEMO and other sources. Regulations have been made to allow the publication of a second report in 2022.

This 2021 IIO Report will enable the NSW Consumer Trustee and the investor and developer community to plan for the competitive tenders for long term energy service agreements as set out in the 10-Year Plan. The first tender will be run as a pilot in the first half of 2022 and likely before the publication of an updated report.

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1. Introduction

1.1 Transformation of electricity generation

NSW, like the rest of the world, is experiencing a transformation, driven by technological innovation, in the production of electrical energy.

The challenge for NSW is that four coal-fired power stations, providing around three quarters of the state's energy needs, have reached the ends of their technical lives. All four are scheduled to close within the next 15 years, and all four are claimed to be encountering marginal economic returns for their owners.

There is significant uncertainty as to the precise timing of future coal plant withdrawals. Asset owners must consider a range of complex factors in deciding whether to continue operating and updates to the scheduled dates for coal plant withdrawals occur frequently. Historically, unexpected withdrawals of coal capacity in the National Electricity Market (NEM) have had significant impacts on wholesale electricity prices. Accordingly, there is a need to ensure that sufficient electricity supply is available ahead of coal withdrawal to minimise prices.

Renewable energy is now the cheapest form of energy generation. It has the potential to create enormous opportunities for NSW.

However, renewable energy also poses challenges due to its sources being both variable and more dispersed than existing generation assets. Long-duration storage solutions are needed to fill the gaps in production that can occur, and transmission augmentations are required to deliver sufficient electricity to load centres.

Although private providers now supply electricity through a national market, historically, government has played a significant role in the development of energy generation in Australia.

In this context, the case for action in NSW was clear.

The result was the *Electricity Infrastructure Investment Act 2020* (EII Act), enabling the delivery of the NSW Government's Electricity Infrastructure Roadmap (Roadmap) to ensure the long-term affordability, reliability, security and sustainability of NSW's electricity supply.

Meeting the EII Act objectives for the construction of new infrastructure will be challenging. The investment required in new generation, storage and network infrastructure is unprecedented in Australia in both its scale and the relatively short time frame in which it must be made.

However, the market is already responding to this challenge. Since the passage of the EII Act, NSW has continued to experience significant growth in investment in renewable energy projects¹¹. These projects will support the achievement of the legislated objectives, while the finalisation of the Roadmap's implementation will support a further expansion of investment over the next two decades.

¹¹ As at August 2021, 140 distinct projects totalling about 22,700 megawatts (MW) of large-scale renewable energy projects are either approved or progressing through the New South Wales planning system, representing about \$34.2 billion in investment.

1.2 The NSW Consumer Trustee

The EII Act establishes the NSW Consumer Trustee, an independent statutory role with various planning, advisory and procurement functions.

It must conduct those functions in the long-term financial interests of NSW electricity customers. In the context of this report, the NSW Consumer Trustee has sought to develop a plan for the delivery of electricity infrastructure that is intended to minimise costs to NSW electricity customers and produce outcomes that are resilient to change in the face of a rapidly transforming energy sector. The NSW Consumer Trustee is also incorporating consideration of the long-term financial interests of NSW customers in its systems and processes for the performance of its other functions under the EII Act.

In July 2021, the NSW Minister for Energy and Environment (Minister) appointed AEMO Services Ltd (AEMO Services), a specially constituted subsidiary of the Australian Energy Market Operator (AEMO), as the NSW Consumer Trustee. The appointment became effective on 31 October 2021.

The NSW Consumer Trustee has several important functions which require it to make decisions in the long-term financial interest of NSW electricity customers. The main functions are set out in the EII Act and include:

- planning for the construction of electricity infrastructure to meet legislated objectives,
- conducting competitive tenders for long-term energy service (LTES) agreements to support the financing of such infrastructure, and
- authorising the construction of network infrastructure in NSW renewable energy zones (REZs).

1.3 NSW Electricity Infrastructure Roadmap

The Roadmap is the NSW Government's plan to modernise the state's electricity system, by coordinating private investment in new network, generation, long-duration storage, and firming infrastructure.

The NSW Consumer Trustee plays a key role in the broader Roadmap, working closely with other entities appointed to new roles under the EII Act. Its efforts to facilitate the achievement of the legislated infrastructure investment objectives through system planning activities and the making of LTES agreements will be supported by a range of other NSW Government policies and programs.

To support the development of new generation and long-duration storage infrastructure, the EII Act establishes five REZs. The Energy Corporation of NSW (EnergyCo), as the Infrastructure Planner for these five REZs, is responsible for developing recommendations for the network infrastructure needed to deliver them. EnergyCo, working with AEMO, the NSW Jurisdictional Planner, NSW distribution network service providers and other relevant parties, will also develop a Network Infrastructure Strategy for NSW. This strategy will inform future system planning activities and the detailed design of individual network projects.

The NSW Government has also established the Pumped Hydro Recoverable Grants Program, to support the development of pumped hydro projects. Pumped hydro technology is expected to provide the most cost-effective long-duration storage solutions, but only a small number of projects are currently well-progressed in NSW.

The EII Act also established the Renewable Energy Sector Board (Sector Board), consisting of industry, union and consumer representatives, to prepare a plan for the NSW renewable energy sector. Among its

other work, the Sector Board has commissioned studies into the opportunities and challenges for local supply chains associated with the Roadmap.

1.4 Overview of the Infrastructure Investment Objectives Report

The EII Act requires that the NSW Consumer Trustee prepare a report every two years about the Roadmap's infrastructure investment objectives. This 2021 Infrastructure Investment Objectives Report (2021 IIO Report) is the first such report.

Box 1: Infrastructure Investment Objectives

The EII Act establishes the infrastructure investment objectives which include:

- Minimum objectives for the construction of infrastructure by the end of 2029 including:
 - At least the same amount of generation as 12 GW of renewable energy
 - At least 2 GW of long-duration storage
- Overall objectives to construct:
 - Generation infrastructure to minimise electricity costs for NSW electricity customers
 - Long-duration storage infrastructure to meet the reliability standard
 - Firming infrastructure to meet the energy security target and reliability standard.

The infrastructure investment objectives, including their interpretation for the purposes of the 2021 IIO Report, are set out in Section 2.

Each report on the infrastructure investment objectives must contain:

- a **development pathway** for the construction of the infrastructure to meet the infrastructure investment objectives over the following 20 years, and
- a **10-year plan** for competitive tenders for LTES agreements that the Consumer Trustee will conduct to give effect to the development pathway.

In addition, regulations made under the EII Act set out additional items that the report must contain, or matters that the NSW Consumer Trustee must have regard to in preparing the report¹². Regard has been given to these requirements in preparing this 2021 IIO Report.

The report is a key input to the decision-making for the NSW Consumer Trustee with respect to indicative timing, scale and scope of competitive tenders for LTES agreements as well as advising on the declaration of REZs and the authorisation of REZ network infrastructure projects.

Box 2: What is a long-term energy service (LTES) agreement?

Under the EII Act, LTES agreements are option contracts intended to encourage private investment in NSW by providing minimum cash flows for generation, long-duration storage or firming projects in the event of unexpectedly low electricity prices. A project that is awarded a LTES agreement will have a fixed number of options (e.g. 10 options) to enter a derivative arrangement of a fixed duration (e.g. two years) during the contract term (e.g. 20 years). The terms and conditions for LTES agreements will be different for each type of infrastructure (i.e. generation, long duration storage, firming).

¹² Electricity Infrastructure Investment Regulation 2021, clauses 16B and 16C.

The NSW Consumer Trustee will award LTES agreements periodically through competitive tenders (unless another procurement method is agreed with the scheme regulator). Subject to the infrastructure investment objectives in the EII Act, the amount of generation and long-duration storage capacity that is ultimately tendered, and the timing of those tenders, is a decision for the NSW Consumer Trustee. The NSW Consumer Trustee will only conduct competitive tendering for firming LTES agreements if directed by the Minister in accordance with the EII Act.

LTES agreements will be available to projects that are located within or outside of a REZ, but projects located outside a REZ but must show 'outstanding merit'.

1.5 Interaction with AEMO's Integrated System Plan (ISP)

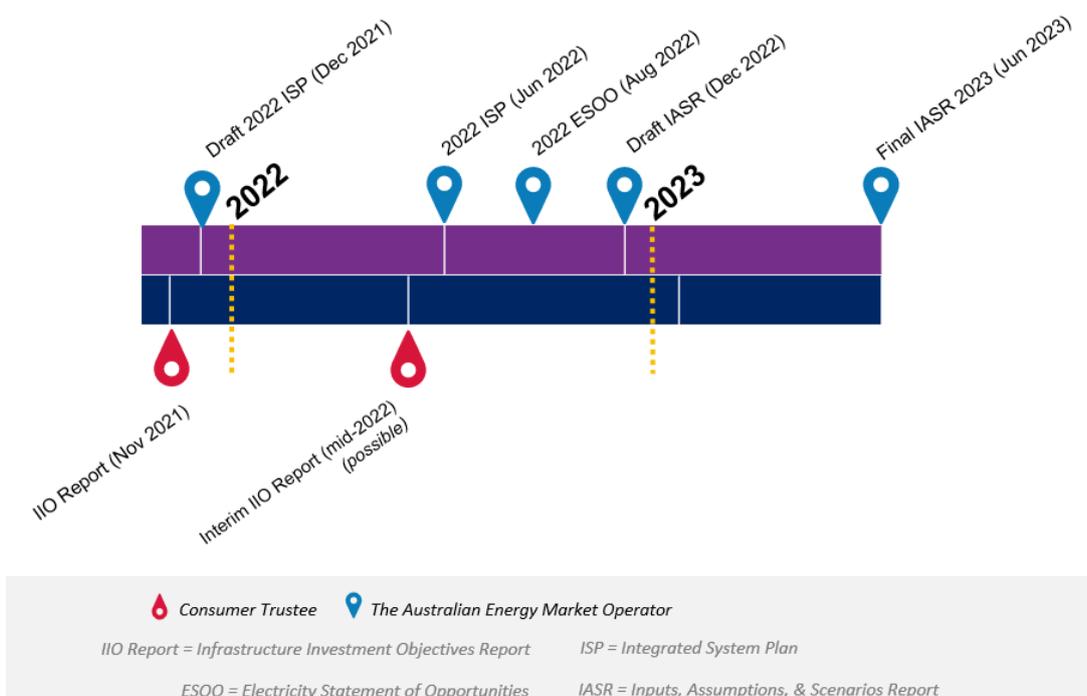
The development pathway component of the NSW Consumer Trustee's infrastructure investment objectives reports will both inform, and be informed by, the planning processes of AEMO via its ISP.

The preparation of this report has been informed by AEMO's 2020 ISP, as well as its 2020 Electricity Statement of Opportunities (ESOO) and draft 2021 Inputs, Assumptions, and Scenarios Report (IASR). The assumptions adopted from these publications are set out in greater detail in Section 5.2.

Similarly, the infrastructure investment objectives report is an input into AEMO's ISP process, in the same way that any state or territory policy that meets certain National Electricity Rules criteria is an input into the ISP. AEMO has already indicated in its final 2021 IASR, which will inform the next ISP in 2022, that it intends to incorporate assumptions from this report in its assumptions workbook¹³. In turn, the update to this report will be informed by further AEMO publications, as set out in Section 1.6.2.

Over time, it is envisaged that close collaboration with AEMO will allow inputs, scenarios and assumptions to be aligned, while allowing for variation to meet different policy intents. An indicative timeline showing iterations of AEMO's publications and the next update to this report is shown in Figure 6.

Figure 6 Indicative Integrated System Plan and IIO Report timeline



¹³ AEMO (July 2021), 2021 *Inputs, Assumptions and Scenarios Report*, page 29.

1.6 Preparation of the 2021 IIO Report

This inaugural 2021 IIO Report was primarily prepared by the NSW Department of Planning, Industry and Environment (NSW DPIE), in close collaboration with AEMO, prior to AEMO Services' appointment as the NSW Consumer Trustee commencing on 31 October 2021. Prior to this date, the Secretary of NSW DPIE was the default NSW Consumer Trustee. The decision to publish the 2021 IIO Report was made by the Board of AEMO Services.

Given its expertise in system planning, AEMO was engaged to undertake market modelling to support the preparation of the Development Pathway. This further ensured greater consistency with the inputs and assumptions used in AEMO's ISP development process. AEMO also engaged Ernst & Young (EY) to assist with the modelling for the Development Pathway.

That work is set out in the following documents, which accompany the 2021 IIO Report:

- AEMO's *Development Pathways Report*, which sets out in detail the alternative development pathways modelled for the NSW Consumer Trustee. This report is intended to provide analysis of various modelled options for the NSW Consumer Trustee's consideration.
- EY's *Modelling Methodology and Assumptions Report*, which provides a detailed description of the modelling methodology and assumptions used by EY in conducting the market modelling for preparation of the Development Pathway.

Further information regarding the methodology underpinning the 2021 IIO Report is set out in Section 5.1.

1.6.1 Timeframes

The EII Act requires the NSW Consumer Trustee to prepare the first report on the infrastructure investment objectives as soon as practicable after 1 July 2021. It is a crucial step in achieving the Roadmap objectives and is a prerequisite for the conduct of the first LTES agreement tender and the delivery of REZ network infrastructure projects.

Consistent with the intent of the EII Act, the NSW Consumer Trustee has sought to act quickly in publishing this 2021 IIO Report in order to:

- bring forward investment to avoid risks associated with supply chain constraints and potential changes in the cost of capital toward the latter part of this decade, and
- allow enough time to run an initial pilot tender and second tender for smaller amounts of generation and long-duration storage infrastructure, which are expected to give rise to significant learnings for both the NSW Consumer Trustee and the market.

The intent of the 2021 IIO Report is to provide project proponents, investors, supply chains and other stakeholders with the certainty needed to facilitate the development of high-quality projects as quickly as possible.

1.6.2 Limitations

This shortened timeframe has led to three limitations associated with the development of the 2021 IIO Report, including:

- **Limited stakeholder consultation** – NSW DPIE consulted in relation to the 2021 IIO Report with AEMO, the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER),

the Renewable Energy Sector Board,¹⁴ and a range of working groups convened by NSW DPIE to seek stakeholder feedback on various elements of the Roadmap. These include an Industry Expert Reference Panel, the Consumer Reference Group and the Regulatory Implementation Working Group. In developing future reports, the Consumer Trustee is expected to provide more consultation opportunities on modelling assumptions and methods.

- **Limited information available on future REZ network infrastructure projects and other network augmentations** – The assumptions regarding such projects were based on the latest AEMO sources available at the time of modelling (i.e. AEMO's 2020 ESOO, AEMO's 2020 ISP and AEMO's draft 2021 IASR). Future reports are intended to draw on more detailed NSW Government and jurisdictional planning for network augmentations in EnergyCo's Network Infrastructure Strategy, and potentially set out a modelled optimised build trajectory for network infrastructure similar to the development pathway for generation and long-duration storage infrastructure.
- **Changes to some assumptions since the modelling for the report was undertaken** – The report necessarily reflects a set of input assumptions as at a certain date. Notwithstanding the timely preparation of the report, some of the sources of these assumptions have subsequently been updated. For example, AEMO's 2021 IASR was published after the modelling for this report was undertaken. The modelling incorporates assumptions from AEMO's draft 2021 IASR and some (but not all) assumptions which were ultimately included in the final 2021 IASR.

The NSW Consumer Trustee intends to commence preparation of an update to this report following the publication of AEMO's draft 2022 ISP, as seen in Figure 6. This is earlier than the two-year timeframe required by the EII Act but will allow the Development Pathway to incorporate feedback from stakeholders and information from updated sources, including:

- the draft 2022 ISP,
- the latest Generation Information Page on AEMO's website,
- Transgrid's 2021 Transmission Annual Planning Report,
- input from EnergyCo's Network Infrastructure Strategy, prepared with AEMO, the NSW Jurisdictional Planner, NSW distribution network service providers and others, which is anticipated to be published in early 2022, and
- early tenders for LTES agreements and network access rights.

1.7 Structure of the 2021 IIO Report

This report consists of the following sections:

- Section 1 provides the background and context for the 2021 IIO Report.
- Section 2 outlines the infrastructure investment objectives established by the EII Act.
- Section 3 provides an overview of the Development Pathway.
- Section 4 provides an overview of the 10-Year Plan.

¹⁴ The Renewable Energy Sector Board is a board established by the Minister under section 7 of the EII Act in relation to the operation of the renewable energy sector and the manufacture and construction of infrastructure in the sector.

- Section 5 outlines the approach to developing the Development Pathway, including the modelling methodology.
- Section 6 provides the evaluation criteria and assessment of alternative development pathways justifying the selection of the 2021 Development Pathway.
- Appendix A contains a glossary of key terms used in this Report.
- Appendix B sets out the mandatory requirements for infrastructure investment objectives reports under the *Electricity Infrastructure Investment Regulations 2021* and where these are addressed in this report.
- Appendix C sets out a schedule of generation infrastructure projects that have been either committed, or have been anticipated, since 14 November 2019.
- Appendix D sets out various supply chain constraints that were considered in preparing the Development Pathway.

2. The Infrastructure Investment Objectives

2.1 Overview

The EII Act establishes the infrastructure investment objectives. These are set out in Figure 7 and include:

- 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.

In addition to the infrastructure investment objectives, the NSW Consumer Trustee must exercise its functions in a way that is consistent with the broader objects of the EII Act¹⁵.

¹⁵ EII Act, section 3(3).

Figure 7 Infrastructure investment objectives and eligible infrastructure¹⁶

Infrastructure type	Definition	Infrastructure Investment Objectives			
		Minimum objective (volume/capacity target)	Minimise electricity prices	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 (~33.6 TWh p.a) constructed by the end of 2029	✓	N/A	N/A
LDS	Storage able to be dispatched at registered capacity for ≥ 8 hrs, and scheduled by AEMO in the central dispatch process under NER	2 GW constructed by the end of 2029	N/A	✓	N/A
Firming	Firm capacity scheduled by AEMO in the central dispatch process under the NER	None	N/A	✓	✓

2.2 Minimum objectives by 2030

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
- 1 additional GW of generation capacity from elsewhere¹⁷.

This objective is an annual generation volume (GWh per year) target rather than a target for capacity at a point in time.

Box 3: Calculation of minimum volume (GWh) target

The NSW Consumer Trustee, with AEMO, has determined this amount of electricity to be approximately 33,600 GWh per year, 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 factors assumed for each technology within each NSW REZ are in line with AEMO's 2020 ISP. 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 MW¹⁸. Infrastructure projects that were identified as committed or existing in a generation information page published by AEMO on or before 14 November 2019 are not counted towards this minimum objective¹⁹. This means that some generation projects which were committed after November 2019, but before the publication of this report, contribute towards the

¹⁶ Of course, certain technologies may serve additional roles beyond those specified in the infrastructure investment objectives. For example, long-duration storage may also assist in further reducing electricity prices associated with variable renewable energy generation.

¹⁷ EII Act, section 44(3)(a).

¹⁸ EII Act, section 43(1)(a).

¹⁹ EII Act, section 43(2).

generation infrastructure minimum objective and may bid in tenders for LTES agreements. These projects are set out in Appendix C.

2.2.2 Long-duration storage infrastructure

The EII Act also establishes a minimum objective for the construction of a total of 2 GW of long-duration storage infrastructure by 31 December 2029²⁰. 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 National Electricity Rules.²¹

As with generation infrastructure, long-duration storage projects that were identified as committed or existing in a generation information page published by AEMO on or before 14 November 2019 are not counted towards the minimum objectives. Unlike generation infrastructure, the EII Act sets an objective for long-duration storage capacity (GW), rather than a volumetric objective of available energy (GWh).

2.2.3 Firming infrastructure

Firming infrastructure refers to infrastructure that provides the capacity to deliver electricity to the market on demand.

Firming can be provided by a range of technologies, including long-duration storage infrastructure such as pumped hydro and batteries, as well as gas generators and demand response. In the future, firming may also be able to be provided by gas generators fuelled by renewable hydrogen or biogas. For the purposes of the infrastructure investment objectives, eligible infrastructure must be scheduled by AEMO in the central dispatch process under the National Electricity Rules²².

The EII Act does not establish a minimum objective for the construction of firming infrastructure. The NSW Consumer Trustee may only conduct a competitive tender for LTES agreements in respect of firming infrastructure if directed by the Minister²³. If the Minister gives such a direction, the NSW Consumer Trustee must prepare an updated report on the infrastructure investment objectives²⁴. No such direction has been given at the time of publication.

2.2.4 Network infrastructure

There are no specific infrastructure investment objectives under the EII Act for network infrastructure. However, the regulations require that the IIO Report must contain details regarding the REZ network infrastructure projects required to achieve the infrastructure investment objectives. The 2021 IIO Report sets out the likely requirements for all network infrastructure, including REZ network infrastructure, to deliver on the infrastructure investment objectives. This is discussed further in Section 3.2.

²⁰ EII Act, section 44(3)(b).

²¹ EII Act, section 43(1)(b).

²² EII Act, section 43(1)(c).

²³ EII Act, section 47(2).

²⁴ EII Act, section 47(2).

2.3 Overall objectives

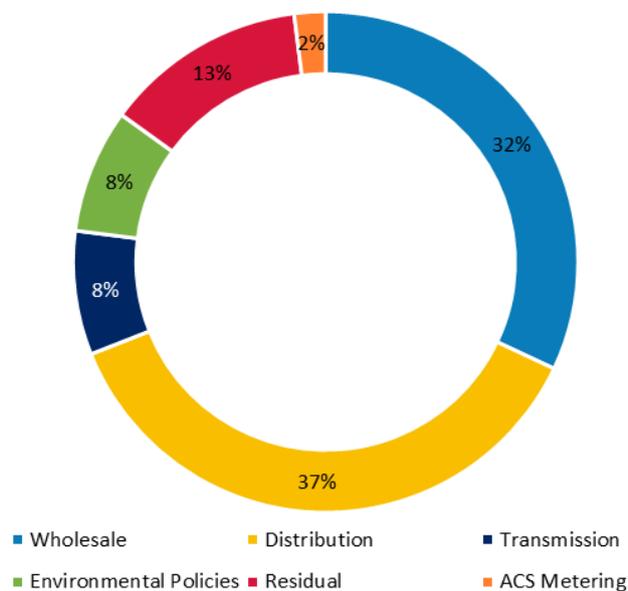
In addition to the minimum objectives, the EII Act establishes ongoing objectives that apply across the full 20-year period of the IIO Report and beyond 31 December 2029²⁵. These are set out below.

2.3.1 Minimise costs to NSW customers

The EII Act establishes an objective for the construction of generation infrastructure that is necessary to minimise electricity costs for NSW electricity customers²⁶. Accordingly, the NSW Consumer Trustee must consider whether generation infrastructure, additional to the minimum infrastructure investment objective both before and after 2029, is required to minimise electricity costs.

In NSW, electricity bills generally consist of six main components, as shown in Figure 8: the wholesale cost of ²⁷, transmission network costs²⁸, distribution network costs²⁹, environmental policy charges³⁰, metering, and 'residual' which includes for retailer costs and profit margin.

Figure 8 NSW general residential electricity bill breakdown (AEMC 2020)



The Roadmap will result in changes to wholesale prices and network costs arising from new REZ network infrastructure. It will also result in the introduction of a new category of 'scheme costs', which are described in Table 2.

The Roadmap may also have indirect impacts on the other categories of costs set out in Figure 8. For example, retail margins may reduce aligned to the reduction in risk in contract market prices and/or the

²⁵ EII Act, section 44(2).

²⁶ EII Act, section 44(2)(a).

²⁷ The total wholesale component of electricity bills.

²⁸ The charges for building, maintaining, and operating the transmission network that delivers the electricity to distribution providers.

²⁹ The cost of building, maintaining, and operating the poles and wires that deliver the electricity to the end consumer.

³⁰ National and jurisdictional green certificate schemes (e.g. Large-scale Generation Certificates).

policy costs for the Large-scale Renewable Energy Target (LRET) may reduce by increasing supply of Large-scale Generation Certificates (LGCs).

Table 2 Costs modelled in preparing the Development Pathway

Bill segment	Description	Cost recovery mechanism
Scheme costs	Generation LTES agreement liabilities – The total net cost paid by the Scheme Financial Vehicle under the LTES agreements with generation projects	Via distribution network service providers
	Long-duration storage LTES agreement liabilities – The total net cost paid by the Scheme Financial Vehicle under the LTES agreements with long-duration storage projects	
	Network build costs – The cost of new network augmentations to enable additional renewable generation and storage in NSW renewable energy zones to be connected and dispatched into the power system	
Wholesale costs	The wholesale electricity purchase costs to NSW customers (assuming that spot prices reflect contract prices)	Via retailers

2.3.2 Meeting the reliability standard with firming and long duration storage

Under the EII Act, both firming infrastructure and additional long-duration storage infrastructure may be developed if required to meet the reliability standard.

The reliability standard is:

- until 30 June 2025, the NEM interim reliability measure of expected unserved energy in a region of 0.0006% of the total energy demanded in that region for a given financial year, and
- from 1 July 2025, the NEM reliability standard which is currently the expected unserved energy in a region of 0.002% of the total energy demanded in that region for a given financial year³¹.

The minimum objective for the construction of long-duration storage capacity means that, by the end of 2029, there will be at least 2 GW of long-duration storage that contribute to meeting the reliability standard. Where the 2 GW 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 required³².

The NSW Consumer Trustee notes that AEMO’s 2021 ES00, published 31 August 2021, indicates that expected unserved energy is forecast to exceed the reliability standard in NSW in 2029-30. However, the ES00 modelling only incorporates existing and committed projects and does not take account of the

³¹ See Electricity Infrastructure Investment Regulation 2021, clause 16A. Under section 43(3), the reliability standard is the standard implemented by AEMO under the National Electricity Rules that has been prescribed by the regulations.

³² AEMO (July 2020), *2020 ISP Appendix 4. Energy Outlook*, Section A4.3, at <https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix-4.pdf>.

additional generation, long-duration storage and network infrastructure included in this report that is required to be constructed to meet the infrastructure investment objectives³³.

Based on the modelling underpinning this report, the NSW Consumer Trustee expects that the entry of additional generation and long-duration storage infrastructure under the Roadmap will be sufficient to meet the reliability standard such that no additional firming infrastructure is likely to be required. This assumes that all other important projects, including the committed Snowy 2.0 and Kurri Kurri projects, and the anticipated Tallawarra B peaking gas turbine, and the HumeLink and Sydney Ring transmission projects, are not delayed.

2.3.3 Meeting the energy security target with firming infrastructure

The EII Act also establishes an overall objective for the construction of firming infrastructure that is necessary to meet the energy security target³⁴. The energy security target is a capacity target for firm-rated plant over the next 10 years and is set at the level of firm-rated capacity needed to service NSW's electricity needs during a one in 10-year peak demand period, with the largest two units of NSW's generators experiencing an outage³⁵.

The NSW Consumer Trustee's Development Pathway is required to include firming infrastructure that is necessary to meet the energy security target (and, as noted above, the reliability standard) only where the Minister has directed the NSW Consumer Trustee to conduct a competitive tender for firming infrastructure, in which case the NSW Consumer Trustee must prepare a new IIO Report.

The modelling undertaken in preparing the Development Pathway indicates that the construction of sufficient generation and long-duration storage infrastructure to meet the minimum infrastructure investment objectives results in the availability of sufficient firm capacity to meet a state-wide energy security target and the reliability standard over the next 20 years without any additional firming infrastructure.

Notwithstanding, there may be a risk to the reliability of supply as a result of the compounding risk of early coal plant withdrawals with delays in critical capacity projects, including the committed Snowy 2.0 and Kurri Kurri projects, the anticipated Tallawarra B peaking gas turbine, and the HumeLink and Sydney Ring transmission projects (to provide network capacity for generation in regional NSW).

The Minister has appointed AEMO as the Energy Security Target Monitor (EST Monitor) under the EII Act. The EST Monitor is required to prepare a report for the Minister that includes any anticipated breaches of the energy security target over the next 10 years. The 2021 EST Monitor report calculates the energy security target taking account of intra-regional network constraints.³⁶ It identifies that, without any new generation or storage capacity (beyond existing committed projects), the energy security target is likely to be breached late in the decade when intra-regional constraints are taken into account. This analysis does not take account of the additional generation and long-duration storage infrastructure that is required to be constructed to meet the infrastructure investment objectives. It does, however, highlight the importance of the development of necessary network infrastructure to alleviate network congestion, consistent with the findings of this report.

³³ The purpose of the ESOO is to assess the resource adequacy of existing and committed infrastructure in meeting forecast demand under a range of weather, demand and outage scenarios. The ESOO's scope does not include forecast capacity expansions as predicted by the NSW Consumer Trustee (or even by AEMO in its ISP).

³⁴ EII Act, section 44(2)(c).

³⁵ ³⁵ See EII Act, sections 47(2) and 45(3).

³⁶ *Electricity Infrastructure Investment Amendment (Safeguard) Regulation 2021*.

Accordingly, the NSW Consumer Trustee considers that the infrastructure set out in the Development Pathway (see Chapter 3) is sufficient to meet the state-wide energy security target over the next 20 years, providing that the necessary network infrastructure is also developed to alleviate network congestion.

Given the matters set out in this section and Section 2.3.2 above, the 2021 IIO Report does not identify a requirement for additional firming infrastructure investments.

3. Development Pathway

The Development Pathway sets out the NSW Consumer Trustee’s plan for the construction of generation and long-duration storage infrastructure to meet the minimum and overall infrastructure investment objectives in a manner that reflects the long-term interests of NSW electricity customers over the 20-year period from 2021 to 2041.

In preparing the Development Pathway, the NSW Consumer Trustee has had regard to various considerations, as summarised in Figure 9. Further information on how the NSW Consumer Trustee has prepared the Development Pathway is detailed in Section 5.

Figure 9 Development Pathway considerations



The Development Pathway is the outcome of a modelling exercise and represents the NSW Consumer Trustee’s preferred pathway for delivering on the infrastructure investment objectives. In conducting competitive tenders, the NSW Consumer Trustee will be guided by the Development Pathway but may recommend LTES agreements that would result in the construction of infrastructure in excess of or less

than the amounts indicated if, in its view, such a result would lead to better outcomes for NSW electricity customers.

The Development Pathway will be updated every two years via the infrastructure investment objectives reporting process. This will enable the NSW Consumer Trustee to respond to material changes in assumptions, especially where these relate to expectations for demand growth, expectations for technology costs, network infrastructure delivery and associated social licence issues, and earlier than planned retirements or sudden failures of coal plants. The importance of maintaining an up-to-date plan is underscored by the energy sector's rapid transformation. Since the EII Act was passed in November 2019, NSW has seen two large coal plants bring forward their retirement dates³⁷, and 20 variable renewable energy projects committed (with an estimated total capacity of approximately 2.4 GW)³⁸. Meanwhile, the number of ASX200 companies with net zero emissions targets tripled in 2020 alone, reaching approximately 25% of the index³⁹.

The NSW Consumer Trustee may also publish interim updates to the Development Pathway more frequently where it considers there is a benefit in providing such updates to market participants outside of the standard two-year cycle⁴⁰.

3.1 The build

3.1.1 Generation

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

The Development Pathway for generation infrastructure is set out in Figure 10 and Figure 11, which show the annual and cumulative annual output of the infrastructure, respectively. The Development Pathway incorporates an annual maximum build of generation infrastructure in NSW capable of generating approximately 6,000 GWh of electricity per year until 2030, with this limit increased to 7,600 GWh of electricity per year from 2030 (see Figure 10)⁴¹.

For at least the first decade, the Development Pathway also avoids periods without any investment.

³⁷ Eraring and Mt Piper.

³⁸ See Appendix C.

³⁹ According to an annual industry survey by the Australian Council of Superannuation Investors, available at <https://acsi.org.au/media-releases/net-zero-targets-jump-among-asx200-companies/>.

⁴⁰ The NSW Consumer Trustee is working with NSW DPIE on possible regulations to enable this.

⁴¹ The upper limit considers the potential for supply chain constraints for materials and labour in the electricity infrastructure sector, commissioning bottlenecks as well as the pipeline of civil works planned in NSW over the medium-term.

Figure 10 Development Pathway (Generation – Annual)

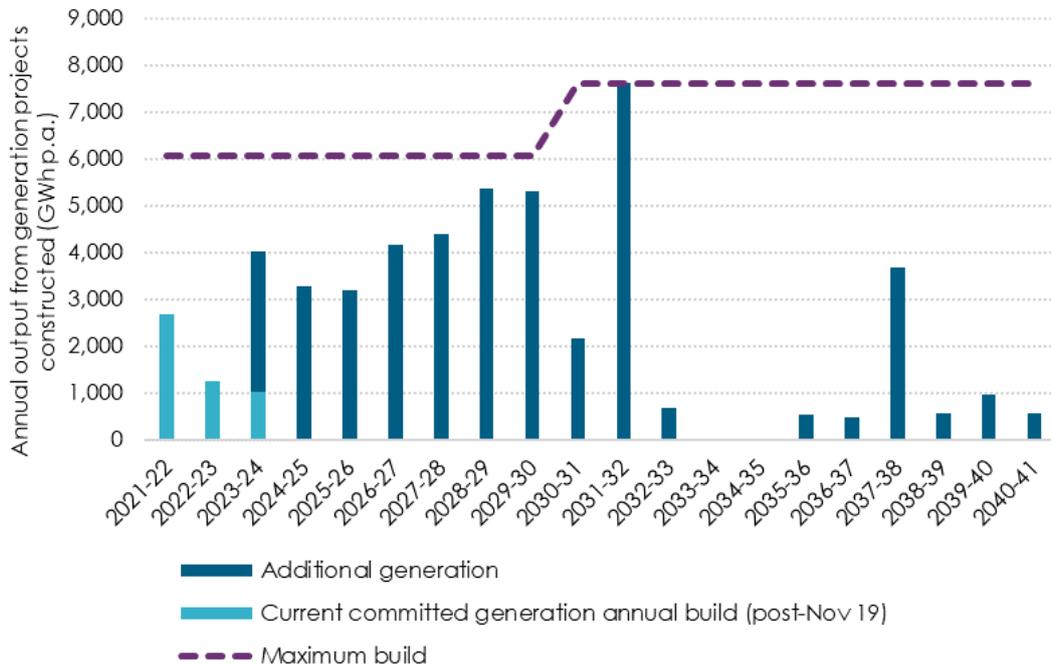
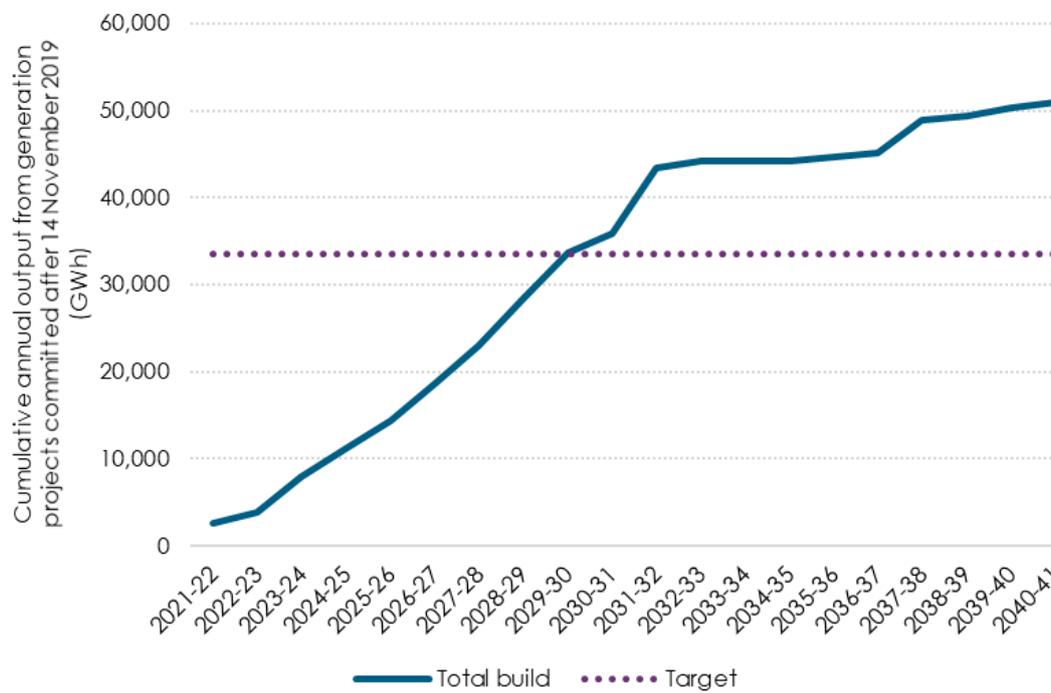


Figure 11 Development Pathway (Generation – Cumulative)



The annual trajectory of output fluctuates between approximately 1,400 GWh per year in the early part of the decade and a peak of approximately 7,600 GWh per year in 2031-32. Most of the build is concentrated

in the period prior to the end of 2032, although the Development Pathway does forecast some construction of new generation infrastructure in the second half of the 20-year period⁴².

Across the initial three financial years (2022 to 2024) of the 20-year trajectory, existing and committed generation (since 14 November 2019) is expected to constitute the majority of the required build trajectory. This includes newly committed projects such as the Rye Wind Park, the Wellington Solar Farm, Hilston Sun Farm and the New England Solar Farm⁴³.

From 2023-24 onwards, the Development Pathway then shows a significant increase in new generation. New generation in the early part of the decade is expected to both lower prices for NSW electricity customers and provide for a level of resilience against unexpected early withdrawals of coal plants. Generation construction then gradually increases from a lower rate in 2024-25 to the end of the decade until the minimum objectives are met.

Following the achievement of the minimum infrastructure investment objectives by the end of 2029, the modelling indicates further generation infrastructure is required in response to ongoing coal withdrawal. The build trajectory for the 2030s indicated in Figure 10 is less staged than that shown in the first decade. The NSW Consumer Trustee has not applied the same supply chain-related build constraints in the modelling of the 2030s, due to forecast demand and the scale of necessary generation construction being subject to a high degree of uncertainty.

Demand for electricity in this decade will be strongly impacted by trends in electrification of transport and other sectors which currently depend on fossil fuels. The emergence of a hydrogen production industry could also have significant impacts on the demand for electricity and the corresponding requirement for generation. Where these trends accelerate, for example in line with AEMO's recent 'Hydrogen Superpower' scenario (see Box 4), forecast demand is likely to be greater and, accordingly, additional generation in this decade, beyond that included in Figure 10, is likely to be required.

Box 4: Uncertainty in forecast demand during the 2030s

AEMO, in its 2021 ESOO, considers future demand forecasts to be highly uncertain due to the unknown rate of decarbonisation in other sectors of the economy, the speed of energy efficiency increases, and the potential for reduced costs associated with economy-wide electrification. Changes in demand are likely to be driven by electric vehicles, rooftop solar PV and individual / community battery storage uptake, economic and population growth, climate impacts, energy and efficiency measures, and fuel switching.

The Development Pathway was modelled based on a demand forecast taken from AEMO's 2020 ESOO Central Scenario, with a revised rooftop PV and small non-scheduled solar PV uptake, and NSW policy assumptions (i.e. the Peak Demand Reduction Scheme and the Energy Savings Scheme). The model assumes annual NSW operational demand falling from approximately 65,000 GWh to 56,000 GWh by 2030, and then rising over the following decade to 58,500 GWh in 2040-41.

However, forecast demand in the 2030s could vary materially. For example, forecast demand for NSW in AEMO's 2021 IASR is approximately 61,500 GWh by 2030 and 75,000 GWh in 2040-41 under the Net Zero scenario, and approximately 67,500 GWh by 2030 and 96,000 GWh in 2040-41 under the Hydrogen Superpower scenario.

In preparing future updates to the Development Pathway, the NSW Consumer Trustee will have close regard to unfolding events that are likely to impact on forecast demand into the 2030s.

⁴² The model uses AEMO's Central demand forecast. This projection does not include additional demand stemming from increased economy-wide electrification policies (i.e. greater electric vehicle uptake, hydrogen electrolyzers, and/or heating). These occurrences would lead to increased annual demand, which in turn would necessitate a rise in generation capacity, impacting the Development Pathway's projections.

⁴³ See Appendix C for further information.

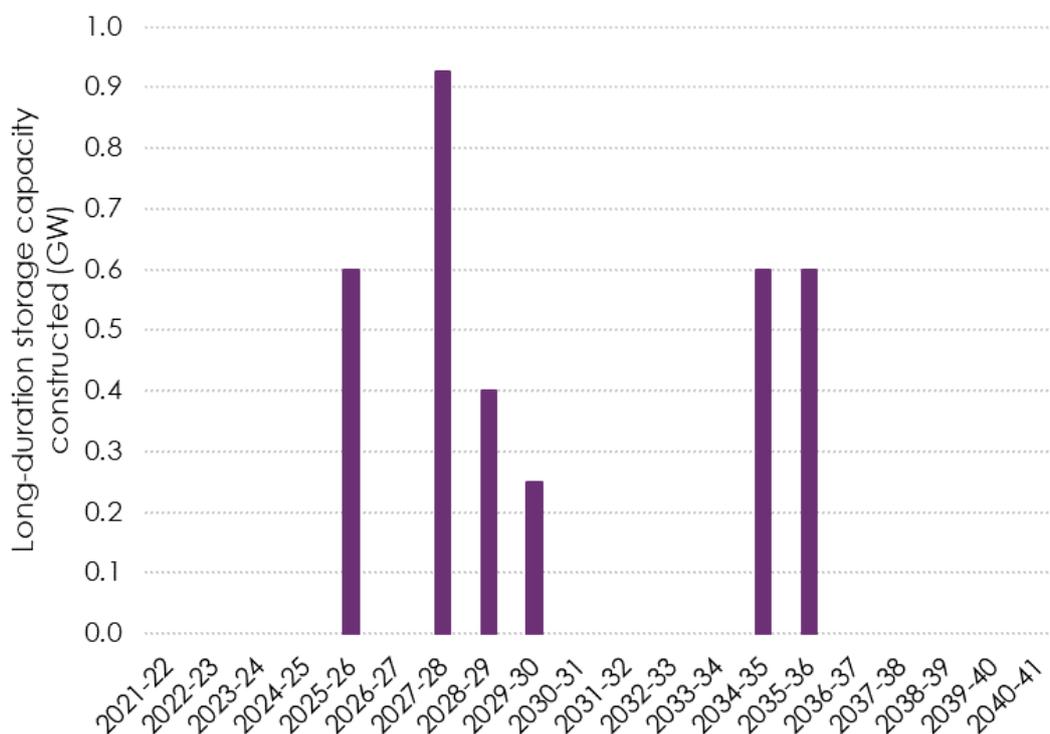
The Development Pathway aligns the anticipated construction of generation infrastructure with the anticipated timeframes for construction of REZ network infrastructure (i.e. for the Central-West Orana and New England REZs). However, it should be noted that the Development Pathway is neither technology- nor location-specific, and any eligible generation project connected to the NSW NEM region may be eligible for LTES agreements, subject to the ‘outstanding merit’ requirement under section 48(3) of the EII Act.

3.1.2 Long-duration storage

The Development Pathway for long-duration storage infrastructure is set out in Figure 12 and Figure 13, which show the annual and cumulative storage capacity installed, respectively.

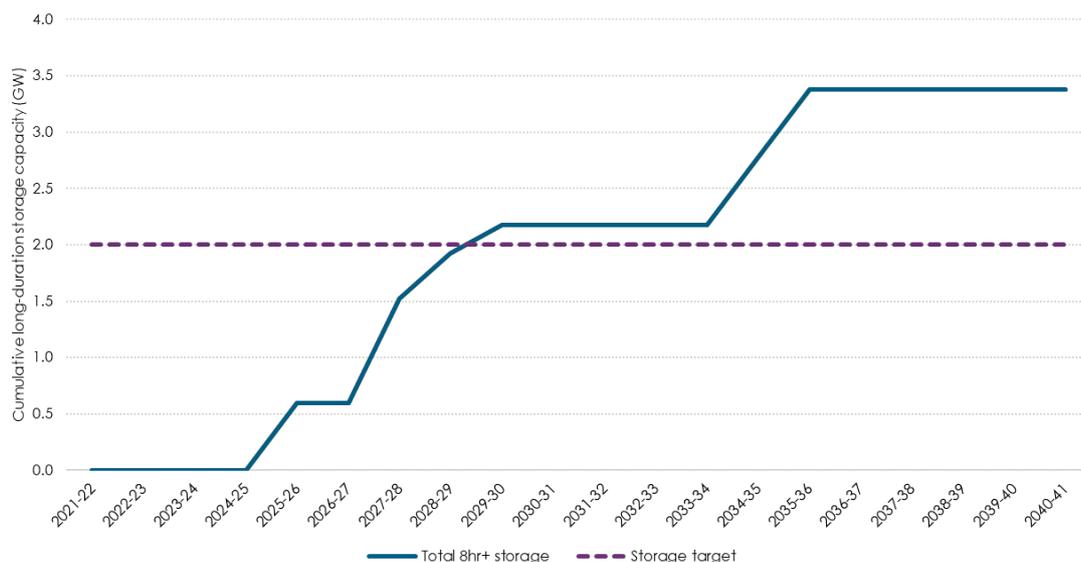
Long-duration storage infrastructure is first developed under the Development Pathway in 2025-26. This early long-duration storage is needed to meet additional capacity requirements⁴⁴ and minimise costs to NSW electricity customers by reducing curtailment of renewable generation. The minimum infrastructure investment objective of 2 GW is then met by development in 2027-28 and 2028-29.

Figure 12 Development Pathway (Long Duration Storage – Annual)



⁴⁴ The capacity need is not necessarily required to be met by *long* duration storage. However, given the 2 GW objective, it is prudent that long-duration storage is developed which can both meet the 2025/26 capacity need as well as contribute to the 2 GW objective.

Figure 13 Development Pathway (Long Duration Storage – Cumulative)



The modelling of the Development Pathway for long-duration storage accounts for the staged entry of the Snowy 2.0 project in 2025-26 and 2026-27 (and the HumeLink network augmentation in 2026, which is needed to support it). While Snowy 2.0 will provide long-duration storage, it is ineligible to participate in LTES agreement tenders, due to the project having been committed prior to 14 November 2019 (the cut-off date specified in the EII Act). Notwithstanding, it is a critical input to the shape of the Development Pathway for long-duration storage.

Like the Development Pathway for generation infrastructure, this plan is also technology- and location-neutral. However, the Development Pathway for long-duration storage is subject to significant uncertainty.

NSW is regarded as having significant potential for the development of large-scale pumped hydro energy storage projects. Analysis undertaken for the NSW Pumped Hydro Roadmap identified approximately 20,000 reservoirs in NSW that could be harnessed as part of a pumped hydro scheme⁴⁵. However, pumped hydro projects are bespoke and involve long lead-times, significant development risk and high capital costs.

As noted in Section 1.3, the NSW Government has established the Pumped Hydro Recoverable Grants Program to support feasibility studies into potential projects. This program, and the earlier development of potential new projects that it will support, should provide greater certainty in the future as to whether sufficient pumped hydro long-duration storage will be able to be constructed quickly enough to meet the infrastructure investment objectives.

Meanwhile, the costs of long-duration batteries and other emerging technologies are expected to significantly decline in coming years. However, the extent of this reduction and the rate at which it will take place remain uncertain.

In planning for this uncertainty, the NSW Consumer Trustee has selected a Development Pathway for long-duration storage that minimises NSW electricity customers' costs through a build trajectory beginning in 2025-26 (likely the very earliest date for eligible pumped hydro projects). On this trajectory, the

⁴⁵ Department of Planning and Environment (December 2018), NSW Pumped Hydro Roadmap.

minimum objective of 2 GW storage capacity would be met in 2028-29. However, if the costs of batteries or other technologies with shorter lead times become competitive more quickly, then the build trajectory could commence earlier and still meet the objective of minimising costs for NSW electricity customers.

The combined Development Pathway for long-duration storage and generation is also forecast to meet (and exceed) the reliability standard. The results of the reliability modelling undertaken by AEMO are set out in Section 6.3.

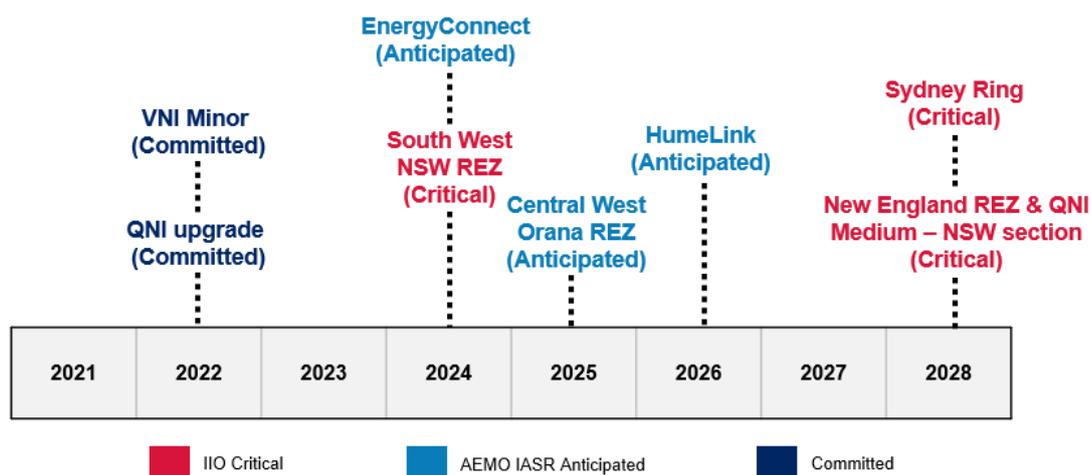
3.2 Network infrastructure

The Development Pathway sets out a plan for the construction of generation and long-duration storage infrastructure. While there are no specific infrastructure investment objectives under the EII Act for network infrastructure, the regulations require that the IIO Report must contain details regarding the REZ network infrastructure projects required to achieve the infrastructure investment objectives.

AEMO has identified that network augmentations will be critical to maintaining reliable electricity supply as NSW moves to being powered by dispersed, intermittent renewable energy sources. New network infrastructure will also be required to accommodate the significant additional amount of generation that is to be constructed in the renewable energy zones contemplated by the EII Act. The need for timely development of transmission infrastructure has also been recognised by the AEMC, with the commencement of its Transmission Planning and Investment Review⁴⁶.

The Development Pathway is underpinned by assumptions regarding the planned network augmentations and additional network infrastructure required to enable the establishment of NSW REZs (see Figure 14). The assumptions are drawn from AEMO’s 2020 ISP and draft 2021 IASR, as well as additional inputs developed specifically for this report in relation to the network infrastructure required to establish NSW REZs.

Figure 14 Network augmentation schedule



However, these inputs do not represent a detailed or optimised design of the transmission network. Issues relating to the technical configuration of individual projects, such as when generators are to connect, the

⁴⁶ Information regarding the AEMC’s Transmission Planning and Investment Review is available here: <<https://www.aemc.gov.au/market-reviews-advice/transmission-planning-and-investment-review>>

route of the infrastructure, technical parameters, and where a substation may be located, are not yet settled. EnergyCo, in its role as Infrastructure Planner for the five REZs specified in the EII Act, is responsible for designing these projects. EnergyCo will also work with AEMO, the NSW Jurisdictional Planner, NSW distribution network service providers and other relevant parties to develop a Network Infrastructure Strategy, which will be a detailed plan for network infrastructure in NSW. That strategy – as well as work to be performed by AEMO as part of future iterations of the ISP and the AEMC’s review – are intended to inform future iterations of the Development Pathway.

The schedule illustrates six network projects that are required to achieve the outcomes set out in the Development Pathway as seen in Table 3.

Table 3 AEMO network augmentation schedule

Project	Status	Importance to IIO
QNI upgrade	Under construction	Increase southerly and northerly transfer limit between Queensland and New South Wales
Project EnergyConnect	Under construction	-
Central West Orana REZ	2021 IASR anticipated	Key to unlocking generation in the short-medium term
South-West NSW	Transgrid released PADR as part of its ongoing RIT-T process	Critical – New 330 kV line between Darlington Point and Dinawan substation
Sydney Ring	ISP identified	Critical – New transmission links reinforcing the network north and south of Sydney
New England REZ	ISP identified	Critical – New transmission links from Bayswater to Uralla and a new Uralla substation

Three REZ-critical projects are set out in further detail below.

3.2.1 South-West NSW REZ

South-West NSW is already at its maximum generation hosting capacity. Currently, the ability of the network to transfer energy is largely limited by voltage stability restrictions, leading to a maximum hosting capacity of between 400 and 550 MW. Solving this issue requires the construction of a new transmission line between Dinawan and Darlington Point. AEMO estimates the cost effectiveness of this augmentation to be \$0.31M/MW, and when compared to other REZ capacity upgrades in the 2021 IASR, it sits in the top 20% of REZ expansion projects in terms of cost effectiveness for unlocking generation.

Project EnergyConnect (recently approved by the NSW Government) and HumeLink, when commissioned, will provide additional hosting capacity in South-West NSW and enable new generation in the South-West REZ.

3.2.2 New England REZ

The New England REZ (NE REZ) is projected to be the largest REZ in NSW. At present, the indicative geographic area of the NE REZ hosts generation projects with a capacity of 577 MW, with additional forecasted generation expected to be tenfold this. While the Development Pathway is technology- and

location-neutral, the underpinning market modelling indicates 8 GW of generation potential in the NE REZ, particularly from wind resources.

Upgrading the NE REZ may be achieved via the actioning of the southern components of another ISP designated future transmission upgrade, QNI Medium.

QNI Medium is an upgrade to the existing interconnector between Queensland (Qld) and NSW. For the purposes of achieving the infrastructure investment objectives, only the southern portion of the upgrade is required to be actioned because of its benefits in realising the required capacity increase of the NE REZ. AEMO's 2020 ISP notes that the 'QNI Medium' transmission upgrade offers benefits to Qld and NSW in the form of greater sharing of energy, storage and firming, following the closure of Eraring or to support local jurisdictional REZ initiatives. However, with the Roadmap's minimum objective of 2 GW of long-duration storage being met in the Development Pathway, the need for interstate sharing of firming infrastructure is reduced. This results in only the southern portion of the QNI Medium upgrade being required for the purpose of enabling 5-6 GW increase in network capacity for NE REZ.

3.2.3 The 'Sydney Ring'

The modelling for the Development Pathway reiterated the importance of upgrades to the 'Sydney Ring', the network around Sydney, Newcastle and Wollongong, to meet the infrastructure investment objectives.

The Sydney Ring was originally established to deliver large volumes of coal plant generation into the three major NSW load centres and their surroundings. Following the expected retirement of the area's coal plants, additional supply will be needed. At present, future supply within the network in this area is not expected to expand sufficiently to cover these retirements⁴⁷. This necessitates sourcing electricity for the Sydney, Newcastle and Wollongong load centres from generation assets located throughout NSW. However, the existing network configuration does not have sufficient transfer capability to enable this.

In its 2021 ESOO, AEMO forecast expected unserved energy in NSW to reach 0.008% in 2030-31⁴⁸, predominantly occurring in the Sydney, Newcastle and Wollongong area. This was the result of network congestion around the Sydney Ring limiting the ability of dispersed generation to reach the key load centres. AEMO predicts significant load shedding if this were to eventuate, equivalent to 250,000 to 750,000 households in the Sydney, Newcastle and Wollongong area being without power for an average of three events per year, with each event lasting up to five hours, typically during very high temperature conditions (40°C days).

The modelling underpinning the Development Pathway indicates this can be addressed by actioning two transmission upgrades, known as the (Sydney) Northern⁴⁹ and Southern⁵⁰ Loops, as set out in AEMO's 2020 ISP. The need for these augmentations is a consequence of the expected withdrawal of the area's coal plants.

Due to the uncertainty around these dates and lead times for development of network infrastructure, the modelling indicates it would be prudent to develop this infrastructure early to provide optionality to maintain reliable supply in the event of early withdrawal of coal plants.

⁴⁷ Vales Point B in 2029, Eraring staged across 2030 to 2032, and Bayswater in 2035 (based on AEMO's Generation Information page).

⁴⁸ Under the 2021 ESOO's 'Central' scenario.

⁴⁹ Extending 500 kV network from Bayswater to Eraring.

⁵⁰ Extending 500 kV network from Bannaby to a new substation between Mt Piper and Kemp's Creek.

AEMO intends to perform a more detailed assessment of the Sydney Ring as part of the 2022 ISP. This reflects the increasing importance of this project to the security and reliability of electricity supply for Sydney, Newcastle and Wollongong. This work, along with the more detailed planning set out in EnergyCo's Network Infrastructure Strategy in relation to the Sydney Ring augmentation, will inform future iterations of this report.

3.3 Costs for the supply of wholesale energy services to NSW customers

In preparing the Development Pathway, the NSW Consumer Trustee modelled the impact of new electricity infrastructure on wholesale and network costs under the Roadmap (i.e. new REZ network infrastructure) as well as the new scheme costs from generation and long-duration storage LTES agreements. Scheme costs are calculated as the difference between total levelised cost of energy (LCOE) for each unit, and the wholesale market revenues achieved by that unit. This is effectively a representation of the 'missing money' required by the unit to breakeven on its costs and a proxy for payments required from the LTES agreement. Together these costs can be considered to represent the spending on wholesale electricity to service NSW electricity customers and can therefore be compared to current and historical spending on wholesale electricity.

The modelling for this report indicates that the net present value (NPV) of total costs over the 20-year modelling horizon for the supply of wholesale energy services to NSW electricity customers is approximately \$36 billion, while previous modelling undertaken for NSW DPIE to inform the development of the Roadmap estimated the 20-year costs to supply wholesale energy services to NSW consumers, in the absence of the Roadmap, to be in the order of \$50.1 billion.⁵¹

As seen in Figure 15, total spending on wholesale electricity is expected to increase from 2021-22 to 2022-23 in line with Liddell's planned closure. This is followed by a downward trajectory to 2025-26, driven by new generation infrastructure.

⁵¹ NSW DPIE (November 2020), NSW Electricity Infrastructure Roadmap: Building an Energy Superpower – Detailed Report, Figure 19.

Figure 15 Modelled costs for the supply of NSW wholesale energy services over time (total)

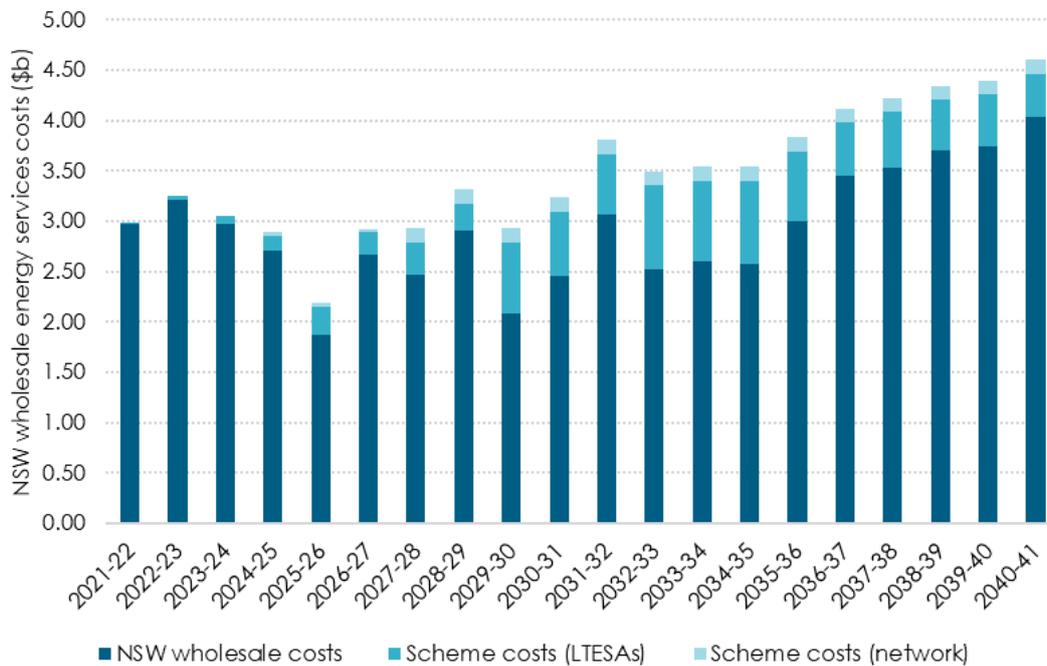
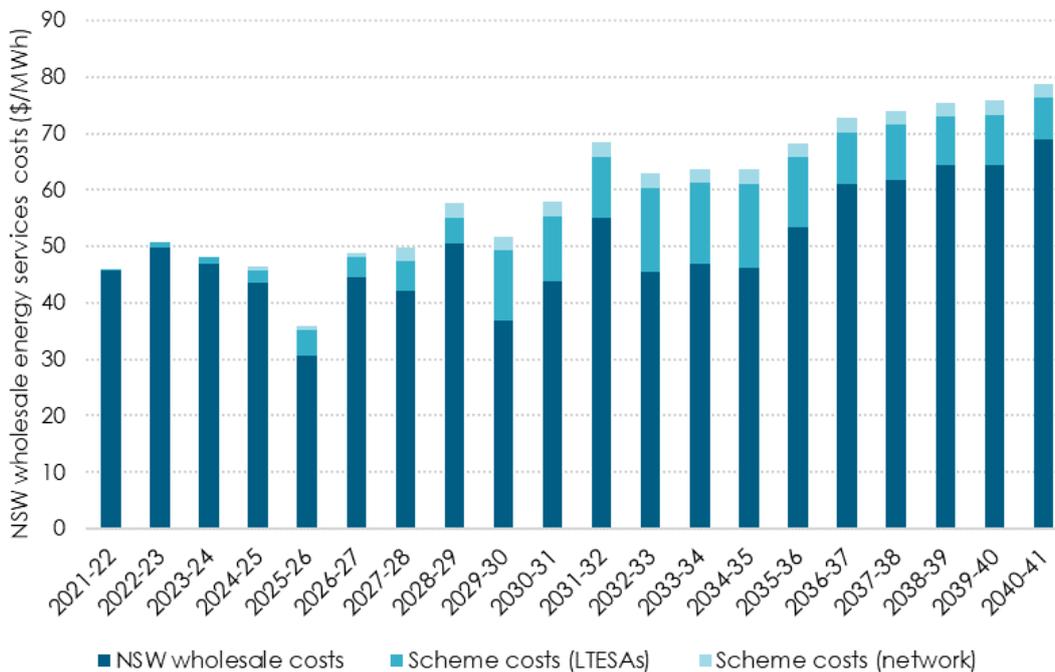


Figure 16 Modelled costs for the supply of NSW wholesale energy services over time (\$ per MWh)



It should be noted that the modelling of the second decade is subject to a high degree of uncertainty, especially after 2035. As noted above in section 3.1.1, there is significant uncertainty regarding demand and other factors affecting the electricity market in the 2030s.

The modelled results for this period are not relevant to either the selection of the Development Pathway or the design of the 10-Year Plan. Subsequent IIO Reports will provide greater certainty as to the likely investment required to minimise NSW electricity customer prices in this period.

4. 10-Year Plan

The 10-Year Plan sets out the schedule and indicative amount of infrastructure for tenders for LTES agreements in respect of generation and long-duration storage infrastructure. The NSW Consumer Trustee intends for the 10-Year Plan to provide a level of certainty to investors to enable them to plan for participation in upcoming competitive tenders for LTES agreements and improve the likelihood of receiving high-value submissions.

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

Further, the 10-Year Plan, particularly in respect of those tenders in the later years of the plan, is subject to change in future IIO Reports published every two years. The NSW Consumer Trustee may withdraw or amend the timing for or indicative amount of infrastructure to be procured under a future tender depending on the outcomes of the previous tenders or external changes to the assumptions underpinning the most recent Infrastructure Investment Objectives report. Where this is to occur, the NSW Consumer Trustee will notify stakeholders of the change. Under the EII Act, the NSW Consumer Trustee cannot conduct a competitive tender that is not included in the 10-Year Plan.

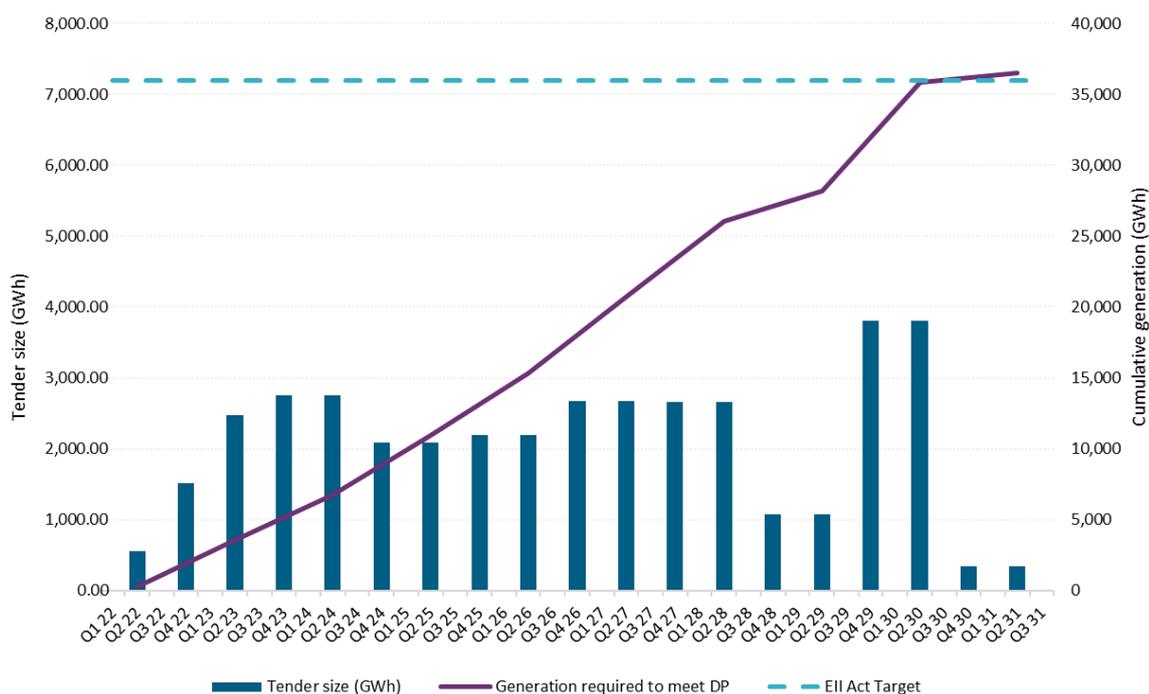
The timing and indicative scale of the generation (in GWh) and long-duration storage (in GW) tenders are detailed in the following sections.

4.1 Generation tenders

The timing and indicative size (in terms of amount of generation) for competitive tenders for generation over the next 10 years is shown in Figure 17. The volume of annual generation enabled by this schedule closely aligns to the Development Pathway, noting that the schedule of tenders accounts for a nominal two-year development lag⁵². The Development Pathway markers in Figure 17 represent the generation required in the Development Pathway, but brought forward two years (based on assumed two-year lead-times).

⁵² These lead-times assume that the projects have already progressed preparatory steps in the development process.

Figure 17 10-Year Plan (Generation)



Tenders for LTES agreements in respect of generation infrastructure projects are scheduled to occur biannually over the next 10 years, with an indicative targeted volume of 500 to 2,700 GWh of electricity per year to be delivered by projects from each tender until 2030⁵³.

The first tender will be conducted as a pilot and is scheduled to commence in Q2 2022, with the second tender to be in Q4 2022.

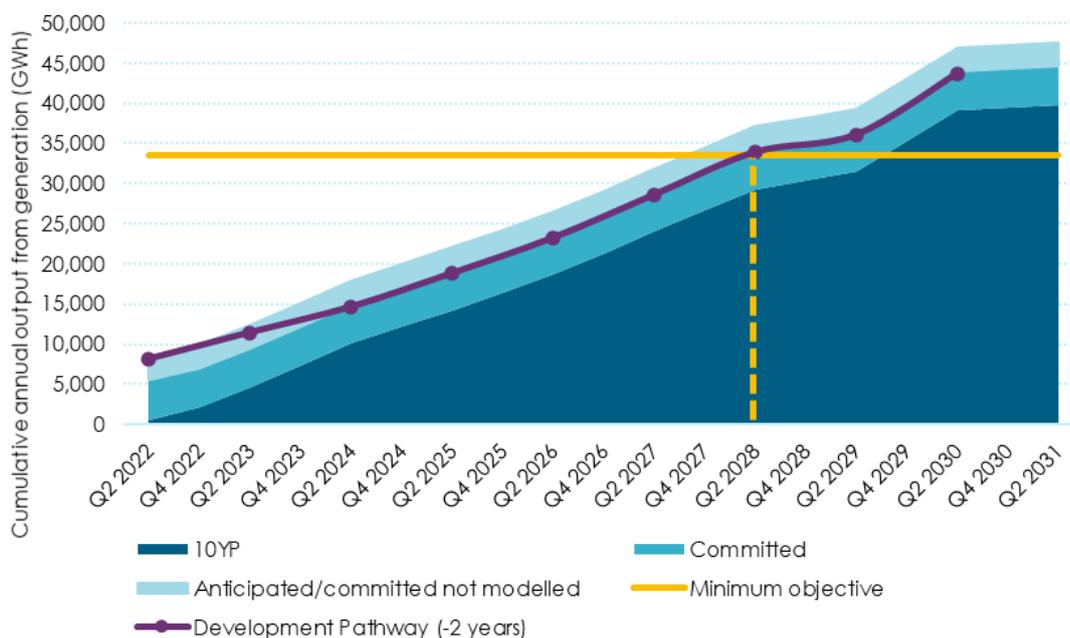
These first two tenders are designed to be smaller than subsequent tenders, to enable the piloting and refinement of tenders in the early rounds and maintain competition⁵⁴.

As seen in Figure 18, generation committed since November 2019 (included in the modelling), and generation that was committed in the last quarter (not modelled), leads to the NSW Consumer Trustee running in synch with the development pathway from the first tender.

⁵³ As noted above, tenders, particularly those in the later years of the 10-Year Plan, are subject to change. The NSW Consumer Trustee is required to prepare a 10-Year Plan every two years to give effect to the development pathway, and the timing and indicative sizing of tenders may be amended to reflect NSW's changing electricity environment.

⁵⁴ International Renewable Energy Agency and Clean Energy Ministerial, Renewable Energy Auctions: A Guide to Design, 2015, (https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_RE_Auctions_Guide_2015_3_demand.pdf?la=en&hash=A8224547C476A18F424841958F8DCB449574B33A)

Figure 18 10-Year Plan and Development Pathway comparison



Box 5: Objectives of competitive tenders and implications for initial tenders

In designing the 10-Year Plan, the NSW Consumer Trustee’s primary objective is to enhance competition for LTES agreements and access rights.

The NSW Consumer Trustee expects investors and developers will be able to submit the most competitive tender bids when they have sufficient certainty regarding:

- the operation of the tender process, LTES agreements and access scheme rights, and
- the design and technical standards of the REZs to be established in NSW.

Based on the Energy Corporation of NSW’s current planning, near final clarity on the operational aspects and timing of delivery of the Central-West Orana REZ should be achieved by the third quarter of 2022. In addition, by this time, it is expected there will also be greater clarity in relation to the design and timing of delivery of the other four REZs contemplated by the EII Act. The NSW Consumer Trustee also acknowledges that a period of learning is required before investors and developers fully understand the competitive tender process and the value of the LTES agreement and access right product.

For the above reasons, the NSW Consumer Trustee has determined that the first two tenders will take place in Q2 and Q4 2022. The first tender should be considered a pilot tender, an opportunity for proponents to learn how the new mechanisms will work. The second tender will also be relatively small, a further chance to learn but with more information available on REZ to better inform proponents.

Following the initial two tenders, the NSW Consumer Trustee expects that the tender process will become more competitive so that the indicative size of each tender then increases to deliver on the Development Pathway. At this point, the NSW Consumer Trustee expects that there will be greater certainty for tender participants resulting in greater competition better overall value for NSW consumers compared to early tenders.

The NSW Consumer Trustee may not allocate any LTES agreements in the first round or indeed in any round if bids do not reflect sufficient value to NSW electricity customers. Notwithstanding, the NSW Consumer Trustee has indicated some volume for this first tender in recognition of two possibilities: first, there may be high value projects

under development outside anticipated REZ boundaries that were committed after 14 November 2019, and second, there may be projects within those REZ boundaries that will connect to existing network infrastructure. Work is continuing on what, if any, access scheme fees will apply to such projects. The NSW Consumer Trustee acknowledges the ultimate judge of price will be the market, indicative tender sizes are just that, indications that align with the development pathway. Final volumes in any tender will be based on assessment of value to the consumer. To drive further competition and rapid learning by the market, the 10-Year Plan provides for frequent tenders for LTES agreements, every six months over the full 10-year period. This frequency will ensure that both the tender participants and the NSW Consumer Trustee can continue to evolve their understanding of value over time in response to ongoing changes in the market increasing the chances of highly competitive and high value submissions.

Following the first two tenders, the size of each subsequent tender will rise significantly, in line with the build trajectory for generation infrastructure that is required to meet the infrastructure investment objectives under the Development Pathway.

Box 6: Relationship between LTES agreements, REZ declarations and access rights

The 10-Year Plan is solely focused on the timing and sizing of the LTES agreement tenders. However, many participants in tender process will be intending to locate within a REZ and / or participate in a REZ access scheme. There will therefore be an interaction between the timing of LTES agreement tenders, the timing of the Minister's REZ declarations and the timing of the Minister's access scheme declarations.

Projects located outside of a REZ will need to show outstanding merit to be awarded an LTES agreement. To avoid this requirement, projects intending to locate within a REZ will need to wait until the relevant REZ has been declared by the Minister.

The NSW Consumer Trustee understands that it is the NSW Government's intention that, where possible, LTES agreement tenders also allocate access rights. Accordingly, projects seeking both an LTES agreement and an access right may choose to wait until both the relevant REZ and the relevant access scheme have been declared by the Minister before participating in a tender process.

The NSW Consumer Trustee is working with the NSW Government to ensure that multiple REZ declarations and access schemes declarations can be made in a timely manner to support participation in tender processes.

More information on the current timeframe for Minister's declaration of REZs can be found at <https://www.energy.nsw.gov.au/renewables/renewable-energy-zones>.

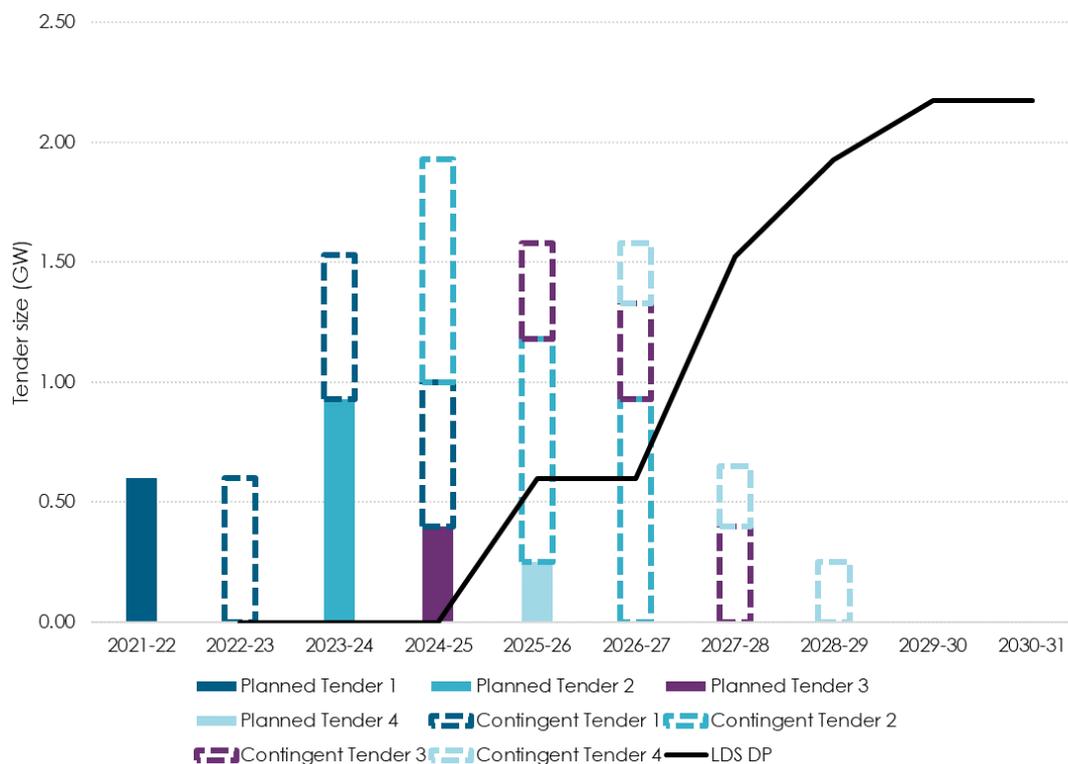
4.2 Long-duration storage tenders

The timing and indicative sizing for tenders for long-duration storage LTES agreements over the next 10-year period is shown in Figure 19.

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

The indicative sizing of each long-duration storage tender ranges between approximately 0.2 GW and 0.9 GW across the 10-year period. The first tender is scheduled to occur in 2021-22 with an indicative sizing of 0.6 GW.

Figure 19 10-Year Plan (Long Duration Storage)



The NSW Consumer Trustee has planned for ‘contingent tenders’ for long-duration storage infrastructure each year, including in years where the Development Pathway does not indicate a need for additional long-duration storage capacity (see Figure 19). Whether a tender proceeds in a given year is contingent on the outcomes of preceding tenders. It will only proceed if sufficient long-duration storage capacity is not recommended for an LTES agreement in preceding tenders. Any unallocated capacity from a tender round will also be rolled into the next round, as seen by the dotted lines in Figure 19.

The NSW Consumer Trustee’s approach allows for the possibility of not conducting a tender in some years because of the significant uncertainty associated with long-duration storage technology prices and lead-times.

Pumped hydro is expected to be the most cost-effective long-duration storage technology in NSW (although this is yet to be tested in Australia in a competitive process). However, this assumption could prove incorrect if battery costs reduce or if emerging technologies, such as compressed air energy storage, can be developed at scale. The Development Pathway suggests long-duration storage infrastructure may be required by 2025-26.

As discussed in Section 3.1.2, there are many potential pumped hydro projects in NSW, but only a small number are advanced to the stage where the proponent is likely to have sufficient confidence regarding project costs to participate in a tender for LTES agreements. It is expected that the NSW Government’s Pumped Hydro Recoverable Grants Program will assist in progressing other potential projects to advance towards a 3 GW pipeline of shovel-ready pumped hydro projects to participate in future tenders.

Given the uncertainty around which long-duration storage technology is likely to be optimal to meet the required capacity, the NSW Consumer Trustee intends to hold a tender for long-duration storage in 2021-22. This will allow the NSW Consumer Trustee to test the market, with the option to recommend

LTES agreements in early tenders if alternative technologies demonstrate they are more cost-effective than the expected future cost of a pumped hydro project.

If the NSW Consumer Trustee chooses not to recommend LTES agreements for projects with 0.6 GW of capacity in the 2021-22 tender, the NSW Consumer Trustee would run another tender for any residual capacity in 2022-23, and so on. To ensure transaction costs for the NSW Consumer Trustee and tender participants are minimised, the NSW Consumer Trustee intends to allow information provided in one tender to be used again including the assessment of a proponent's eligibility.

5. Approach to the Development Pathway

This section outlines the modelling methodology and process used to identify and assess alternative development pathways during the selection of the Development Pathway.

5.1 Overview of approach

The NSW Consumer Trustee engaged AEMO to undertake market modelling to inform its development of the Development Pathway. AEMO's modelling considered the build trajectory required over a 20-year period in respect of generation and long-duration storage infrastructure to meet the infrastructure investment objectives at least cost to NSW electricity customers, assuming a common set of enabling network infrastructure investments⁵⁵. The model was designed to assist the NSW Consumer Trustee in selecting a Development Pathway that best met the infrastructure investment objectives, having regard to the resilience of the modelled results against various real-world uncertainties.

The overarching approach to the Development Pathway, which is represented in Figure 20, was as follows:

- EY, on behalf of AEMO, developed a market model and, working with NSW DPIE, a set of alternative development pathways.
- Each alternative development pathway was based on a consistent set of baseline assumptions, including operational demand, consumer technology drivers, technology cost curves and project lead-times. The inputs and assumptions were broadly consistent with the 'Central' scenario in AEMO's draft 2021 IASR⁵⁶, although they also drew from AEMO's 2020 ISP and 2020 ES00, NSW DPIE data regarding prospective pumped hydro projects, and other publicly available documents.

⁵⁵ For the reasons discussed in sections 2.2 and 2.2.3, the Development Pathway does not model additional firming infrastructure.

⁵⁶ Following the publication of the draft 2021 IASR, certain updated inputs and assumptions (which were ultimately included in the final 2021 IASR) also became available and were included in the development pathway modelling. However, there are some key discrepancies between the assumptions used in preparing the 2021 Development Pathway and the final 2021 IASR. These are set out in AEMO's Development Pathways Report.

- Each alternative development pathway included a different set of considerations which influenced the rate of build, such as alignment to network augmentations or supply chain constraints. The timing and choice of network augmentations are common to all alternative development pathways.
- The model's objective was to minimise the wholesale, scheme and network costs for NSW electricity customers across the 20-year period. The model's objective was constrained in that the build was required to meet the infrastructure investment objectives for generation and long-duration storage while satisfying a state-wide energy security target, which was used as a proxy in the modelling for the reliability standard. The model iterated build outcomes to achieve its objective and meet these constraints. This produced a build trajectory (for generation and long-duration storage) in NSW, as well as a generation technology mix, wholesale electricity, scheme costs and cumulative emission reductions for each alternative development pathway.
- Sensitivities were then tested on the alternative development pathways to assess the resilience of these to changes in a range of external factors.
- The Development Pathway was selected by the NSW Consumer Trustee, based on NSW electricity customer cost outcomes, resilience to changes in external factors and performance against a number of additional criteria.
- A reliability assessment was then performed on the preferred Development Pathway to check that it met the reliability standard across the 20-year period.

The following sections describe these steps in further detail.

Figure 20 Overview of approach to the Development Pathway

Develop input assumptions	Set consistent inputs and assumptions across alternative Development Pathways
Define alternative Development Pathways	Design alternative Development Pathways which explore different sets of considerations which influence the rate of build
Iterate towards modelling objectives	Minimise cost to NSW electricity customers while meeting IIOs
Sensitivity modelling	Test key input changes for impact to NSW consumer outcomes
Selection of the 2021 Development Pathway	Select the alternative Development Pathway based on resilience and NSW consumer outcomes and perform reliability assessment

5.2 Modelling Inputs

The development pathway modelling included a set of consistent input assumptions for demand, technology costs and network developments across all alternative development pathways.

As noted above, the inputs and assumptions were broadly consistent with the 'Central' scenario in AEMO's draft 2021 IASR, although they also drew from AEMO's 2020 ISP and 2020 ESOO, NSW DPIE data regarding prospective pumped hydro projects, and other publicly available documents. These assumptions differ somewhat from the final 2021 IASR, which will underpin AEMO's draft 2022 ISP.

In the scenarios to be used in its 2022 ISP, AEMO has revised several of its ‘middle of the road’ assumptions, including an increase in electric vehicle uptake, behind-the-metre storage uptake, committed generation and peak demand forecasts. The NSW Consumer Trustee does not consider that the differences in assumptions impact the validity of the modelling for this report, because they mostly relate to the later periods of the Development Pathway where this is significant future uncertainty in any case (as noted in Section 3.1.1). Further, the NSW Consumer Trustee will have regard to the latest information when exercising its procurement functions in relation to LTES agreements and network infrastructure project authorisations.

Further detail is provided in EY’s Modelling Methodology and Assumptions Report. An overview of key inputs and their sources is set out below.

5.2.1 Demand side assumptions

Demand side assumptions in the development pathway modelling are listed in Table 4.

Table 4 Demand side assumptions

Assumption	Source	Comparison to 2021 IASR
Load – annual consumption and maximum demand	Central scenario of AEMO’s 2020 ESOO as presented in AEMO’s draft 2021 IASR, except adjustments to the rooftop PV and small non-scheduled solar PV (PVNSG) uptake and the inclusion of the NSW Energy Saving Scheme and Peak Demand Reduction Scheme. Both 10% and 50% Probability of Exceedance (POE) peak demand trajectories were modelled.	With the adjustments for NSW policies and rooftop PV uptake, the maximum demand assumptions align closely to the 2021 ESOO Central maximum demand forecast until 2024-25, and are lower than the 2021 ESOO Central forecast by approximately 12% by 2030-31.
Rooftop PV and non-scheduled generation	Sourced from AEMO’s draft 2021 ESOO Forecasting Reference Group consultation on PV, which are higher than the 2020 ESOO Central scenario projections.	Aligns with the 2021 IASR Net Zero forecast.
Behind-the-meter battery storage uptake	Projections are sourced from AEMO’s 2020 ESOO Central scenario.	Higher than the 2021 IASR Slow Change scenario and significantly lower than the 2021 IASR Net Zero scenario projection.
Electric vehicles (EVs)	Projections are sourced from AEMO’s 2020 ESOO Central scenario.	Aligns with 2021 IASR Slow Change scenario until 2032-33 and is higher than the 2021 IASR Slow Change and lower than the 2021 IASR Net Zero scenarios by 2041-42.
Demand side participation	Projections are sourced from AEMO’s 2020 ESOO Central scenario.	Aligns with 2021 IASR Steady Progress scenario.

5.2.2 Existing and new entrant technology assumptions

Assumptions relating to existing and new generation and storage technologies in the development pathway modelling are listed in Table 5.

Table 5 New technology assumptions

Assumption	Source
Technology cost curve	Sourced from the Central scenario of AEMO's draft 2021 IASR
Weighted Average Cost of Capital (WACC)	Sourced from NAB's report on WACC for the NSW Electricity Infrastructure Roadmap ⁵⁷ .
Build lead times	Sourced from AEMO's draft 2021 IASR.
Existing and committed capacity	Sourced from AEMO's May 2021 Generator Information Page, with the addition of some anticipated dispatchable capacity identified by AEMO as progressing to become committed soon.

5.2.3 Network augmentation assumptions

Augmentations to the transmission network, and their assumed timing, were also inputs to the Development Pathway modelling. The key network augmentations assumed in the modelling are listed in Table 6. These projects encompass network augmentations that enable Roadmap-specific generation and long-duration storage infrastructure, as well as NEM network augmentations determined to be significant by AEMO in its 2020 ISP modelling and draft 2021 IASR. The costs assumed for these augmentations are sourced from public reports from the AER, AEMO and Transgrid as well as internal AEMO estimates.

Table 6 Network augmentation timing assumptions

Project	Timing assumed
QNI minor (option 1A from the 2020 ISP)	1/07/2021
VNI minor (VIC-NSW option 1 from 2020 ISP)	1/07/2021
Project EnergyConnect (from 2020 ISP)	1/07/2024
Central-West Orana REZ (from 2020 ISP)	1/07/2024
SW NSW stability improvement Option 1A (from Transgrid TAPR 2020)	1/07/2025
Western Victoria (from AEMO's 2018 PADR)	1/07/2025
HumeLink (from 2020 ISP) ⁵⁸	1/07/2026
Sydney Ring 500 kV North and South paths (from Transgrid's 2020 TAPR)	1/07/2027
New England REZ (from Transgrid's 2020 TAPR), including QNI medium- west of the path (southern portions only, Option 2E from the 2020 ISP)	1/07/2027
Marinus link stage 1 (from the 2020 ISP)	1/07/2028
Gladstone Grid Reinforcement (from the 2020 ISP)	1/07/2035

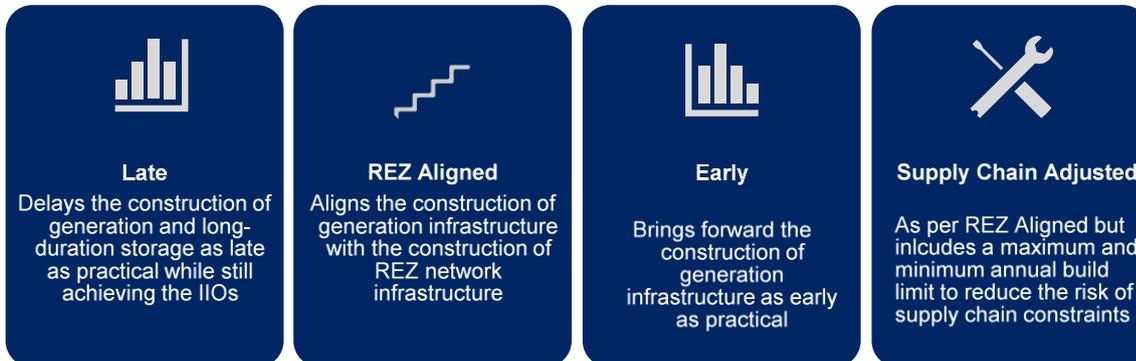
⁵⁷ See <https://energy.nsw.gov.au/sites/default/files/2020-11/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20WACC%20Report.pdf>.

⁵⁸ At the time of modelling, the latest available information for the expected service date for HumeLink was in line with the 2020 Integrated System Plan, as 2025-26. Since the time of modelling, Transgrid has estimated this date to be 'late 2026'.

5.3 Alternative development pathways

Four alternative development pathways were modelled, as outlined in Figure 21. As noted above, each scenario is based on a consistent set of input assumptions, but varies in the rate of build.

Figure 21 Alternative development pathways



5.3.1 Late development pathway

The 'Late' development pathway aims to achieve the infrastructure investment objectives at the least cost to NSW electricity customers. It represents the pathway that the NSW Consumer Trustee would adopt if:

- a key object of the EII Act was not to improve the sustainability of electricity supply, including that emissions are not valued,
- there were no supply chain constraints, including in relation to skilled labour, civil construction, equipment, capital or grid connection, and
- there was absolute certainty as to input assumptions, including continued availability of coal plants in NSW, Victoria and Queensland and the timing of major network infrastructure projects.

While not initially designed to represent a Late pathway, without constraints on build, the modelling shows new generation entering the market as late as possible in the 2020s is the lowest-cost approach to achieving the minimum infrastructure investment objectives. The Late development pathway chooses to wait until assumed declines in the cost of technology are realised before ramping up construction. Further development of renewable energy generation also occurs after 2029 to continue to minimise costs for the supply of wholesale energy services to NSW electricity customers.

5.3.2 REZ Aligned development pathway

The 'REZ Aligned' development pathway prioritises generation construction that aligns with the development of REZ network infrastructure for the Central-West Orana and New England REZs. The purpose of this is to maximise the utilisation of REZ infrastructure network as soon as it is available. This development pathway may also have benefits for local communities and offer efficiencies to EnergyCo through the coordination of generation and transmission network infrastructure development. Further development of renewable energy generation also occurs after 2029 to continue to minimise costs for the supply of wholesale energy services to NSW electricity customers.

Because of the earlier and less concentrated build, this development pathway has greater carbon emissions reductions compared to the Late pathway and reduced risk of supply chain constraints.

5.3.3 Early development pathway

The 'Early' development pathway represents the earliest plausible build trajectory. The Early development pathways seeks to both minimise cumulative carbon emissions, mitigate the risk of early coal withdrawals as well as potential risks of increased supply chain disruptions, which could result in higher prices for labour and materials.

This development pathway brings the trajectory forward to as early as 2023-24 (and in advance of REZ network infrastructure development). The locations, technology type and capacity are adjusted to minimise costs for the supply of wholesale energy services to NSW electricity customers. Additional generation also enters post 2030 to reduce costs for the supply of wholesale energy services to NSW electricity customers.

5.3.4 Supply Chain Adjusted development pathway

The Supply Chain Adjusted development pathway considers a minimum and maximum amount of generation entry in NSW per year to reflect supply chain constraints. A limit of generation infrastructure in NSW capable of producing approximately 6,000 GWh per year was assumed until 2030. The rationale for this limit is discussed in Appendix B.

The annual build limit results in a steady increase of generation entry to 2030, albeit with higher volumes of entry towards the second half of the 2020s. Post-2030, a build constraint of generation infrastructure in NSW capable of producing approximately 7,600 GWh per year is applied.

5.4 Model objectives

The model's objectives are to minimise NSW electricity customer costs across the forecast horizon in all alternative development pathways, while achieving the minimum infrastructure investment objectives of approximately 33,600 GWh per year of generation volume and 2 GW of long-duration storage completed construction by the end of 2029. The model allows for the entry of additional generation or long-duration storage infrastructure both before and after 2029 if it is calculated to be in the financial interests of NSW electricity customers or required to maintain reliability.

As outlined in Section 3.3, the model seeks to minimise wholesale, scheme and network costs. The calculation methodologies for these are described below.

- **Wholesale costs** – The wholesale electricity component of electricity bills observed by NSW electricity customers⁵⁹. This is the load-weighted average of NSW spot prices, multiplied by NSW region operational demand.
- **Scheme costs (generation and storage LTES liabilities)** – The total cost paid by the Scheme Financial Vehicle to LTES agreement counterparties due to the exercise of the contractual option in respect of a generation or long-duration storage facility. These scheme costs also include any new capacity built to meet the state-wide energy security capacity target, if applicable.
 - This category of scheme costs is calculated as the difference between total levelised cost of energy (LCOE) for each unit, and the wholesale market revenues achieved by that unit. This is effectively a representation of the 'missing money' required by the unit to break even on its costs and a proxy for

⁵⁹ The contract market was not considered in the calculation of wholesale electricity costs to NSW customers.

payments required from the LTES agreement⁶⁰. It should be noted that the LTES agreement structure has not been considered in the modelling, and thus costs to the Scheme Financial Vehicle from LTES agreements are representative proxies only.

- **Scheme costs (network build)** – The total cost of new network augmentations attributable to the achievement of the infrastructure investment objectives, annualised over time using a 6.54% rate of return⁶¹. These scheme costs are the estimated cost of building particular transmission augmentations to enable additional renewable generation and long-duration storage capacity in NSW to be connected and appropriately dispatched into the power system. The network augmentation schedule and associated costs are an input to the development pathways modelling and therefore this category of scheme cost is not co optimised within the objective function.

5.4.1 Electricity market modelling

NEM-wide electricity market modelling for the 20-year horizon was undertaken to forecast the future capacity mix across each jurisdiction, on a half-hourly basis for all alternative development pathways. The input assumptions and objectives in the modelling are consistent across all alternative development pathways and are described in sections 5.2 and 5.3, respectively.

The build of new generation and storage infrastructure, and the withdrawal of existing generation infrastructure, is iterated to minimise overall customer costs across the modelling horizon, while ensuring:

- the minimum objectives for generation and long-duration storage infrastructure were met,
- the state-wide energy security target – a proxy measure of reliability in the modelling – was met⁶²,
- the Queensland, Victorian and Tasmanian renewable energy targets⁶³ were met,
- economic entry of new capacity (in addition to any capacity expansion to meet the minimum objectives), and
- economic retirement of existing generation capacity.

Iterations of capacity entry and exit lead to the least-cost trajectory for NSW electricity customers under each of the alternative development pathway considerations. These capacity mixes are dispatched in market modelling simulations, which result in half-hourly wholesale market outcomes including wholesale prices, generation mix and emissions. The key market modelling outputs are summarised below:

- **New build of generation and long-duration storage capacity**, including timing, capacity, technology type and location. This output is the basis of the alternative development pathways.
- **Electricity spot prices**. This output is used to calculate the wholesale component of customer costs and the merchant revenue for new generation and storage capacity, which is then used to calculate scheme costs.
- **Emissions from the generation of electricity**. This output is used to calculate emission reductions for each alternative development pathway.

⁶⁰ The 'missing money' calculation considers wholesale market revenues alone and ignore revenues from the sale of green certificates or provision of ancillary services in other markets. This makes the scheme costs a conservative estimate.

⁶¹ As per the Australian Energy Regulator's final decision on Transgrid's transmission determination for the 2018–23 regulatory control period.

⁶² Additional reliability modelling was then undertaken as described below.

⁶³ 50% QRET by 2030; 45% and 50% VRET by 2025 and 2030 respectively; 100% TRET by 2022, 150% by 2030, and 200% by 2040

5.5 Sensitivity modelling

A number of sensitivity tests were undertaken to assess the materiality of changes to certain input parameters or assumptions for the alternative development pathways. The purpose of these sensitivity tests was to inform the selection of a Development Pathway that was resilient (in terms of cost outcomes) to changes in external factors.

The sensitivities that were tested were:

- Earlier than expected withdrawal of NSW coal generation,
- Earlier than expected withdrawal of Queensland coal generation,
- Delays in network augmentation, and
- Slower than expected demand growth, due to slow economic recovery and industrial closures.

These sensitivities were selected as they are both subject to a high degree of uncertainty, and have the potential to materially impact cost outcomes for NSW electricity customers.

Technology mix outcomes across the 20-year horizon from the market modelling stage were used for each alternative development pathway as inputs to the sensitivity modelling. In each sensitivity test, an additional input assumption was changed (i.e. an existing generator was withdrawn early, a network augmentation was delayed or the demand forecast was reduced). The dispatch modelling was then repeated to test the impact of this 'shock' on costs for the supply of wholesale energy services to NSW customers if the build trajectory under the original pathway did not change.

These tests represent an extreme (and unlikely) outcome in that the modelling assumes that the NSW Consumer Trustee does not respond to the 'shock', but rather continues to facilitate a build trajectory in line with the original development pathway. The outcomes of the sensitivity analysis were then used to aid the resilience assessment (see Section 6.4 for further details).

The results of the sensitivity testing are discussed in the resilience assessment in Section 6.4. Further detail of the approach and the results are included in AEMO's Development Pathways Report.

6. Selection of the Development Pathway

The NSW Consumer Trustee assessed the four alternative development pathways and selected the Development Pathway based on its performance against six selection criteria.

The criteria, the rationale for inclusion and the metric used to assess performance against each criterion are set out in Table 7.

Table 7 Development pathway selection criteria

Criteria	Criteria rationale	Performance metric
Minimises financial costs for the supply of wholesale energy services to NSW electricity customers	Aligns with infrastructure investment objectives	Net present value of costs to supply wholesale energy services to NSW customers (wholesale costs, transmission network costs and scheme costs) over a 20-year period
Improves sustainability of electricity supply	Aligns with object of the EII Act and the requirement for the Consumer Trustee to consider these objects	Cumulative carbon dioxide emissions
Maintains reliability	Alignment with infrastructure investment objectives for long duration storage	Margin between state-wide energy security target and firm capacity across 20 years ⁶⁴ (also indicative of the expected unserved energy relative to the reliability standard)
Promotes resilience	A more resilient pathway will minimise costs to NSW customers under uncertainty and therefore aligns with infrastructure investment objectives	Qualitative assessment against key variables
Enhances competition	Enhanced competition will place downward pressure on bidders' prices, which minimises costs to customers and therefore aligns with the infrastructure investment objectives	Consistent build that enables regular tenders
Considers supply chain impacts	Minimising supply chain constraints will assist in avoiding price rises and project delays, and therefore aligns with infrastructure investment objectives	Build trajectory that avoids uneven periods of investment and annual builds of generation infrastructure of a size that is greater than that capable of producing 6,000 GWh of electricity per year to 2030 (and 7,600 from 2030).

Table 8 presents a summary of each alternative development pathway's performance against the selection criteria. As shown in Table 8, the Supply Chain Adjusted development pathway generally performs the best across almost all criteria compared with the other alternative development pathways. Accordingly, it was selected as the Development Pathway.

⁶⁴ The NSW-wide energy security target was calculated by reference to forecast peak demand from NSW electricity customers (based on a 10% probability of exceedance (POE) forecast methodology) plus a reserve margin of the sum of the amount of electricity capable of being produced by NSW's two largest generating units.

Table 8 Alternative development pathway performance against selection criteria

Criteria	Late	REZ aligned	Early	Supply Chain Adjusted
Minimises financial costs for the supply of wholesale energy services to NSW customers (NPV \$b)⁶⁵	\$35.78	\$36.91	\$36.57	\$36.06
Improves sustainability (reduction in cumulative carbon emissions relative to Late)	-	-22.76 MtCO ₂ e (-7%)	-44.23 MtCO ₂ e (-14%)	-25.67 MtCO ₂ e (-8%)
Maintains reliability (smallest annual margin between state-wide energy security target and firm capacity across 20 years)⁶⁶	2.93%	2.93%	2.52%	2.93%
Promotes resilience	Delayed schedule provides least flexibility and is the most inherently vulnerable to uncertainties	Coordinated build schedule aligns with other REZ developments and allows for advance or delay against plan in response to uncertainty	Advanced schedule is vulnerable to misalignment with other developments including transmission augmentation	Adjusted schedule offers the most resilience as it provides the greatest optionality to respond to uncertainties
Enhances competition	Late peak provides minimal learning opportunities for both CT and participants	Peaks in build reduce opportunity for participants to refine bids over time	Peaks in build reduce opportunity for participants to refine bids over time	Frequent low volume tenders leads to better value bids for NSW consumers over time
Minimises supply chain constraints	Supply chain risks exist compounded if network augmentation also delayed	Supply chain risks exist based on generation build peaks	Supply chain risks exist based on generation and network build peaks	Lowest risk of supply chain risk across the available pathways

6.1 Minimising costs for the supply of wholesale energy services to NSW customers

The costs of supplying wholesale energy services to NSW customers are an output of the development pathway modelling and include wholesale costs, scheme costs and network costs (as described in

⁶⁵ Net present value (NPV) of total costs over the 20-year modelling horizon to supply wholesale energy services to NSW consumers. This cost is not a new cost and can be compared to spending on wholesale electricity that would be required without the Roadmap. See Section 3.3 for more detailed discussion regarding costs for the supply of wholesale energy services under the development pathway.

⁶⁶ This metric is calculated as the smallest annual value of the percentage of firm capacity in NSW in excess of the firm capacity target across the 20-year horizon. That is, the minimum of (total NSW firm capacity – firm capacity target)/ firm capacity target, calculated annually for 20 years.

Section 5.4). The criterion of minimising these costs is a measure of the net present value (NPV) of total costs to supply these services over the 20 year modelling horizon, where a lower NPV of costs indicates higher performance against the criterion.

The costs for the supply of wholesale energy services to NSW electricity customers under the Development Pathway are described in Section 3.3.

The NPV for NSW electricity customers under each alternative development pathway is set out in Figure 22. Of the alternative development pathways, the Supply Chain Adjusted development pathway has the second lowest NPV of total costs, being only 0.7% higher than the NPV of costs under the lowest cost option, the Late development pathway, as shown in Figure 22. The REZ Aligned and Early development pathways are 3.0% and 2.1% higher in terms of costs than the Late development pathway, respectively.

Figure 22 Net present costs for the supply of wholesale energy services to NSW customers for each alternative development pathway



In selecting the 2021 Development Pathway, the NSW Consumer Trustee also considered the resilience of the modelled costs to incorrect assumptions or shocks. The Late scenario was determined to lack resilience in this regard, due to the large peak in investment required in the second half of the 2020s.

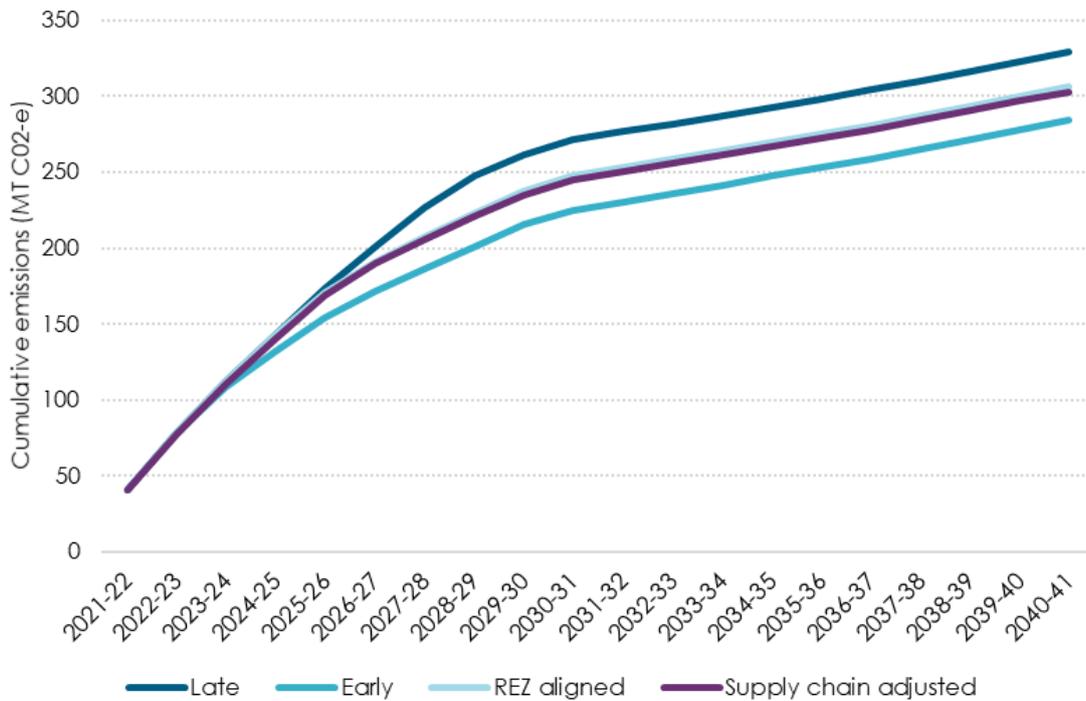
Such a steep build trajectory would likely result in increased costs due to supply chain constraints and potential inflationary pressures. Accordingly, despite having the lowest NPV of costs, the Late development pathway was deemed to create a risk to NSW electricity customers of material wholesale price increases. The NSW Consumer Trustee selected the Supply Chain Adjusted development pathway, given its associated costs are the next lowest and its superior performance against the other selection criteria.

6.2 Reducing carbon emissions

A key object of the EII Act is the improvement of the sustainability of NSW’s electricity supply⁶⁷. The NSW Consumer Trustee is required to have regard to this object, among others, in preparing the 2021 IIO Report⁶⁸. Accordingly, in selecting the Development Pathway, the NSW Consumer Trustee sought to minimise cumulative carbon emissions from NSW electricity generation over the 20-year period⁶⁹.

While the modelling indicates that all alternative development pathways achieve an equal annual emissions value by 2030, the Early development pathway achieves lower cumulative emissions over the 20-year period (as it sees greater renewable generation earlier in the period and earlier coal plant withdrawal). In comparison, the Late development pathway results in higher cumulative emissions due to comparatively delayed renewable generation entry. The Supply Chain Adjusted development pathway, with its staged build trajectory, results in cumulative emissions between the Early and Late development pathways, as shown in Figure 23.

Figure 23 Cumulative emissions by alternative development pathway



6.3 Maintaining reliability

In addition to the infrastructure investment objectives, the EII Act requires the NSW Consumer Trustee to consider reliability and security of electricity supply generally in its decision-making process. The NSW Consumer Trustee has considered these objects by modelling the margin between state-wide energy security target and firm capacity across 20 years. As noted above, this measure was used in the market modelling as a proxy for reliability.

⁶⁷ EII Act, section 3(1)(a).

⁶⁸ Electricity Infrastructure Investment Regulation 2021, clause 16C.

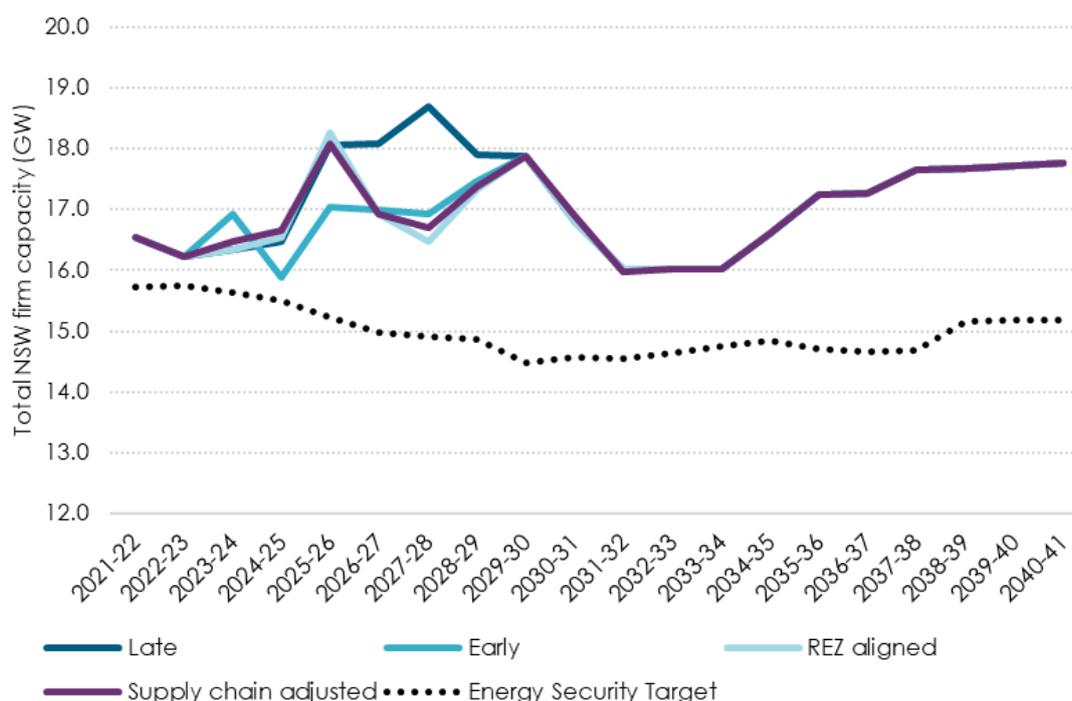
⁶⁹ Emissions are an output of the modelling and are measured in million tonnes of CO₂ equivalent (Mt CO₂-e).

All alternative development pathways result in sufficient firm capacity to meet the state-wide energy security target, with the average amount of exceedance remaining consistent across all development pathways, as seen in Figure 24.

The Early development pathway has the lowest firm capacity margin compared to the other alternative development pathways. This is a result of earlier capacity entry leading to earlier modelled economic withdrawals of existing coal plant. By contrast, the Supply Chain Adjusted development pathway provides a minimum firm capacity margin of 3%, reached in 2022-23, and has a margin of 23% in 2029-30. The degree by which firm capacity under the Supply Chain Adjusted development pathway exceeds the state-wide energy security target is the result of construction of additional long-duration storage (above the minimum objective of 2 GW by 2029) intended to reduce customer costs.

The firm capacity margin under the Supply Chain Adjusted development pathway aligns closely to that under the REZ Aligned development pathway. Both present a smoother trajectory than the Early and Late development pathways.

Figure 24 Development pathways' firm capacity and the state-wide energy security target



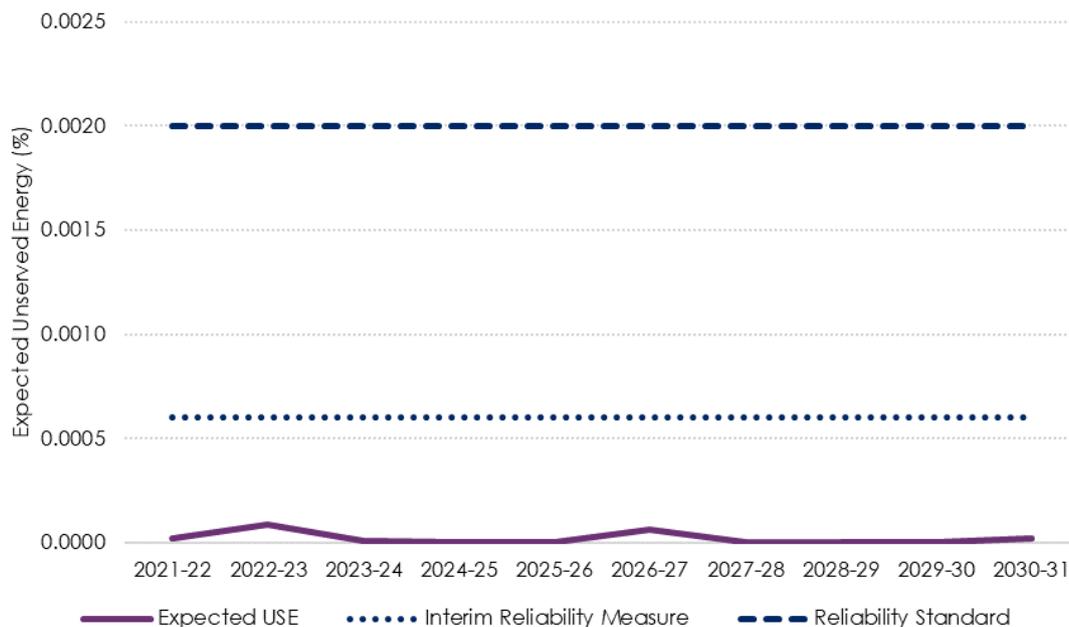
While AEMO and EY modelled firm capacity required to meet the target, this is a proxy measure for reliability and does not guarantee the legislated reliability standard is met. Following the selection of the Development Pathway, AEMO undertook a reliability assessment to ensure the Supply Chain Adjusted development pathway met the reliability standard.

The reliability assessment used a statistical approach to assess unserved energy outcomes under a range of market conditions including levels of varying demand, historical weather patterns and generator availabilities. This involved modelling time-sequential Monte-Carlo⁷⁰ simulations of the Supply Chain

⁷⁰ A modelling technique used to understand the impact of risk and uncertainty by simulating the probability of different outcomes in a process that cannot easily be predicted.

Adjusted technology mix, with probabilistic weighting of events to identify likelihood and severity of supply shortfalls. This assessment was applied to the first 10 years of the modelled 20-year horizon, and to three additional years in the second half of the modelled horizon (2032-33, 2033-34 and 2038-29), which were selected as those closest to breaching the state-wide energy security target. The reliability assessment demonstrated that the identified technology mix in the Supply Chain Adjusted development pathway, coupled with the assumed network infrastructure developments, met the reliability standard across all modelled years, as shown in Figure 25 for the first 10 years.

Figure 25 NSW unserved energy outcomes from the reliability assessment



6.4 Promoting resilience

Given the high degree of uncertainty in relation to many of the modelling inputs, the NSW Consumer Trustee also considered the resilience of the modelled results to changes in input assumptions or shocks. The purpose of this exercise was to test the alternative development pathways' resilience to uncertainty.

The following variables were identified as material uncertainties which may impact the evaluation of each alternative development pathway:

- Weighted average cost of capital (WACC)
- Peak demand growth
- Slower economic growth
- Rooftop solar generation
- Early coal plant withdrawals
- Delays to transmission augmentation and firming projects.

These uncertainties, and an evaluation of their potential impact on the selection of the 2021 Development Pathway, are outlined below.

6.4.1 Weighted average cost of capital

The cost of renewable electricity infrastructure is primarily related to capital (rather than operating) expenditure. Capital costs are dependent on matters such as technology prices, the cost of financing, returns on equity, and relative proportions of debt and equity funding (weighted average cost of capital, WACC). Projects perceived by lenders and investors to carry higher risks may face higher WACCs.

WACC can also be influenced by broader macro-economic conditions such as competition for finance and interest rates. Interest rates are presently at historical lows and the potential for interest rate variation may increase toward the end of the decade and beyond. This suggests the potential for adverse cost consequences for NSW electricity customers under the Late development pathway, which concentrates investment in the late 2020s.

6.4.2 Peak demand growth

The electrification of other sectors, including transport, space and water heating and thermal processing, have the potential to greatly increase demand for electricity beyond that modelled for this report. However, while electrification is expected to drive substantial increases in aggregate load over the coming decades, the rate of change and the characteristics of this load are uncertain. There is the potential for demand management to reduce total infrastructure investment requirements.

However, without technological or other controls, there is the possibility of large increases in demand concentrated during certain periods (e.g. electric vehicle convenience charging). The Early development pathway is likely to be most resilient to earlier and larger increases in peak demand, provided that coal plant withdrawals under that scenario are delayed in order to meet that demand.

6.4.3 Slower economic growth

The electricity sector is strongly linked to other sectors of the economy. Slower economic growth may result in lower electricity demand. Changes to energy-intensive manufacturing may result in changes to the extent and characteristics of demand. If demand is significantly lower than modelled, this could result in lower wholesale electricity prices but higher scheme liabilities. This possibility could have a significant adverse impact on cost to NSW electricity customers.

A sensitivity test was undertaken to determine the impact of low demand on costs for the supply of wholesale energy services to NSW electricity customers. Intuitively, the Late development pathway is likely to be most resilient to adverse cost consequences resulting from lower demand, as it results in the accumulation of fewer scheme liabilities in the early years. However, the sensitivity modelling revealed that costs associated with any build trajectory were not particularly sensitive to slow demand growth. Total costs for the supply of wholesale energy services to NSW customers were lower across both the Early and Late pathways due to forecast spot price collapse resulting from oversupply, as shown in Figure 26.

The primary impact of the slow demand growth sensitivity is on the scale of subsidies required under LTES agreements to make whole the revenue stream of contracted investments, particularly in the absence of additional market response (such as more accelerated thermal generation withdrawal).

Figure 26 Sensitivity testing for slow demand growth



6.4.4 Rooftop solar generation

The uptake of rooftop photovoltaics (solar PV) in Australia has been repeatedly underestimated. Large quantities of distributed solar generation are likely to reduce demand, specifically minimum demand during daytime hours, and increase intraday price spreads. Greater than expected market penetration may have an adverse impact for certain generation mixes. For example, high uptake of rooftop solar could increase the LTES agreement liability associated with large-scale solar. No alternative development pathway is likely to be significantly more resilient to increased solar PV uptake, as they do not vary significantly in terms of their modelled generation mix.

6.4.5 Early coal plant withdrawals

Approximately three quarters of NSW’s electricity is supplied by ageing coal plants, which are scheduled to withdraw from the market over the next 15 years. There is significant uncertainty as to the precise timing of future coal plant withdrawals.

The withdrawal of a coal plant is a decision for the asset owner and updates to expected coal plant withdrawals occur frequently. Asset owners must consider a range of complex factors – including maintenance costs, supplier and customer contracts, and competition from other coal plants – in deciding whether to continue operating. In 2021 alone, the planned withdrawal dates for the Yallourn⁷¹, Mt Piper⁷², and Eraring coal plants were all brought forward. In February 2021, several asset owners – including

⁷¹ AEMO (March 2021), *Energy Australia announces early retirement of Yallourn*, available at <<https://aemo.com.au/en/newsroom/media-release/energy-australia-announces-the-early-retirement-of-yallourn>>.

⁷² Energy Australia (September 2021), *EnergyAustralia pledges to accelerate the clean energy transition*, available at <<https://www.energyaustralia.com.au/about-us/media/news/energyaustralia-pledges-accelerate-clean-energy-transition>>.

Origin⁷³, Energy AGL⁷⁴, and Delta Electricity⁷⁵ – also announced significant write-downs regarding, or cancelled planned upgrades of, their respective coal plant assets.

Historically, unexpected withdrawals of coal capacity in the NEM have had significant impacts on wholesale electricity prices⁷⁶.

Of all the sensitivities, the modelling of the earlier than expected withdrawal of NSW coal generation produced the most material impacts for NSW electricity customers. The sensitivities are set out in respect of the Early and Late alternative development pathways to indicate the likely range of impacts on costs for the supply of wholesale energy services to NSW customers (noting that the results for the Supply Chain Adjusted and REZ Aligned scenarios will fall between those under the Early and Late scenarios).

Table 9 Summary of sensitivity impacts on NPV of costs for the supply of wholesale energy services to NSW customers (\$b)

Sensitivity	Early	Late
Baseline	\$36.6	\$35.8
Early NSW coal withdrawal	\$36.6	\$41.7
Early QLD coal withdrawal	\$39.6	\$39.8

Early coal withdrawals in Queensland

Historically, NSW has been a net importer of electricity from neighbouring NEM regions. The impact of earlier than expected withdrawal of coal generation from Queensland has the potential to materially impact NSW customer outcomes.

This sensitivity tested the impact of extending the Callide Power Station outage indefinitely, in order to explore the resilience of build trajectories to early inter-regional generation withdrawals.

As seen in Figure 27, both the Late and Early alternative development pathways see increased NSW costs due to the earlier than expected coal plant withdrawal in Queensland, predominantly across the 2020s. This impact is more significant in the Late development pathway, with a \$4.0 billion net present value cost increase, compared with the Early development pathway, which sees a \$3.0 billion increase in this sensitivity. These results suggest that a more accelerated build pathway leads to greater resilience against coal plant withdrawals in neighbouring regions to NSW.

Unlike the withdrawal of coal plants in NSW, the withdrawal schedule of neighbouring regions' coal plants does not directly impact the amount of firm capacity in NSW and therefore does not present any risk of breaching the modelled state-wide energy security target.

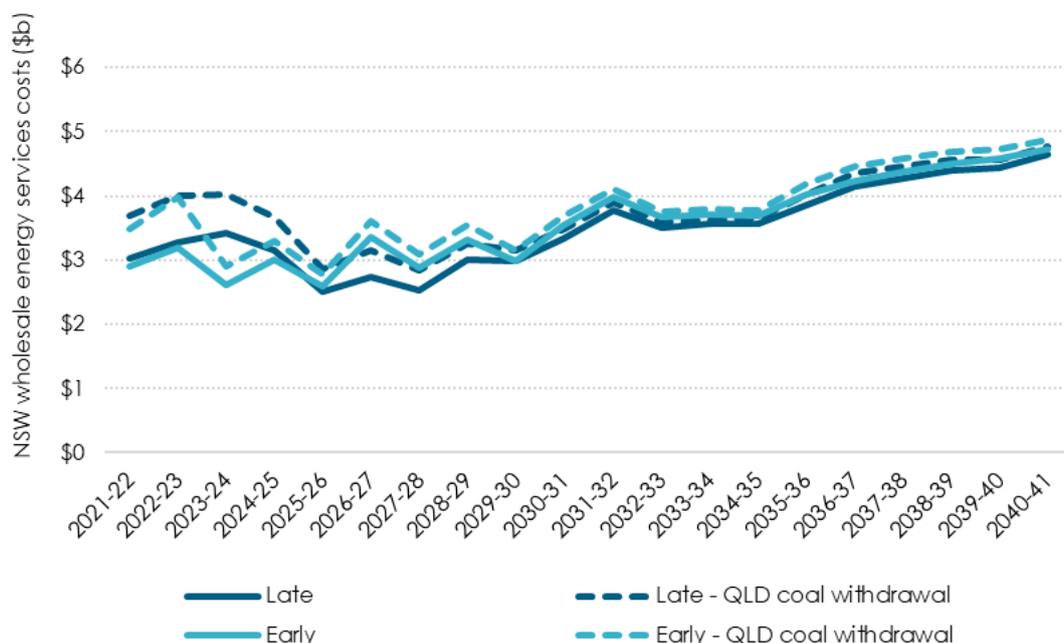
⁷³ The Australian (February 2021), *Origin downgrades guidance, AGL takes giant writedown*.

⁷⁴ Australian Financial Review (February 2021), *AGL Energy hit by \$2.69b of write-downs*.

⁷⁵ The Guardian (February 2021), *Vales Point coal plant drops controversial bid for government funding*.

⁷⁶ For example: in respect of the closure of Hazelwood (Victoria) see Australian Energy Regulator (March 2018), *AER electricity wholesale performance monitoring: Hazelwood advice* available at https://www.aer.gov.au/system/files/AER%20electricity%20wholesale%20performance%20monitoring%20-%20Hazelwood%20advice%20-%20March%202018_0.PDF; in respect of Callide C (Queensland) see AEMO (July 2021), *Quarterly Energy Dynamics Q2 2021* available at <https://www.aemo.com.au/-/media/files/major-publications/qed/2021/q2-report.pdf>.

Figure 27 Total costs for the supply of wholesale energy services to NSW customers – early Queensland coal withdrawal sensitivity



Early coal withdrawals in NSW

Given the potential severity of this risk in respect of customer costs, two sensitivities were conducted to assess the resilience of the alternative development pathways to early NSW coal plant withdrawal. The first was a ‘shock’ coal withdrawal where, like the other sensitivities, the build trajectory remained the same. An additional ‘optimised’ sensitivity was also modelled to assess the impact of an earlier than expected coal withdrawal, but with sufficient notice to enable the NSW Consumer Trustee to respond by adjusting the build trajectory.

‘Shock’ withdrawal sensitivity

The modelling for each alternative development pathway results in a unique generation withdrawal schedule. The ‘shock’ sensitivity assessed the impacts to the Late and Supply Chain Adjusted alternative development pathways if they were to be based on a coal withdrawal schedule aligned with the Early development pathway.

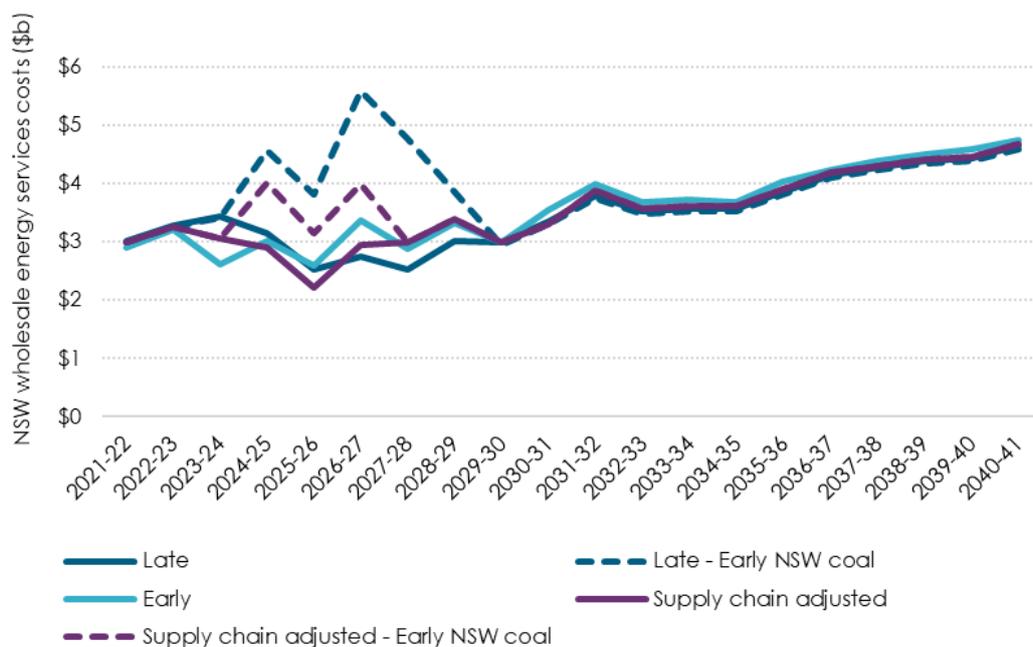
As shown in Table 10, the modelling indicates that an earlier build pathway is more resilient to earlier than expected coal withdrawal. This is the result of more generation and long-duration storage infrastructure being available to take the place of coal plants in the event of an unexpected withdrawal. Under the Late development pathway, the ‘shock’ withdrawal resulted in a \$5.9 billion increase in costs for the supply of wholesale energy services to NSW electricity customers.

Table 10 Impact of earlier than expected NSW coal withdrawal on NPV of costs for the supply for wholesale energy services to NSW customers (\$ billion)

Development pathway	Costs with expected assumptions	Costs with earlier than expected NSW coal withdrawal	Difference
Late	35.8	41.7	+5.9
Early ⁷⁷	36.6	36.6	0.0

As shown in Figure 28, the model indicates that the impact of an unexpected early coal withdrawal would be mostly felt in the 2020s, with costs returning to align with the original modelling of the alternative development pathways in the 2030s.

Figure 28 Total costs for the supply of wholesale energy services to NSW customers – early NSW coal withdrawal sensitivity

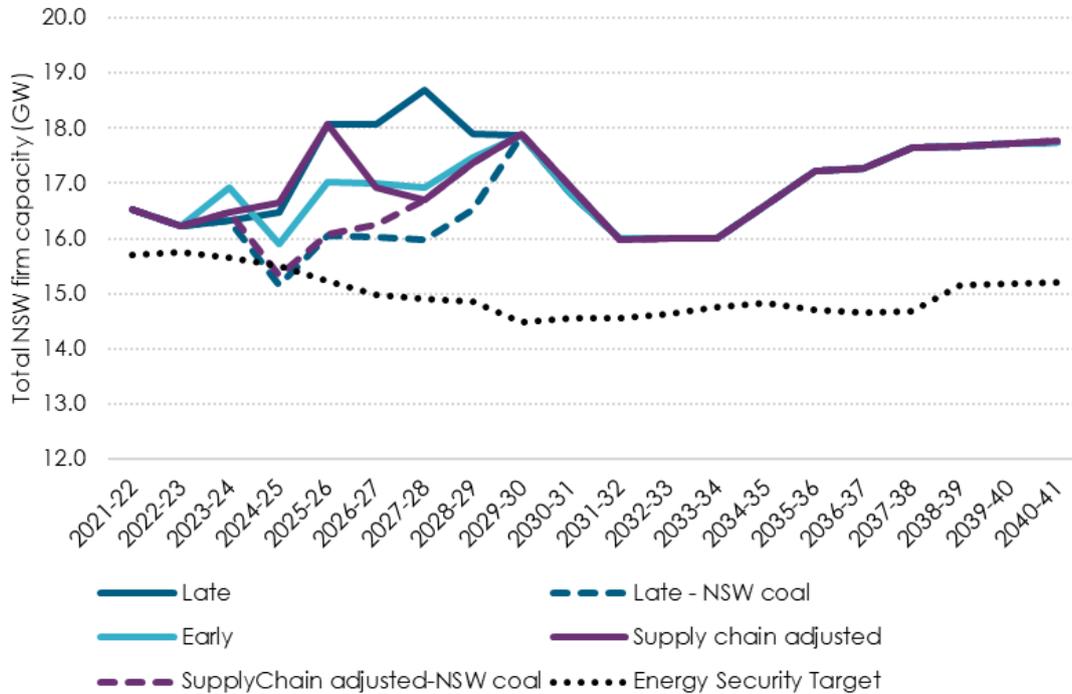


Earlier than expected withdrawal of NSW coal generation also has the potential to create reliability risks. As shown in Figure 29, the modelling indicated that earlier coal plant withdrawal led to an expected breach of the state-wide energy security target in both the Supply Chain Adjusted and Late development pathways. The relative impact on firm capacity levels from this sensitivity was greater in the Late development pathway compared with the Supply Chain Adjusted development pathway, due to lower amounts of generation and long-duration storage infrastructure being in place in time to replace the

⁷⁷ The coal withdrawal schedule for the earlier than expected NSW coal withdrawal sensitivity is assumed to match the Early development pathway, hence the Early development pathway has not had an additional sensitivity completed.

withdrawal coal generation. This indicates that an earlier build trajectory improves the resilience of the development pathway in terms of reliability of supply.

Figure 29 NSW firm capacity – NSW early coal withdrawal sensitivity



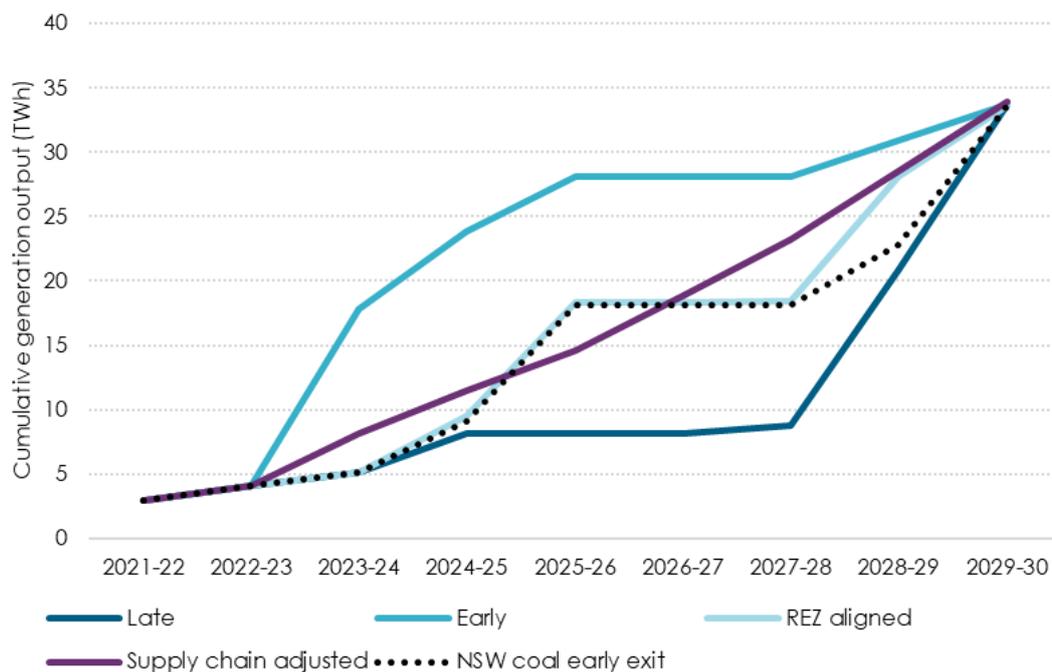
‘Optimised’ withdrawal sensitivity

Due to the potential significance of the impact of earlier than expected NSW coal plant withdrawal, additional modelling was conducted to analyse how the build trajectory might be adjusted to respond to a scenario where an earlier than expected, but not sudden, coal plant withdrawal occurs in NSW. This sensitivity was intended to produce a re-optimised build trajectory and, in turn, test whether the NSW Consumer Trustee could respond effectively to an earlier than expected withdrawal.

In the optimised sensitivity, one NSW coal plant withdrawal was assumed to occur in 2025-26. This sensitivity resulted in more rapid construction of generation infrastructure to replace the withdrawn energy and capacity, leading to a build trajectory more aligned with the REZ Aligned alternative development pathway, as shown in Figure 30. As with the ‘shock’ sensitivity, this optimised sensitivity suggests that an earlier build promotes greater resilience against early coal generation withdrawal.

The sensitivity also shows that the build trajectory under the Supply Chain Adjusted development pathway could be brought forward should such a withdrawal occur.

Figure 30 Cumulative available output from generation infrastructure in optimised withdrawal sensitivity compared with alternative development pathways



6.4.6 Delays to transmission augmentation and firming projects

New renewable energy generators will depend on the development of transmission infrastructure, such as HumeLink, to deliver power from REZs to demand centres. The modelling for the Development Pathway also indicates that achievement of the reliability standard relies on the committed Snowy 2.0 and Kurri Kurri projects, and the anticipated Tallawarra B peaking gas turbine, which are expected to provide significant firm generation capacity in NSW.

These network infrastructure and firming projects are complex, large-scale civil works that also face social licence challenges. There remains a risk that complex projects such as these may fall significantly behind schedule, delaying the commissioning of generation and storage or resulting in further congestion. The potential impacts on reliability and costs to NSW electricity customers of such delays are very high under any development pathway.

In respect of delays to transmission infrastructure, the risk is more pronounced for an earlier planned build that pushes generation construction ahead of transmission infrastructure. However, in respect of delays to firm capacity, development pathways with an earlier build may be more resilient from a cost perspective because delays to committed and anticipated firm capacity would likely also delay the withdrawal of existing coal plants (and the price increases that accompany them).

6.4.7 Overall assessment

The potential variations to the modelling inputs set out above were used to assess the resilience of the alternative development pathways to change. Overall, the selection of the Development Pathway was influenced by the uncertainties associated with supply and demand drivers under both the Early and Late scenarios. The Early development pathway was particularly vulnerable to delays in transmission augmentation and announced projects. The Late development pathway was particularly vulnerable to early coal plant withdrawals and uncertainties associated with the weighted average cost of capital.

Variations from peak demand and minimum demand assumptions, driven by electrification or economic restructuring, may favour earlier or later construction depending on the direction of the relevant trends but are not as significant as other uncertainties.

The resilience assessment reinforces the value of maintaining flexibility in planning and decision-making over the longer term. The Late development pathway, with its delayed infrastructure construction schedule, provides the least flexibility and is hence the most inherently vulnerable to uncertainties. Flexibility could be seen to favour the Early development pathway, however the risks of misalignment with other developments are high. The coordinated planning inherent in the REZ Aligned development pathway addresses this issue. The Supply Chain Adjusted development pathway offers the most resilience, providing the most optionality to respond to future deviations from assumptions.

6.5 Enhancing competition throughout the tender process

A strong and competitive tender process is expected to maximise the chance of achieving outcomes in the long-term financial interests of NSW electricity customers by encouraging high-value submissions in LTES agreement tenders. This is important for the NSW Consumer Trustee, particularly in relation to generation infrastructure, given the overall infrastructure investment objective to minimise costs to NSW electricity customers.

When selecting the Development Pathway, the NSW Consumer Trustee considered the ability to conduct tenders on a regular basis (i.e. every six months), with the aim of enhancing competition. Alternative development pathways that involved periods of little or no investment did not perform well against this criterion, as this would have required irregular-sized and infrequent tenders, with detrimental effects on competition.

Box 7: Designing tenders to enhance competition

The International Renewable Energy Agency (IRENA) emphasises the importance of a systematic approach to tenders/auctions, and within this, the benefits that are possible by running multiple rounds in its report *Renewable Energy Auctions: A Guide to Design*⁷⁸. Crafting a long-term tender plan allows market agents to adjust their expectations and plan for the long-term, while maintaining a steady stream of new projects and helping governments promote the development of local supply chains. With respect to tender offers, IRENA underscores the learning-curve benefit demonstrated via multi-round tenders, denoting the improvement in offers (i.e. financial, qualified bids and/or bids received) between tender rounds of auctions taken place around the world.

The Supply Chain Adjusted development pathway was explicitly designed with consideration of a regular capacity build trajectory over time, while maintaining alignment with REZ infrastructure development, and avoiding the peaks of capacity entry characteristic of other alternative development pathways. This smooth trajectory is expected to enhance competition.

6.6 Minimising supply chain constraints

Achievement of the infrastructure investment objectives will require the construction of an unprecedented amount of new generation, storage and network infrastructure over a short period of time. This has the

⁷⁸ International Renewable Energy Agency and Clean Energy Ministerial (2015), *Renewable Energy Auctions: A Guide to Design*, available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_RE_Auctions_Guide_2015_3_demand.pdf?la=en&hash=A8224547C476A18F424841958F8DCB449574B33A.

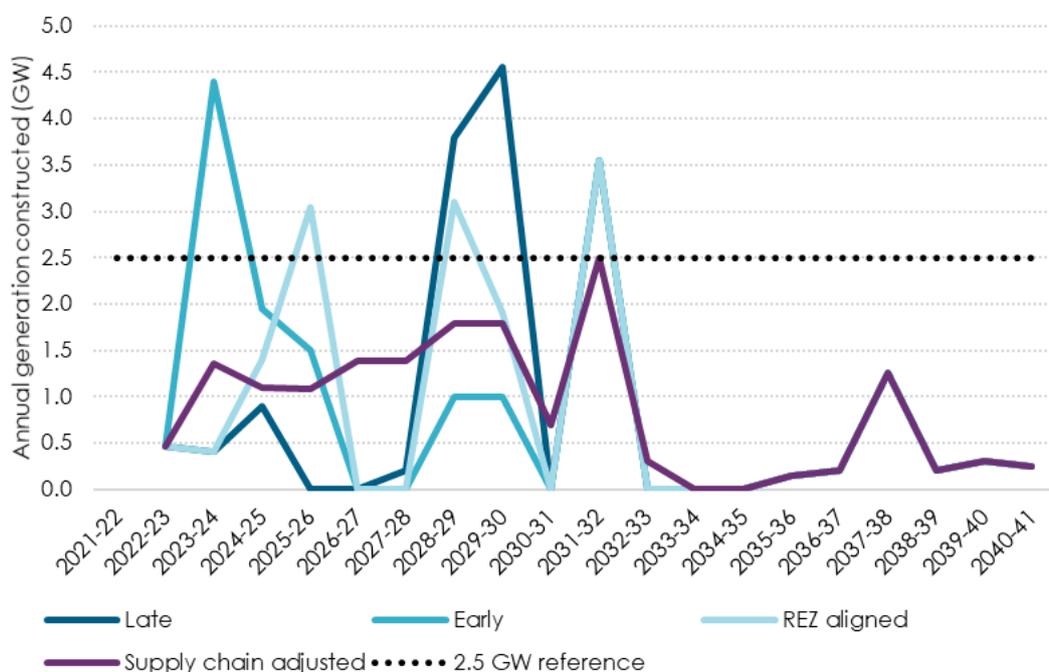
potential to result in project delays and significant inflationary pressures due to supply chain constraints, with adverse cost outcomes for NSW electricity customers. Accordingly, in preparing the Development Pathway, the NSW Consumer Trustee has prioritised consideration of the risk of supply chain constraints. Consideration of these issues is set out further in Appendix D.

The NSW Consumer Trustee considers the Early, REZ Aligned and Late development pathways as posing higher risks to NSW electricity customers. These alternative development pathways present build trajectories with significant peaks and sustained periods of little investment. Investment peaks generally align with the withdrawal of existing coal plants from the market or the commissioning of transmission augmentations. Such peaky trajectories are expected to result in constraints on existing supply chains, particularly in certain years, and inhibit the development of sustainable local supply chains, placing undue risk on NSW electricity customers. Supply chain constraints risk causing project delays, higher project costs due to lower availability of resources, and adverse community and employment impacts across the state.

In contrast, the Supply Chain Adjusted development pathway results in a staged capacity entry trajectory to meet the infrastructure investment objectives, with generation infrastructure capable of producing a maximum of 6,000 GWh and a minimum of 1,400 GWh per year being constructed in NSW each year until 2030.

Given their peaky build trajectories, the other alternative development pathways performed poorly against this criterion compared with the Supply Chain Adjusted Pathway. Figure 31 shows the annual build trajectory for each alternative development pathway and demonstrates the smoother trajectory of the selected Development Pathway compared with the other alternative development pathways.

Figure 31 Annual build trajectory for alternative development pathways



Appendix A: Glossary

Term	Definition
AEMO	Australian Energy Market Operator
EII Act	Electricity Infrastructure Investment Act 2000 (NSW)
LDS	Long-duration storage
LTES agreement	Long-term energy service agreement
Minimum objectives	The minimum infrastructure investment objectives established by section 44(3) of the EII Act.
NEM	National Electricity Market
Overall objectives	The overall infrastructure investment objectives established by section 44(2) of the EII Act
NSW DPIE	NSW Department of Planning, Industry and Environment
REZ	Renewable Energy Zone
Roadmap	NSW Electricity Infrastructure Roadmap

Appendix B – 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.⁷⁹

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:	Section 3.1
(i) the infrastructure required under the development pathway, and	Section 3.2
(ii) REZ network infrastructure projects that may be required,	
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 2.2.4 and 2.3.2
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,	Sections 3.3 and 5.6.1
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,	Section 5.2
an analysis, including the methodology, of the risks to NSW electricity customers of early or delayed investment in relevant infrastructure,	Sections 5.3 and 5.6
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 2.2.1
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 2.3.3
the forecast of unserved energy from the most recent statement of opportunities published by AEMO under the National Electricity Rules,	Section 2.3.2

⁷⁹ Electricity Infrastructure Investment Regulation 2021, clauses 16B and 16C.

Regulation	Report reference
the most recent Integrated System Plan published by AEMO under the National Electricity Rules,	Section 5.2
the market conditions, including supply chains and labour and capital constraints,	Sections 3.1, 5.3.4 and 5.6.6 Appendix D
the payments required to be made by the scheme financial vehicle under existing and planned LTES agreements,	Sections 2.3.1 and 3.3
how the development pathway in the report will contribute to the object under section 3(1)(a) of the EII Act,	Section 5.6
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 5.3
analyse the resilience of the outcomes for each scenario, including in relation to the reliability of supply and the financial exposure risks to NSW electricity customers.	Section 5.6 (in particular, section 5.6.4)

Appendix C – Committed and anticipated generation

A1.1 Committed

The projects listed in Table 11 are eligible generation infrastructure projects that have become committed since November 2019, based on AEMO’s generation and information data set and State of the System quarterly update.⁸⁰ Under the EII Act, these projects may contribute to the achievement of the infrastructure investment objectives. At the time of writing, a total of approximately 2.4 GW (i.e. 5 GWh) of committed generation is anticipated to contribute to the achievement of the objectives (noting that, at the time of modelling, only 1.6 GW were considered committed).

Table 11 Committed renewable projects

Project	Technology	MW	Included in the model
Bango 973 Wind Farm	Wind turbine	159	Yes
Bango 999 Wind Farm	Wind turbine	85	Yes
Collector	Wind turbine	227	Yes
Gullen Range Wind Farm 281	Wind turbine	111	Yes
Corowa Solar Farm	Solar PV - Single axis tracking	36	Yes
Gunnedah Solar Farm	Solar PV - Single axis tracking	110	No
Jemalong Solar	Solar PV - Single axis tracking	55	Yes
June Solar Farm	Solar PV - Single axis tracking	36	No
Metz Solar Farm	Solar PV - Single axis tracking	135	Yes
New England Solar Farm	Solar PV - Single axis tracking	400	Yes
Riverina Solar Farm	Solar PV - Single axis tracking	32	No
Sebastopol Solar Farm	Solar PV - Single axis tracking	90	Yes
Suntop Solar Farm	Solar PV - Single axis tracking	150	Yes
Wagga North Solar Farm	Solar PV - Single axis tracking	36	Yes
Wellington Solar Farm	Solar PV - Single axis tracking	211	Yes

⁸⁰ The projects listed in Table 11 are based on AEMO’s generation database, current at October 2021. <https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information>. That page also explains AEMO’s commitment criteria.

⁸¹ Previously named ‘Biala’.

Project	Technology	MW	Included in the model
Yanco Solar Farm ⁸²	Solar PV - Single axis tracking	60	No
Hillston Sun Farm	Solar PV - Single axis tracking	85	No
Rye Wind Park	Wind	396	No
Hillston Sun Farm	Solar PV - Single axis tracking	85	Committed

Anticipated

Projects outlined in Table 12 are eligible generation infrastructure projects that, at time of writing, are expected to become committed and, accordingly, contribute to the achievement of the infrastructure investment objectives⁸³.

Table 12 Anticipated projects

Project	Technology	MW	Status
West Wyalong Solar Farm	Solar PV - Single axis tracking	105	Financial close
Wollar Solar Farm	Solar PV - Single axis tracking	280	Anticipated
Wyalong Solar Farm	Solar PV - Single axis tracking	62	Anticipated

⁸² Confirmed as committed by AEMO in their October quarterly Statement of the System update - <https://www.aemo.com.au/newsroom/news-updates/state-of-the-system-update-october-2021>

⁸³ The projects listed in Table 12 are based on AEMO's generation database, current at October 2021.

Appendix D – Supply chain considerations

Introduction

A key intention of the Roadmap is to support a sustainable renewable energy industry with a strong social licence.

Supply chains will be critical to the delivery of the infrastructure investment objectives established by the EII Act. In this regard, the objects of the legislation include:

- supporting economic development and manufacturing,
- creating employment, including for First Nations people,
- investing in education and training, and
- promoting local industry, manufacturing and jobs.

Supply chain constraints have the potential to lead to project delays and increased construction costs. The NSW Consumer Trustee, acting in the long-term interests of NSW electricity customers, has been concerned to design a development pathway that has the best chance of meeting the minimum objectives by the end of 2029 and mitigates the risk of supply chain-induced cost increases.

Accordingly, in modelling the Development Pathway to meet the infrastructure investment objectives and the broader intent of the EII Act, the NSW Consumer Trustee has considered the potential impacts of supply chain constraints and how these can be managed.

In preparing the 2021 IIO Report, the NSW Consumer Trustee has had the benefit of studies in relation to constraints and opportunities for renewable energy supply chains in NSW. These analyses, undertaken:

- by MBB Group (MBB) for NSW DPIE, and
- by the University of Sydney's Institute for Sustainable Futures and SGS Economics and Planning (ISF/SGS) for NSW on behalf of the Sector Board,

have informed several key assumptions in the modelling of the Development Pathway and the structure of the 10-Year Plan.

The NSW Consumer Trustee has also had regard to publications prepared by the Commonwealth Scientific and Industrial Research Organisation (CSIRO)⁸⁴ and by Accenture for the Future Battery Industries Cooperative Research Centre⁸⁵.

Key implications for Development Pathway

The capacity of relevant supply chains necessarily has implications for both the Development Pathway and the 10-Year Plan.

⁸⁴ Bruce S, Delaval B, Moisi A, Ford J, West J, Loh J, Hayward J (2021), *Critical Energy Minerals Roadmap*, CSIRO, Australia, available at <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/futures-reports/critical-energy-minerals-roadmap>.

⁸⁵ Accenture (June 2021) *Future Charge: Building Australia's Battery Industries*, available at <https://fbicrc.com.au/wp-content/uploads/2021/06/Future-Charge-Report-Final.pdf> (Future Charge Report).

As noted in Section 3.1.1, the key supply chain-related assumption used in preparing the Development Pathway was a limit on annual construction of generation infrastructure capable of producing a maximum of 6,000 GWh of electricity per year to 2030, rising to 7,600 GWh per year from 2030. For at least the first decade, the Development Pathway also avoids periods without any investment.

In addition, under the 10-Year Plan, the initial two LTES agreement tenders for generation, and the first tender for long-duration storage, are intended to be relatively small to enable industry participants to familiarise themselves with the process.

The rationales for including these assumptions in the Development Pathway and adopting this approach to the initial tenders are as follows.

- **Upper limit for annual build** – MBB expects that, due to labour and material constraints, the civil construction sector is likely able to sustain a maximum build of 2 to 3 GW of capacity per year in NSW (equivalent to \$5 billion of investment per year). UTS/SGS also identified the potential for labour market constraints in certain REZs. Accordingly, the Development Pathway assumes that no more generation infrastructure than is capable of producing a maximum of 6,000 GWh of electricity per year will be built in any single year over the period to 2030 (rising to 7,600 GWh per year from 2030 onwards)⁸⁶.
- **Lower limit for annual build** – Industry feedback collected by MBB suggests that most supply chain constraints can be managed via engagement between government and the private sector, and a staged rollout of infrastructure. This staged rollout – including preventing any periodic collapse in investment – is also important to facilitate regional economic development and ensure that local communities benefit from Roadmap projects. This will be important to mitigate potential labour market constraints identified by UTS/SGS. The 10-Year Plan is intended to provide industry with certainty and serve as a basis for further engagement. The Development Pathway results in no less generation infrastructure than is capable of producing 1,400 GWh of electricity per year being built in any single year over the period to 2030, which is intended to avoid ‘boom and bust’ cycles of development and support sustainable supply chain and workforce development.
- **Ramp-up of tender capacity** – As well as serving to familiarise industry with the LTES agreement tender process, the ramp-up of tender capacities will also provide local industry with time to prepare for greater levels of investment.

These assumptions and rationales were informed by the following considerations regarding energy sector supply chains.

- **Overlap with civil construction** – The energy industry overlaps significantly with civil construction in other sectors, as civil works form a significant part of generation and storage infrastructure construction. The transport sector is a particular source of competition for labour and materials.
- **Labour and skills shortages** – Labour and skill shortages may become a significant factor for the build out of generation and transmission infrastructure, especially in regions with tight labour markets. Labour market volatility also presents challenges for local communities, workforce development and contractors. A staged infrastructure rollout and coordinated approach to skills development will assist in overcoming potential constraints.

⁸⁶ MBB's 2 to 3 GW figure was converted to GWh given the EII Act establishes a volumetric objective for generation infrastructure construction (see Section 2.2.1).

- **Contractor risks (workforce and financial capacity)** – Engineering, procurement and construction (EPC) contractors face challenges in terms of workforce availability and financial capacity. Skills shortages in the energy sector and overlap with other forms of civil construction have the potential to create industry-wide constraints. Further, EPC contractors' balance sheet capacities limit their ability to be involved in multiple projects simultaneously (given many projects require the provision of financial guarantees).
- **Logistics constraints** – International freight and local logistics capacity represent potential supply chain constraints. The cost and availability of shipping to Australia is extremely constrained and has been exacerbated by the COVID-19 pandemic. Freight constraints between logistics hubs and into regional areas also have the **potential to cause project delays, as well as creating social licence issues.**
- **Manufacturing** capacity and lead-times – The infrastructure contemplated by the 2021 IIO Report will initially rely on technology and equipment sourced mostly from global supply chains, but it also presents opportunities to develop local manufacturing capacity. The concentration of certain equipment from a limited number of suppliers (in terms of both company and country) present potential supply chain risks. Industry feedback suggests that long manufacturing lead-times can be managed via engagement and a staged rollout.

Background on supply chain constraints

The delivery of the electricity infrastructure required to meet the infrastructure investment objectives will be reliant on the sufficient supply of relevant labour, materials and equipment. The scale and speed of the necessary investment is likely to place pressure on the local and international networks that provides these components. Some of these pressures are inherent to the energy sector, while others are exacerbated by an overlap with demand for similar resources in other sectors.

As discussed in Section 6, in designing the Development Pathway, the NSW Consumer Trustee has sought to balance:

- the benefits to NSW electricity customers of lower technology costs associated with delayed development of the necessary electricity infrastructure, and
- what is realistically required for the energy sector and its supply chains to achieve the necessary level of construction activity to meet the infrastructure investment objectives.

Background information relating to key supply chain components is set out below.

Overlap with civil construction in other sectors

The Roadmap will create significant demand for civil construction expertise and materials. The ability of the civil construction industry to meet this demand is the primary supply chain issue for the achievement of the infrastructure investment objectives. In this regard, the energy sector in NSW faces significant competition for labour and materials from a range of other sectors, including transport, water and mining.

The transport sector is the key source of competing demand on the civil construction industry for the Roadmap. It is a more mature industry, with a large volume of transport infrastructure projects constructed across Australia in the last five years. This demand is forecast to increase, with a large peak in committed investment in transport infrastructure over the next five years (particularly in NSW and Victoria) – rising to

\$11 billion in 2023 in NSW. Notwithstanding the ramp-up over the past five years, there is evidence of cost escalation in the sector already due to supply chain constraints.

Labour market

The construction and maintenance of large-scale renewable energy and transmission projects will require a skilled workforce, likely beyond the size of that which currently exists in NSW. Industry feedback suggests there are significant structural issues with NSW's vocational education and training sector. While REZs present challenges in that they concentrate development, they will likely also serve as opportunities for better co-ordination of training, skills and workforce development. This has the potential to reduce the labour supply risks, while improving regional economic outcomes and job quality.

While skills shortages have the potential to impact the achievement of the infrastructure investment objectives, the disadvantages for participants in the labour market of peaky development cycles must also be managed. Staging the construction of electricity infrastructure in a manner that resulted in 'boom and bust' cycles would potentially create excess labour in off years. If the Development Pathway and 10-Year Plan were structured in this way, it would likely require the private sector to draw on international 'fly-in-fly-out' (FIFO) labour resources, which would further prevent the development of a sustainable workforce and undermine local economic development objectives (with negative outcomes for the Roadmap's social licence).

EPC contractors

EPC contractors will be central to the delivery of electricity infrastructure under the Roadmap. These contractors typically face constraints in relation to:

- workforce availability, and
- financial capacity.

These constraints have the potential to arise for Roadmap infrastructure due to the scale and timing of constructions, while also being exacerbated by demand from other sectors.

The ability of an EPC contractor to source an appropriately skilled workforce to undertake civil construction works is dependent on the timing and location of a project. These factors impact the ability to draw on existing labour resources in the region of the project, transfer an existing workforce from projects in other regions, train a new local workforce, or import an international FIFO workforce. A pipeline of future projects is key to justifying investment in new labour.

EPC contractors also face constraints in relation to their financial capacity. Large, complex projects (including renewable energy or transmission projects) often require an EPC contractor to guarantee project delivery on a 'fixed time, fixed cost' basis. The ability of a company to provide such financial guarantees is limited by its balance sheet. The result is that an EPC contractor will only be able to support a limited number of projects simultaneously.

Logistics

Local and international logistics have the potential to create significant bottlenecks for the construction of the electricity infrastructure required to meet the infrastructure investment objectives.

The cost and availability of shipping to Australia is already constrained. In particular, there are shortages of shipping containers due to capacity issues in the shipping industry and the COVID-19 pandemic. The

cost of shipping presents opportunities for the expansion of local manufacturing, though this will take time to develop.

The transportation of equipment from ports to regionally located project sites is also likely to require management. In particular, regional roads may require upgrades to facilitate large pieces of renewable energy equipment, such as wind turbines.

Logistical impacts and resource scarcity also have potentially significant implications for social licence. For example, delivering construction materials and generation parts to regional areas can disrupt local traffic and degrade local roads. Large temporary workforces and operations will also increase pressure on local resources, which may be limited.

Manufacturing

The construction of renewable energy infrastructure requires high technology equipment. Currently, this is only able to be sourced at large volumes from international suppliers. While manufacturing capacity is unlikely to present significant constraints, the limited number of suppliers of some components and materials, and their concentration in jurisdictions with higher sovereign risk, do present potential challenges. For example, Accenture has noted that, globally, there are efforts underway to diversify supply chains in respect of batteries given recent trade tensions and the disruption caused by the COVID-19 pandemic. In Australia, there is some local manufacturing and assembly capability, with significant opportunities to expand this.

The relevant equipment typically involves long manufacturing lead-times (for example, some components typically require 12 months' notice prior to manufacturing commencement). However, industry feedback suggests that this can be managed via the provision of certainty regarding a staged rollout of infrastructure.

Commodities

In terms of commodities, MBB considers the likelihood of constraints is currently reduced by the wide range of relevant suppliers. However, MBB further notes the potential for commodities constraints if other jurisdictions rapidly expand their reliance on renewable energy technology (for example, in a manner aligned with the goals of the Paris Agreement). The risk of such constraints is likely to increase over time, as global decarbonisation efforts expand.

The CSIRO notes that mining of critical energy minerals in Australia is relatively nascent compared to the broader mining sector. If industry is to be rapidly expanded to support larger-scale extraction of, and manufacturing of products from, these minerals, suppliers will likely face some challenges, particularly in respect of certain minerals. However, these constraints do not arise specifically from the construction of infrastructure to meet the infrastructure investment objectives.